MAPS OF THE FUTURE

– a modern crime-analysis- and crime-prediction-based tool to increase the effectiveness and quality of public administration performance in crime prevention

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1. LIST OF ABBREVIATIONS

3D	Three-dimensional
ADF	Application Development Framework
AI	Artificial intelligence
AJAX	Asynchronous Javascript And XML
ALSCAL	Multi-dimensional scaling
ANOVA	Analysis of variance
ARJIS	Automated Regional Justice Information System
ATAC	Automated Tactical Analysis of Crime
BI	Business Intelligence
BIEE	Business Intelligence Enterprise Edition
BKA	Bundeskriminalamt (Federal Criminal Police Office)
BKG	Bundesamt für Kartographie und Geodäsie (Federal Agency for Cartography and Geodesy)
C&DS	Collaboration & Deployment Services
CIC	Crime and Intelligence Center
CPU	Central processing unit
CriPA	Criminal Predictive Analysis
CRISP-DM	Cross Industry Standard Process for Data Mining
CRM	Customer Relationship Management
CSV	Comma-separated values
CV	CrimeView
D.C.	District of Columbia
EBP	Evidence-based policing
ERP	Enterprise Resource Planning
ESISPZ	Elektronické služby informačních systémů Ministerstva vnitra na úseku policejního sboru (Electronic Services of Information Systems of the Ministry of the Interior in the National Police

	Force)
ETŘ	Criminal-proceedings register (Evidence trestního řízení)
EU	European Union
FBI	Federal Buerau of Investigation
GB	Gigabyte
GDI-Zoll	Geodateninfrastruktur Zoll
GfK	Growth from Knowledge company
GHz	Gigahertz
GIS	Geografic information systems
GPS	Global Positioning System
GPU	Graphical Procesor Unit
HDD	Hard Disk
HTML	Hypertext Markup Language
IBM	International Business Machines Corporation
ICT	Information and communication technology
IfmPt	Institut für musterbasierte Prognosetechnik (German Institute for Pattern-based Prediction Technique)
ILP	Intelligence-led policing
IRKS	Institute for the Sociology of Law and Criminology
IS	Information system
IT	Information technology
KDE	Kernel Density Estimation
KSIP	Krajowy System Informacyjny Policji (National Police Information System, Poland)
LA	Los Angeles
LAPD	Los Angeles Police Department
MB	Megabyte
MPD	Memphis Police Department
MS	MicroSoft

NRC	Near-Repeat Calculator
ODBC	Open Database Connectivity
OGC	Open Geospatial Consortium
OS	Operating system
OSCE	Organisation for Security and Co-operation in Europe
OTE	Operativně taktická evidence (Operating and tactial register)
PAD	Packet Assembler Disassembler
POP	Problem-oriented policing
PPU	Policyjna platforma Uslug (Police Platform Service)
PRECOBS	Pre-crime observation system
PredPol	Predictive Policing
RACR	Real-Time Analysis and Critical Response Division
RAM	Random-access memory
REST	Representational State Transfer
RSS	Rich Site Summary
RTM	Risk terrain modeling
RV	Repeat victimisation
SA	System Analityczny (Analytical system)
SaaS	Software as a Service
SAP	Systems - Applications - Products in data processing
SARA	Scanning, Analysis, Response and Assessment
SAS	Statistical Analysis System
SDE	Spatial Database Engine
SDPD	San Diego Police Department
SDHPD	San Diego Harbor Police Department
SDSD	San Diego Sheriff´s Department
SEMMA	Sample, Explore, Modify, Model, Assess
SIGR	Integrated System for the Georeferencing of Crimes

SIMO	Security Monitor
SIS	Schenghen information system
SOA	Service-oriented architecture
SOAP	Simple Object Access Protocol
SPARC	Strategic Planning and Research Center
SPSS	Statistical Package for the Social Sciences
SQL	Structured Query Language
STAC	Spatial and Temporal Analysis of Crime
SW	Software
SWD	Command&Control system
UCL	University College London
U. S.	United States
USA	United States of America
WEKA	Waikato Environment for Knowledge Analysis
W3C	World Wide Web Consortium
XML	Extensible Markup Language
$	American Dollar
€	Euro
£	British Pound

2. PREFACE

Michal Barbořík

Head of the Prevention Programmes, Volunteer Services and Human Rights Unit, with the Security Policy and Crime Prevention Department of the Ministry of the Interior of the Czech Republic

Project supervisor

It was the inspiration drawn mainly from the United States of America that stood at the beginning of the crime-prevention department of the Ministry of the Interior (*note: Security Policy and Crime Prevention Department of Security Policy and Crime Prevention since June 1st 2015)* in the areas of crime mapping, analysis and prediction, with videos from Los Angeles and other cities on the West coast of the USA, which had more in common with science-fiction movies such as *Minority Report*, rather than the commonplace policing in the Czech Republic.

In these videos, police officers were given maps with highlighted squares at the beginning of their shift, which they were to patrol. The officers trusted their orders, knowing that scientific work and sophisticated computer analyses formed their background. They also knew that due to such organised work, crime had been declining in their beats. During their shift, they were after a perpetrator of crime-related offences in one of the highlighted areas. Being in constant touch with the operation centre, which was observing and analysing the crime situation in the city in real time, through mobile devices even in the field, the patrol was provided with updated orders, which enabled it to interrupt a theft of a luxurious car in a newly appearing area during their next patrol.

These police officers saw a real sense in their work, and the community felt safer. Despite feeling there was not enough officers in the streets, the people knew that those involved were in the necessary place an the necessary time. Consequently, even in times of budget cuts, the police could work in a more effective and efficient manner than ever before. Crime rates had dropped by as much as 30%, going hand in hand with the rise in clearance rates, resulting in a higher public trust in the police.

This was the moment that we realised this was necessary for the National Police Force, as well as municipalities and city police forces. Crime, property crime in particular, still besets the Czech Republic. The number of police officers as well as the police budget was undergoing cutbacks, and even up to the present moment it has not reached the levels from five years ago. Owing to considerable stress and related complex administration, police officers spend more time in offices than streets. Patrol-planning still relies on traditional local knowledge, which, however, is insufficient in times of large fluctuation in the departments and in the enormous volume of acquired information.

In such a situation, it appears that this targeted analytical and predictive approach to working with spatial crime data and associated tools comes in as a gift from above. Still, is it really working? Is it not but a hollywood tale? If so, can it work in our conditions also? Specialists responded in a variety of manners, generally being either exhilarated or sceptical.

That is why we decided to cast more light on this issue, attempting to dispel all doubt and to reply to all questions. It gave rise to the *Maps of the Future* project, which aims at garnering practical experience – mainly from abroad (but also from the domestic setting) – from the field of geographic and information tools for crime prevention and elimination. We have embarked on the process using analyses and predictions.

This experience was meant to show the way these tools work exactly, the conditions for their application, their background, their related costs and the benefits they bring; whether they really *are* effective and cost-efficient.

By means of this study, we hereby present the outcomes to the representatives of the target groups: the National Police Force, city police forces, employees and elected representatives of municipalities and the Ministry of the Interior, but also other interested parties we got in contact with us during the execution of the project (from academia, the non-profit sector and other areas). In the course of the project, we cooperated with the target groups closely, among other things by holding two international specialised workshops on the issue in question, in order to share their views and the opinion whether such tools for crime mapping, analysis and prediction can be contributive also in the Czech Republic, whether this country provides adequate conditions for their use, which foreign models would be best to apply in the Czech context and what is necessary for doing this. The experience and viewpoints are reflected upon in this study, mainly in the proposal part.

One of the conclusions of the study is that there are multiple ways of working with crime predictions and tools executing it. It would be misguided to think of these as a panacea to eradicate crime. Behind these tools is an effort of those who helped develop and implement these instruments in particular settings. Moreover, these tools may not even replace the work of experienced analysts and officers; what they can do, nonetheless, is serve as a complement to render the people's work more effective and time-efficient. Under these conditions, the results mentioned in the introduction are attainable.

Consequently, based on the information acquired through this project (and simultaneously executed activities by the Ministry of the Interior of the Czech Republic in this area, such as a project dealing with GIS as a support for security and rescue forces), we would like to cooperate with the National Police Force (or other partners, such as municipalities and local police forces, for that matter), carrying on with this work. By means of follow-up ventures, we would like to test or even develop and verify analysis-and-prediction-based models that could be utilised in the Czech Republic. Were the verification process to have a positive outcome, these tools would be purchased and spread throughout the National Police Force, and their active users, mainly managing staff and analysts, would undergo a training in operating them. We would also like this solution to be used at the municipal level, by local police forces in particular.

Should you like to get to know more about the project, this study and other outcomes of the project, including videos and presentations recorded at the workshops, are available on the webiste *www.prevencekriminality.cz*.

To conclude, I would like to extend my personal thanks to Ms Jitka Gjuričová, a former head of the crime-prevention department of the Ministry of the Interior, who gave rise to this project and who is still providing her active support to its ideas.

Václav Kučera

Director of the regional police directorate of the central Bohemian region

Head of the coordination group IS criminal-proceedings register

Following the government Crime Prevention Strategy in the Czech Republic for years 2012-2015, which elevates analytical approach for crime prevention purposes as a priority, the Ministry of the Interior of the Czech Republic commissioned a study entitled “Maps of the Future – a modern crime-analysis- and crime-prediction-based tool to increase effectiveness and quality of public administration performance” in 2014. The title makes it apparent what expectations the study holds. Apart from an international comparison of processes and instruments in mapping, analysing and predicting crime, the study also puts forward recommendations for the National Police Force on how these processes and instruments should be applied in this environment.

Results of the study are delivered in times when the National Police Force reaches its peak in shifting administrative processes into digital environment. This involves not only internal administration, but also – and mainly – information acquired in relation to criminal activity. Digitalised processes can be observed, measured, statistically compared and evaluated more precisely, swiftly and in larger volumes. In an attempt to increase effectiveness, analytical tools are developed, capable of interconnecting gathered data and exporting relevant output for further processing.

The vast volume of information generated by these applications can not be used effectively without spatial analysis. It is the enormous volume of relevant data impacting on our naturally limited memory capacity that can lead to distortion and deformation, resulting in direct errors in the final outcome. Spatial analyses and crime visualisations of good quality delivered through relatively straightforward images, in smart maps, considerably facilitate the evaluation and elimination of ineffective steps.

Implementation of new methods and tools as a reasonable step towards a more effective police work is by no means an uncommon phenomenon in the National Police Force. Up-to-date applications are implemented and operated at different levels, which is corroborated by this study as well. Initiative at all levels should be welcomed, supported, and, in the case of an adequate result, implemented systemically as best practice across law-enforcement agencies.

This submitted study provides a comprehensive view of the development of one crime-analysis area, advises target groups accountable for implementation of new, advanced tools, and provides space to responsible parties in order to meet with, grasp and decide accordingly about this issue.

When Tomáš Baťa postulated in the early 1900s that every human activity needs to be reflected on in figures eventually, he might have had no clue that one day in the future, this would be happenning not only in the usual decimal, but also – and mainly – in the binary system, represented by digits 0 a 1. Digitalisation and effective analysis in the National Police Force, supported by best practice of officers and studies of experience from abroad, is in the hands of responsible managers.

3. ABSTRACT

Mainly on the basis of experience garnered by foreign agencies, this study aims to describe elementary preconditions for implementation of modern approaches and tools based on crime mapping, crime analysis and crime prediction so as to enhance the efficiency and quality of public-administration performance, strategic management, crime-prediction planning and law enforcement in the Czech Republic.

For the most part, this International Comparative Study aims at the members of the management of the National Police Force and representatives of the Ministry of the Interior of the Czech Republic, providing information about both foreign and domestic experience from the area of crime mapping, analysis and prediction.

The study provides a description of approaches and tools used in countries of the European Union, Switzerland and states of the United States of America which are experienced in working with crime mapping, analysis and prediction. It focuses on legislative, organisational, technical, professional and other conditions necessary for implementation and usage. Also, it evaluates the costs associated with the application of these approaches and tools, along with their benefits. This study also provides information about the foreign experience with publishing data on crime and crime maps.

Outcomes and recommendations hereby described draw from face-to-face meetings, specialised literature and professional workshops, held in December 2014 and June 2015. During these events, experts from the Czech Republic and abroad acquainted representatives from the Police, municipalities and Ministry of Interior with crime mapping, analysis and prediction.

The study also includes a comparative analysis of approaches applied in law-enforcement agencies abroad, and a final recommendation dealing with the most effective implementation of the given approaches and tools in the environment of domestic law enforcement, mainly the Police of the Czech Republic and local police agencies.

4. INTRODUCTION

Recent years have seen an emphasis on using advanced IT technologies and data in various areas of human activities, including analyses. Crime prevention is no exception.

The strategy of crime prevention in the Czech Republic for years 2012-2015 shows that work with GIS and analytical tools in the sphere of crime prevention is underestimated in the Czech Republic at this juncture, not making full use of their benefits. In terms of this government strategy, the Ministry of the Interior carries out a number of measures which should lead to a wider and more effective use of analytical tools for the sake of crime prevention, internal security and public order at the local level.

Police experience and a whole host of research carried out abroad shows that an analysis- and prediction-based approach is a useful tool to reduce crime-rates effectively. It is estimated that, using predictive analysing, security forces can reduce some sorts of crime by as much as 50%, supposing that demographic and social changes, law-enforcement strategies, local communities and other crime-related trends are also involved.

Crime mapping enables the forces to depict the development of crime in time and space. Crime prediction can help prevent felonies and misdemeanours from happening within an area, and enables effective planning of crime-prevention measures in such a way so as to cease it.

Due to this experience, it is possible to say that crime prediction is far from reading a crystal ball, but a sophisticated scientific branch with convincing outcomes. It can render the police work more effective so as to secure public safety in a more effective and targeted way, notwithstanding the fact that both budgets and staff of police forces are often reduced.

5. OBJECTIVES AND METHODOLOGY

The main objective of the study is to acquire detailed information and hands-on experience, mainly (but not solely) from abroad, pertaining to processes and tools in crime mapping, analyses and prediction, to conditions for their usage, their costs and benefits. Also, the crucial task in terms of the study is an assessment of the knowledge gained through specialised workshops carried out, including information from discussions about key topics with representatives of the target groups.

Besides, based on this information, the further aim of this study is to voice recommendations for the Czech Republic on how to implement these state-of-the-art, functional processes and tools into the environment of security forces of the Czech Republic, mainly the National Police Force of the Czech Republic or local police forces. The study also provides information on foreign experience regarding publishing crime maps.

Part of the paper aims to acquaint the target groups (see Table 1) with this knowledge and experience, obtaining feedback from the target groups about an effective implementation of these tools in the context of the Czech Republic.

1.	Administrative bodies, state organisational units, employees of these authorities, organisations and organisational units administered by these bodies and their employees (*mainly employees of the Police of the Czech Republic and the Ministry of the Interior*).
2.	Territorial self-governments and their bodies, agencies and agencies (*mainly municipalities, particularly those which have established municipal police and their employees, including municipal-police officers*).
3.	Politicians of territorial self-governments, including elected members (*mainly politicians and elected representatives of municipalities*).

Table 1: Target groups

Source: Ministry of the Interior of the Czech Republic 2015

It is expected that this project will initiate processes in the Czech Republic which will contribute to a more effective crime prevention and, in some cases, even to crime reduction and the ensuing higher safety of the Czech citizens.

For the sake of this study, the term "crime" comprises not only felonies, but also misdemeanours and crime-risk phenomena. With respect to the type of crime, it involves "general crime", such as violent crime (*e.g. murder, robbery, aggravated assault)*, vice crime (*rape, procuring prostitution, human trafficking*), crime against property (*mainly thefts, criminal mischief*), narcotics, vandalism, graffiti, threat under the influence of illicit substance, drunken behaviour, and the like, and also offenses of a similar nature and crime-related phenomena.

In describing the practical experience, the study mainly focuses on (legislative, organisational, technical, specialised, and other) conditions for implementing and using the approaches and tools in question, the related costs and benefits.

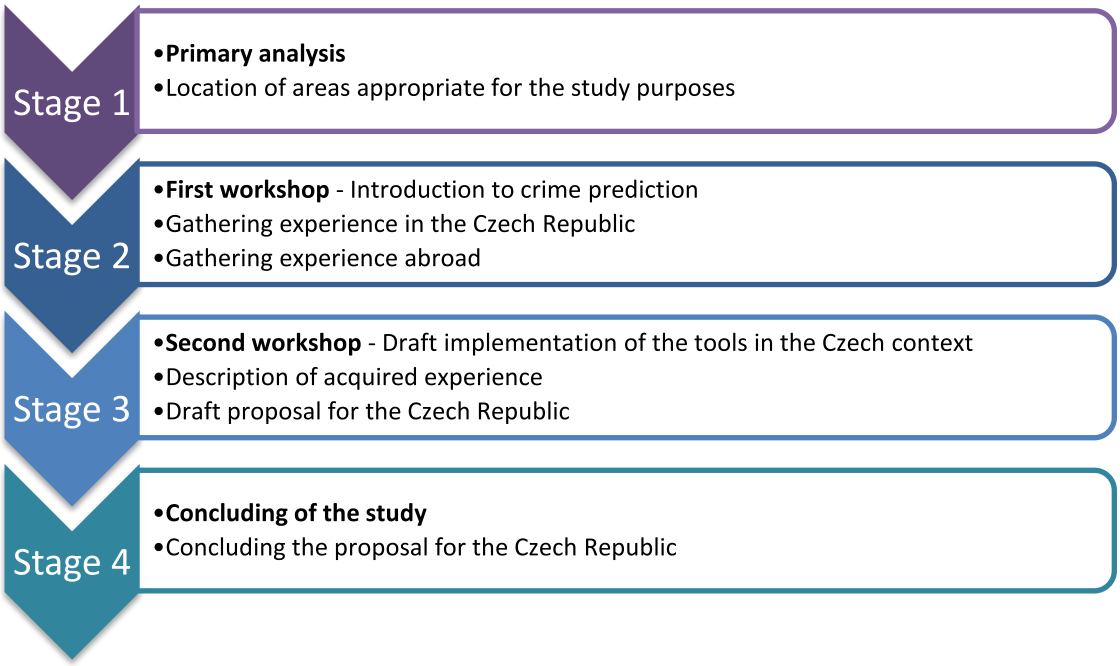

Figure 1: Stages of processing

Source: ACCENDO – Science and Research Centre 2015

The study draws mainly from face-to-face meetings to selected countries/cities, and specialised literature dealing with these territories, which have practical experience with approaches and tools in mapping, analysing and predicting crime. In terms of the primary analysis of secondary data (desk research) on the initial situation both abroad and in the Czech Republic, the following countries have been chosen (see Table 2).

COUNTRY	CITY	CONTACT
USA	Los Angeles	personal meeting
	Lancaster	personal meeting
	San Diego	personal meeting
	Tempe	personal meeting
	Redlands (kampus ESRI)[1]	personal meeting
GREAT BRITAIN	London	personal meeting
	Greater Manchester	personal meeting
	Kent	personal meeting
	Cambridgeshire	personal meeting
AUSTRIA	Vienna	personal meeting
	Graz	personal meeting
GERMANY	Munich	remote communication
ITALY	Bologna	personal meeting
SWITZERLAND	Zurich	remote communication
POLAND	Warsaw	personal meeting
SLOVAKIA	Bratislava	personal meeting
CZECH REPUBLIC	Uherské Hradiště	personal meeting
	Pardubice	personal meeting
	Kolín	personal meeting

Table 2: List of scrutinised countries/cities

Source: ACCENDO – Science and Research Centre 2015

[1] Information obtained from this meeting is used in most examples, not only in those dealing with the USA. It is therefore not a separate section. Participants in the meeting were representatives of software developers focusing on specialised commercial programmes and Dr Spencer Chainey from University College London.

STAGE 1: Primary analysis

Based on primary analysis of locations suitable for the purposes of the study, 19 examples from nine countries were selected. On the basis of an analysis of EU countries and the conclusion that no other countries from the EU could be selected for the sake of further information, areas from the United States of America and Great Britain were added, with considerable experience in predicting and mapping crime.

Also, in December 2014, the first specialised workshop was held, which took place in the premises of the Police Academy of the Czech Republic in Prague, attended by a total of 154 participants.

Day one of this event was divided into four sessions, with contributions by four representatives from the Ministry of the Interior of the Czech Republic, the Police Presidium of the Czech Republic, the National Police Force and city police forces of the Czech Republic, three representatives of Accendo, Science and Research Centre, three project advisers, and seven specialised trainers from abroad and six from the Czech Republic.

During the first day, 23 speakers rendered their speech, introducing the project objectives and activities. Participants were acquianted with the aims of the workshop, other geographic-information-system (GIS) projects carried out through the Ministry of the Interior were presented, the GIS area was introduced, its description, benefits and usage in crime prevention, law enforcement, public order and crime prediction. Apart from that, experience in crime mapping, analysing and predicting, and tools used in the USA, Great Britain, Austria, Germany, the Netherlands, Italy and the Czech Republic were presented.

With regard to the Czech Republic, activities of the National Police Force and city police forces in predicting and mapping crime were introduced. Further, current issues pertaining to collecting and using criminogenic data by law-enforcement agencies were touched upon. Example from the USA dealt with introduction of GIS technologies used for analysing criminogenic data, preparation of supporting documents and developing predictive systems used by police forces in the field in real time. Representatives from Great Britain introduced a criminologic research carried out by a university, its interconnection with Metropolitan police and its practical usage. Representatives of Austria introduced their project tackling the development of tools, methods and approaches for crime prediction which joins research institutions, universities, specialised private companies and other experts in the field. Representatives of the Netherlands and Germany introduced analytical tools used in prevention and improving security. Also, other examples of crime mapping and prediction used in Italy, Switzerland and Liberia were introduced.

On day two, participants were divided into five target groups and the schedule was divided into five sessions, each lasting for fifty minutes. Five separate rooms provided the participants an opportunity to attend each of the five presenters from abroad (USA, Great Britain, Austria, Germany, Netherlands) who, using samples and practical exercises, introduced concrete approaches and tools in crime mapping, analyses and predictions.

The representative of the USA, Mr John Beck, provided a practical example with real data and showed implemented GIS technology used by police forces in the field in real time, from an analyst's, police officer's and commander's perspective. Representatives of Great Britain, Mr Petr Torak and Mr Ken Pease, introduced their experience with practical use and implementation of GIS technologies in field work, along with an analysis of costs. Further, following up on his presentation from the previous day, Mr Pease, a lecturer from University College London, introduced criminological research in greater detail and its connection to activities of police forces. Mr Philip Glasner, an Austrian specialist, introduced the "Criminal Predictive Analysis" project, along with the utilised tools, methods and approaches to execute crime predictions in Austria. The representative of the Netherlands, Mr Johan Huizing, introduced the use of household surveys as supporting data for an analysis of the status quo of crime and improving of security within a territory. Mr Jaap Vink, who represented Germany, acquainted the participants with the analytical tool SPSS Data Modeler, used in activities related to prevention and improved security. Each practical exercise was followed by a topical discussion.

Available are also the workshop proceedings, which, along with other contributions (presentations, videos) can be found at *www.prevencekriminality.cz*.

STAGE 2: Garnering experience

Garnering of experience proper took place in the September-May 2015 period. With the exception of Germany and Switzerland, it entailed personal meeting of competent law-enforcement staff, universities and software companies in the given country/city. So as to acquire necessary information about a specific implementation, a scenario of the interview/list of questions (Appendix 1) was drafted and sent to the interviewees from each country/city prior to the meeting along with an authorisation letter from the Ministry of the Interior of the Czech Republic. These documents provided the organisations with information about the objectives and required information before the meeting itself.

In most cases, the meetings took place on the spot of the described implementation, i.e. a police department. Participants were members of authorised police departments (analysts, GIS operators, commanders), developers, suppliers of the implemented software and other competent parties (members of universities or external consultants, for instance). On the basis of these face-to-face interviews, practical samples and gained materials, this experience is described in the following sections, which deal with the particular countries/examples.

STAGE 3: Description of experience and draft proposal for the Czech Republic

The study is based on specialised literature and activities carried out in this area, and provides a description of the situation in the selected countries, which have obtained practical experience with approaches and tools in mapping, analysing and predicting crime. The description focuses on (legislative, organisational, technical, specialised, or other) conditions for implementing and using the aforementioned approaches and tools, related costs and general benefits. It also addresses whether the created crime maps (along with analyses and predictions) are available for the public and what the related (positive or negative) experience is.

The main source of information were mainly personal meetings in the contacted organisations.

At these meetings, practical experience of police officers was shared. Also, participants provided replies to questions they had obtained prior to the meeting (scenario). All involved parties shared their answers to almost each question, along with other complementary materials. Questions difficult to answer comprised financial and legislative issues and the degree of effictiveness, occasionally resulting in a failure to acquire this information.

Due to a gradual, long-term implementation within a given organisation, the authorised parties were unable to supply financial costs or provided merely approximate estimates. In some cases, the police obtained the implemented software at a bargain price or eliminated the price altogether by cooperating with local universities.

No adjustments to legislation in connection with an implementation have been found in the given examples. Should any changes occur, they were provided as an order at the level of the police or as changes to the manner work was organised.

As for the effectiveness of the implemented solution, police officers hardly observe specific statistical figures of crime reduction. However, commanders provide a subjective feedback regarding a higher effectiveness of officers' work and a positive response from the public. In some cases, a pilot run is still under way, hence no *ex-post* evaluation has been carried out.

In June 2015, second workshop was held, which took place in Prague. Its aim was to summarise the then-current knowledge acquired within the project and to present this information as well as the draft proposal for the Czech Republic.

A total of eleven speakers delivered their speeches during the first day. They presented the targets and acitivities of the project, acquianting the audience with the objective of the workshop and another project from the sphere of GIS carried out by the Ministry of the Interior. First and foremost, the knowledge and approaches from the nine analysed countries (*USA, Great Britain, Austria, Switzerland, and other* countries) were summarised, as well as their description, the benefits of spatial analyses and GIS for crime prevention, law enforcement, public order, crime prediction, its benefits and and usage. The presentation focused on contradictory approaches of individual countries/cities in maintaining criminogenic data, using traditional analytical methods (e.g. *GIS, DataMining, statistical data processing*) up to making use of specialised predictive tools, such as *PredPol, HunchLab, Palantir* or *CrimeView*.

Additionally, experience in mapping, analysing and predicting crime, along with utilised tools in Austria and Great Britain, whose experience appears to be compatible with the environment and conditions of the Czech Republic. Mr Spencer Chainey, from University College London, defines as the initial baseline the fact that clear theoretical framework need be defined for effective police predictions that is capable of explaining crime patterns in space. This leads to the definition that spatial prediction of crime has to be grasped in three temporal dimensions: *immediate future*, for targeting police resources; *near future*, for targeting preventative measures; and *long-term predictions*, for managing strategic policies.

Using the example of Newcastle, UK, he showed the identification potential of near future on the basis of repetitive patterns of behaviour/events. In 2010, 15% of all burglaries were identified on the basis of initial victimisation. The method of *near-repeat victimisation* later defined spots with an increased risk level in near place/time from the original place of an incident. Within the following seven days and the distance of 200 metres from the initial burglary, 23% of all burglaries were identified.

At the same time, this also shows how maps and analyses created with standard GIS tools/analyses, rather than a specific predictive software, can be used for effective predictions of where, when and how a crime will be most probably committed.

Experts from Austria presented the structure of the police in nine federative states and the department of analysis, which creates spatial data analyses while operating GIS systems. Also, they spoke about *Criminal Predictive Analysis* project. Being a joint venture of research institutions, universities, specialised private companies, police forces and other Austrian professionals from the field, it deals with the development of tools, methods and approaches for crime prediction. Among other aspects, the project focuses on whether analyses and methods developed in the USA and Great Britain can be applied in Austria as well. On the basis of a time-space analysis of repeating thefts and burglaries in Vienna, a prediction for the city of Salzburg was created, concluding with a successful forecast of 25-50% of future burglaries, car thefts and robberies. The police are currently carrying out the testing phase.

At the end of the first day, possibilites of receiving subsidies from the EU funds in the 2014-2020 period, in relation to further use of the project outcome and potential of GIS technologies, were introduced. During the introductory session of the second day, the status quo of the National Police Force was presented, along with their activities in crime mapping, as well as first hands-on experience in the Czech Republic in using predictive tools and crime maps in law enforcement.

Throughout the second day, attenders were divided into five target groups, and the schedule consisted of five topic-based discussion panels:

1. Target groups' demands, requirements and expectations
2. Conditions for implementing tools and processes for crime mapping, analyses and predictions in target groups (legislative, technical, financial and personal capabilities)
3. Quality and availability of data on crime and related phenomena
4. Sharing of data and outputs with other subjects, publishing crime data
5. Motivating and involving target groups to work with crime mapping, analysing and predicting tools

Each topic was moderated by a member of the project team, each of whom joined all panels. The participants thus attended all topics. The aim of each group was to propose a recommendation in the given topic based on the discussion.

Available are also the workshop proceedings, which, along with other contributions (presentations, videos) can be found at *www.prevencekriminality.cz*.

STAGE 4: Finalisation of the study

In the final stage of the study, a recommendation was drawn up on how the given approaches and tools could be applied most effectively, drawing from the collected experience and knowledge from both the Czech Republic and abroad, also reflecting on the knowledge from workshops held in terms of the project.

The main aim of this stage was processing of a study that renders information about practical experience, mainly from abroad, but also from the Czech Republic, pertaining to processes and tools from crime mapping, analyses and prediction, to prerequisites for their use, their costs and benefits. Part of the study also describes information gained through specialised workshops held.

6. USE OF SPATIAL INFORMATION AND TOOLS

This chapter deals with selected methods, tools and approaches, used or mentioned by the organisations/analysts in question in terms of the solutions described in the respective countries. These descriptions provide basic information to acquaint the reader with the field. For more detailed information, specialised literature is recommended (e.g. Chainey & Ratcliffe 2005; Perry 2013; Horák 2015; Eck 2005; Caplan et al. 2012).

6.1. INTRODUCTION TO GIS AND SPATIAL DATA ANALYSES

6.1.1. GIS

Geographic information systems (GIS) are computer systems used for acquisition, administration, adjustment, analysis and visualisation of data that is spatially connected with the earth surface (McDonnell & Kemp 1995). This geographic information is understood as data related to space used by the human society. Needless to say, however, that apart from data, software and hardware, also methods and qualified staff add up to the complex understanding of GIS (Figure 2).

Figure 2: GIS components

Source: ACCENDO – Science and Research Centre 2015

Spatial data representation in GIS

Two basic types of spatial data representations are distinguished (vector data model and raster data model). In the **vector data model** spatial objects are represented in the following three ways (Chainey & Ratcliffe 2005):

- **Points**, which are localised and their coordinates X, Y (and alternatively Z) known. They can be visualised as a dot or another suitable symbol. In the context of policing, points usually represent individual crime records.
- **Lines** are curved polylines represented as a series of straight segments connecting vertices (Longley et al. 2001). In the policing context, lines represent, for example, streets.
- **Polygons** are areas/regions delineated by a closed line. In policing, polygons can represent, for instance, a beat.

An indispensable part of spatial analyses is the localisation of the points of interest and their attribute information. In the vector data model, attribute information can contain a great deal of information related to the individual areas. Attribute information is stored in tables (Chainey & Ratcliffe 2005).

A raster data model represents spatial features in regularly arranged cells, called pixels. Each cell represents one value. Individual cells form a grid, which can have different structures (e.g. square, triangle, hexagon). What needs to be considered in a raster represeantion is the size of the individual cells, which influences the resolution (Břehovský & Jedlička 2005). One of the basic GIS functions is generation of spatial analyses, which is a set of techniques and methods for analysing and modelling objects and phenomena in the spatial context. Different spatial issues can be dealt with, from migration, through socio-economic trends, to crime prediction. Spatial analyses serve to derive new facts through geodata (see Spatial Data Analyses).

Crime data suitable for spatial analyses contain information about geographic position, either precisely localised (GPS coordinates, for instance) or approximate (address points). Using this data, GIS tools can carry out necessary analyses and render results. These tools can accumulate, analyse and visualise information quickly, enabling users to understand the analysed phenomenon in the given spatial context.

GIS in police forces focused on crime

The advantage of GIS tools is a relatively straightforward visualisation of criminal phenomena and statistics through cartographic instruments, which allow all interested parties (analysts, officers, etc.) to grasp and interpret the given issue. GIS can be used in a variety of manners in policing, be it identification of potential offenders, areas with concentrated crime, resource planning, strategic and crisis management, but also a broad picture of the current situation in a city or region. According to Chainey & Ratcliffe (2005), GIS can have numerous applications in policing, such as recording and mapping police activity, calls for service, crime reductions projects, supporting the briefing of operational police officers, identifying crime hot spots for targeting crime reduction responses, monitoring the impact of crime reduction initiatives, predicting crime occurrence, or using maps as a medium to communicate crime statistics to the public.

Law-enforcement agencies are currently facing numerous challenges, and GIS, its functions and methods, can be a valuable source of information suitable for decision-making at all levels of the police. It provides information for long-term decision-making and creating strategies to police-force management, based on predictions and analyses. Analysts can use GIS as a supporting tool in their analyses, disseminations and evaluations. GIS also creates an added value for the lowest levels of law-enforcement agencies. Police officers use these tools in the field to gather localised data or as a source of information, which increases their practical effectiveness.

6.1.2. Spatial data analyses

The majority of information met with and used have a spatial nature (**geoinformation**). In a way, being bound to a certain place, it represents it. This place needs to be understood in a broader sense. A place can be represented, for instance, as a dot, a set of dots, a line, a set of lines or a polygon. By formalising a piece of information, data is acquired; similarly, by formalising a piece of geoinformation, **geodata** is acquired (more accurately **spatial data**). Analogically, spatial analyses can be specified as spatial data analyses, which, however, can be misleading as the spatial component is not always used in analysing spatial data. In such case, spatial-data analysis (analysis of spatial data) is an appropriate term, rather than spatial data analysis (spatial analysis of data) (Horák 2015).

Spatial analyses can be defined as follows: *Spatial analyses are a set of techniques for analysing and modelling localised objects, where the results of the analyses depend on the spatial arrangement of these objects and their properties.* (Horák 2015)

Spatial analyses represent a set of analytical methods which require an access to attributes of the studied objects and to information about their localisation. Unlike other forms of analyses, spatial analyses require attribute data and geographic location of objects. Spatial data analyses are intertwined with the study of spatial-data arrangement. In particular, they concentrate on finding new relationships between the arrangement and object attributes or geofeatures in the studied area and modelling of these relationships, aiming for a better understanding and prediction of development within an area (Horák 2015).

General definition of some targets of spatial analyses (Horák 2015):

- **Description of objects (events) in an observed area** (including the description of the arrangement, i.e. the texture). It includes: derivation of statistical attributes of the observed texture of geofeatures (dots, lines or polygons) and their comparison; testing whether the observed distribution differs significantly from a certain hypothetical texture (which is important for the following interpretation of processes); testing of spatial relations and links between entities, but also an ordinary description of the development of a field, such as the calculation of a value in unknown places (interpolation). What is of interest is why certain phenomena accumulate in some places, whether this is a matter of coincidence, how a texture in different areas can be compared, how this difference can be quantified, whether there occur any changes in time.

- **Selection of a certain place on the basis of fulfilling a specific set of conditions** (more generally, in accordance with a certain decision scheme) or investigation of the extent of fulfilment in a given place or area.
- **Interpretation of processes** which led to the observed state of object or event arrangement in the observed space (systematic research), e.g. interpretation of the emergene of observed arrangement of dots, explanation of the territorial development in time (both median values and variables).
- **Optimisation of the arrangement of objects/phenomena** in the observed space, e.g. to localising and allocating tasks, selection of the flow distribution (distribution of the employed, children in schools, goods), but also, e.g. proposal of a suitable system of sampling.
- **Enhancement of the ability to predict and control objects and event in the observed space** (application of predictive models).
- **Reduction of the initial volume of data** to a more compact, transparent set of data, by, for instance, generalising the initial data for an improved description of the observed phenomenon or for the sake of a better operation.

There are numerous types of methods of spatial analyses, divided according to applied techniques, type of data processing and type of spatial representation. Regarding applied techniques, spatial analyses divide into statistical (spatial statistics), mapping, mathematical modelling, interpolation, localisation and allocation (distribution of objects, e.g. analysis of industrial-zone location), network analyses (dealing with transport, technology or nature networks), miscellaneous analyses of surroundings and connections (Horák 2015).

From the viewpoint of data processing, methods of spatial analyses are divided into **visualisation, survey** and **modelling** (Horák 2015). The typical result of visualisation are cartograms or cartodiagrams, which depict statistical data (without major adjustments) in a certain territory.

The following map exemplifies a cartogram visualising the amount of metabolites of crystal meth measured in the sewer of the city of Ostrava, Czech Republic.

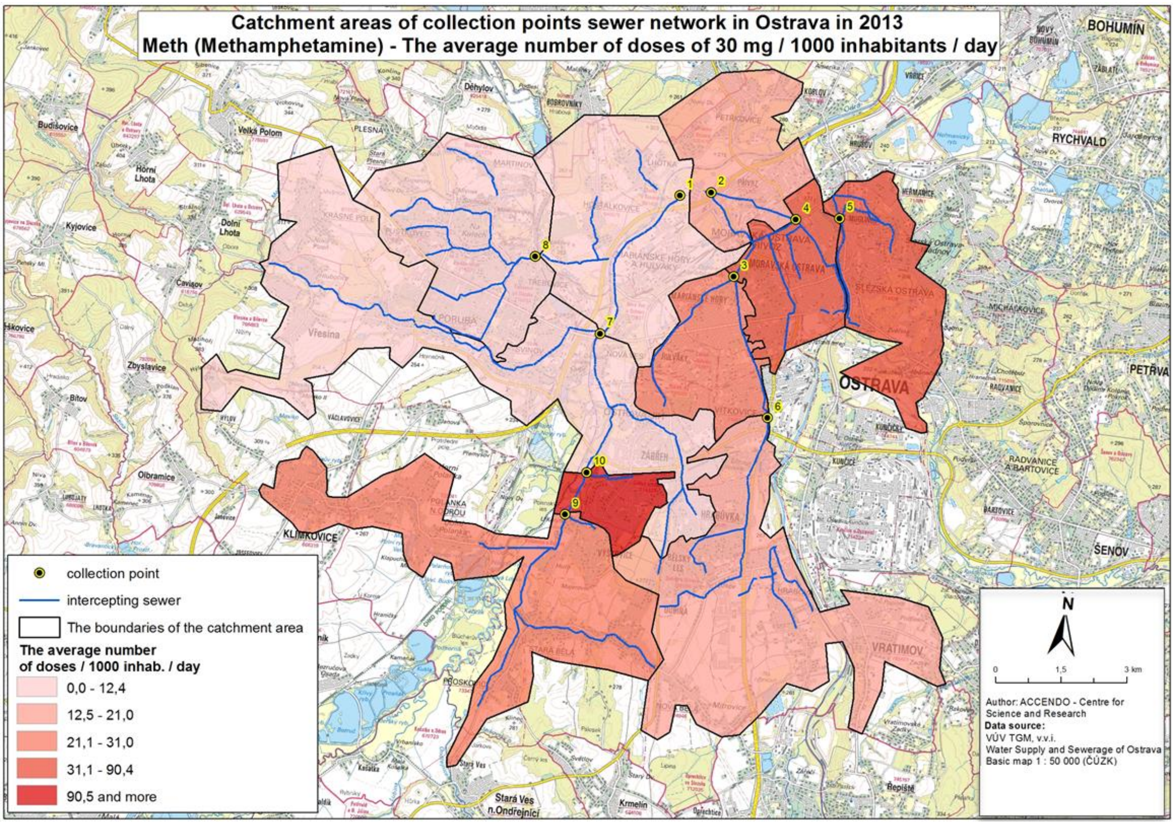

Figure 3: Metabolites of crystal meth in the sewer of Ostrava

Source: ACCENDO – Science and Research Centre 2013

6.2. SELECTED METHODS AND PROCESSES

6.2.1. Hotspot analyses

Hotspots, places with an increased intensity of an investigated phenomenon, are one way of analysing concentration of phenomena in space. From the perspective of crime, these concerns areas with an above-average amount (statistically, these are significant areas) of acts in an investigated area, in which the occurrence of crime is therefore higher. Places of these acts form spatial clusters (Eck 2005).

Methods of hotspot analyses identify high-risk areas on the basis of localised data. Used is the property of crime that the acts are not evenly distributed in an area, and their occurrence is influenced also by other factors. That means that in areas where offences have been taking place repeatedly, such trend will most probably continue. To investigate spatial distribution of a particular phenomenon, offences in this case, a sufficient amount of data is necessary. It is vital to consider the purpose of the analysis and the size of area it should cover. Should a vast area with a relatively low crime rate be analysed, the resulting hotspots will markedly distort the real situation. Therefore, it is important to consider the sufficiency of the data, methods and setting of functions which specialised tools for creating hotspots offer (Perry 2013).

Hotspot analyses tend to be the first step law-enforcement agencies take when identifying risk areas where resources will be targeted. There are a number of techniques used for hotspot analyses. According to Chainey et al. (2008), among the most frequently used are spatial ellipses, thematic mapping of geographic boundary areas, grid thematic mapping, and kernel estimates using the kernel-density function.

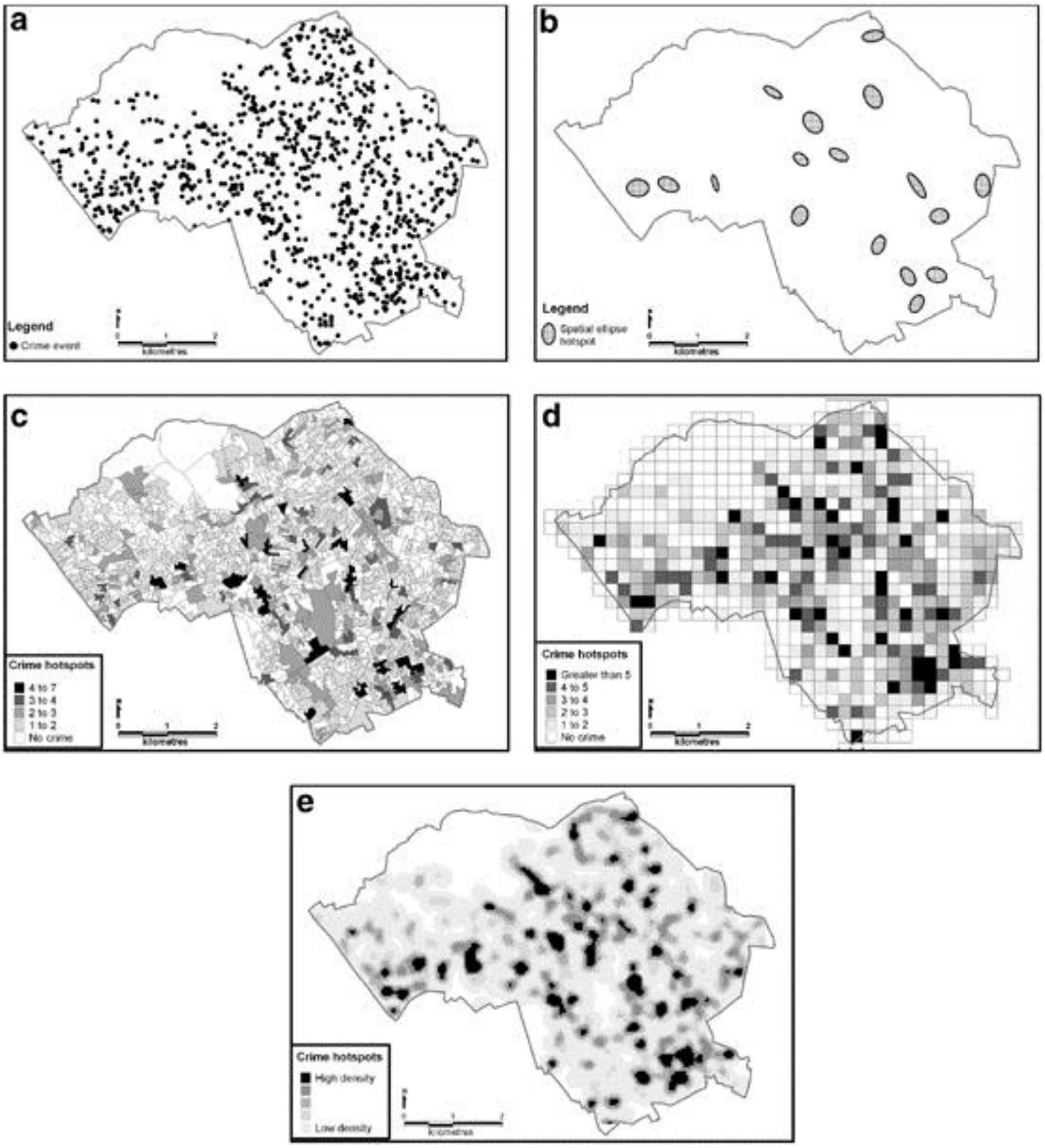

Figure 4: Different hotspot methods (burglarised houses)

Note: a) Localised points, b) Spatial ellipses, c) Thematic mapping of geographic boundary areas, d) Grid thematic mapping, e) Kernel density estimation

Source: Chainey et al. 2008

Spatial Ellipses

Spatial and Temporal Analysis of Crime, STAC, (Illinois Criminal Justice Authority 1996) is a tool used in numerous GIS applications. This tool enables identification and analysis of hotspot areas within a scrutinised area. STAC firstly searches for places with the highest concentration of dots (clusters). Afterwards, a “spatial ellipsis” is calculated for each cluster. The size, shape, position and inclination of these ellipses indicate the spatial distribution and intensity of an observed phenomenon, crime in the present example (Chainey et al. 2008). There are various methods for analysing autocorrelation of dots in space and the generation of spatial ellipses. Seng et al. (2005), for instance, mention methods of nearest neighbours using hierarchical clustering, the above-mentioned STAC, the K-means method, or Moran's I criterion (see references in Recommended reading).

Thematic mapping of geographic boundary areas

This method is based on a simple principle of aggregation of dots belonging to individual administrative areas. Depending on the amount of dots belonging to individually defined geographic units, the intensity of a phenomenon can by visualised with shades of grey or a scale of colours. This method enables a prompt determination of areas beset with crime (Chainey et al., 2008). In order to avoid misleading results, the observed phenomenon has to be converted to relative values. For example, in calculating the intensity of crime, population in the individual administrative areas needs to be taken into account.

Grid thematic mapping

The basis of this method is the observation of the frequency of events in defined cells. Different methods, with regular or irregular grid, are used for transformation. The number of events within each cell provides the value of a continual surface in a given area (Horák 2015). Cells with high values of a phenomenon in question and identified clusters can be referred to as hotspots. What is crucial for the use of grid thematic mapping is the size of a cell, which pre-determines the spatial resolution of analyses.

Kernel Density Estimation

Kernel Density Estimation (KDE) analyses the intensity of an observed phenomenon by way of dots in a specific area visualised with a continuous field. Analysis assesses distance and statistical significance of individual dots with respect to other dots, depending on the pre-set distance of an area. A grid is formed over the field of points, and with the use of the kernel density estimation, the number of individual events is calculated in each square of the grid. For each grid (raster) cell the sum of overlaps is calculated. The outcome is the quantified significance of a phenomenon in particular places of the observed area. Also kernel estimations can be used, which also consider balancing values that have an impact on the analysed phenomenon. A case in point is population density (Perry 2013).

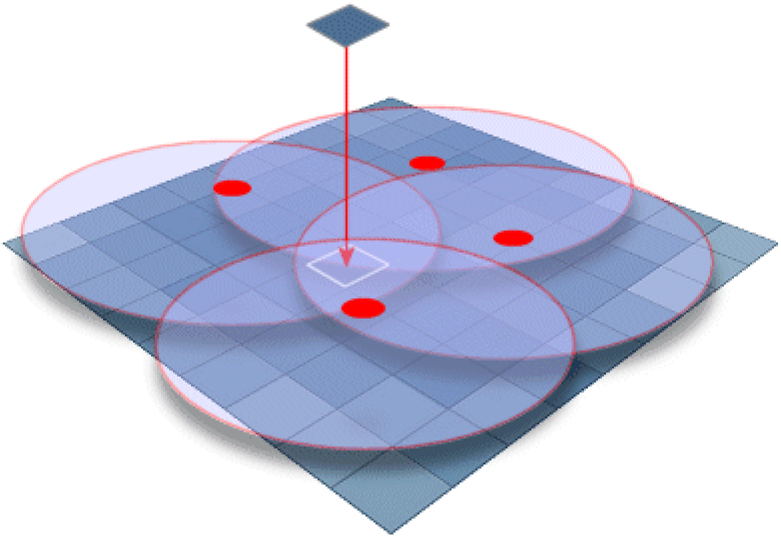

Figure 5: KDE – The basis for calculation of the sum of overlaps in the areas of a grid cell

Source: Department of Geography, Hunter College, CUNY 2015

The following images illustrate the output maps with hotspots generated with a different setting[2] of the analytical function *kernel density*, with the use of identical data and the tool ArcMap 10.1.

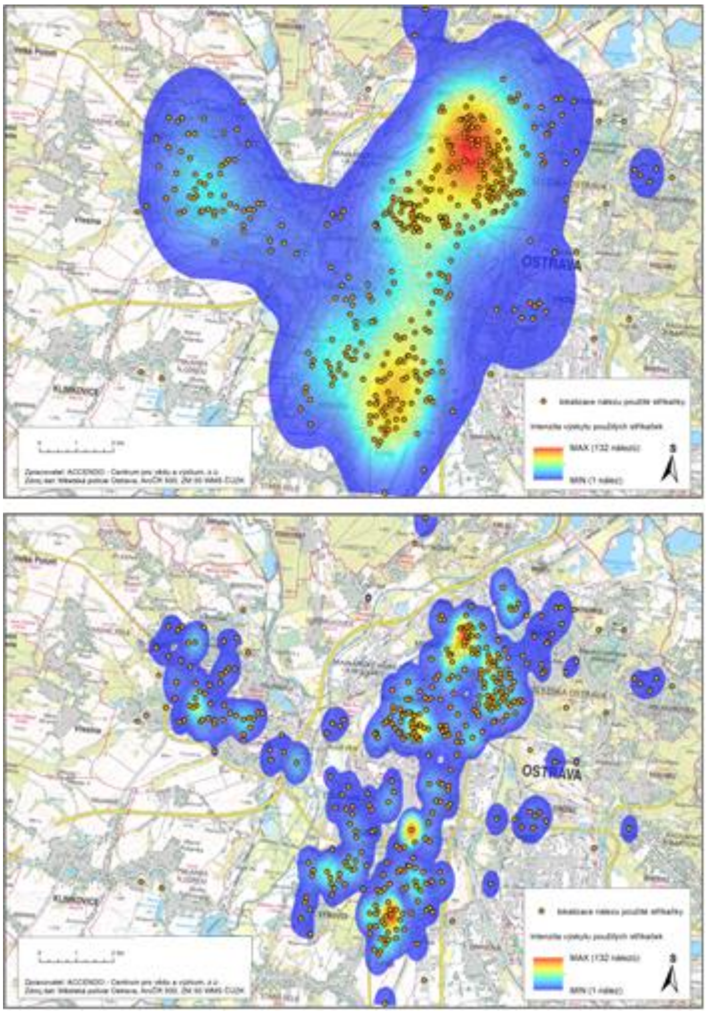

Figure 6: Comparison of different maps with different settings of kernel density

Source: ACCENDO – Science and Research Centre 2015

2 *Kernel density* setting in ArcMap 10.1 (width / resolution): upper image (2,000m / 5m), lower image (500m / 5m)

6.2.2. Heat maps

A term frequently mistaken for *hotspots* are *heat maps*. At first sight, the outcome of some analytical methods for hotspots is identical with the methods for creating heat maps.

Kernel density estimation, mentioned above, as well as heat maps are used to visualise areas with a high intensity of a particular phenomenon. These techniques are, however, fundamentally different, and their results must not be interpreted in the same manner. What heat maps visualise is the density of occurrence within a specific area. Each cell of the resulting raster is assigned with a density value, visualised on a coloured scale. The output is interpreted subjectively. Kernel density estimation uses statistical analysis which enables defining areas with a high occurrence against areas with a low occurrence of a given phenomenon. An area is marked as a hotspot on the condition that the occurrence of the observed phenomenon is statistically significant. The interpretation of the results is more objective in comparison with heat maps (GisLounge 2015).

Heat maps are a method demonstrating spatial concentration of a specific phenomenon. They are a singificant feature for police forces, being able to recognise places with an increased criminal activity. Such materials are an important source of information for police forces when planning the position of patrols or paying increased attention to the places in question.

Figure 7: An example of a heat map

Source: e-Analýza bezpečnosti Uherské Hradiště 2015

6.2.3. Repeat victimisation

Methods of near-repeat victimisation are based on the assumption that some offences will be committed in near temporal as well as spatial distance from the current offences, i.e. that places beset with crime will soon experience higher crime in the surrounding area.

Several studies are in agreement with this idea. Mohler, for instance, argues that crime spreads through local areas, similarly to infectious diseases (Mohler 2011). Were a crime to be committed, the risk of a follow-up crime in the immediate vicinity from the original place is increasing for a short term, which applies specifically in the case of burglaries.

Bridgeman & Hobbs (1997) define repeat victimisation as the situation “when the same person or place suffers from more than one incident over a specified period of time” (in Pease 1998).

Also other terms defining this concept are used in English: *revictimisation*, *multiple victimisation*, *repeat victimisation*, *multi-victimisation*, *repetitive victimisation* and *recidivist victimisation*.

Nevertheless, authors do not see eye to eye regarding what these terms represent. As a result, some (e.g. Farrel & Pease 1993) consider *repeat vicitimisation* and *revictimisation* acceptable, whilst others (e.g. Holder 1997) regard revictimisation synonymous with secondary victimisation, i.e. further mental victimisation of victims as a result of the public reaction. By and large, however, all authors agree on the term *repeat victimisation*. Another type is *near-repeat victimisation*, the victimisation of targets found in the surrounding area of the original target, which takes place soon after the first attack.

“Victimisation is the best single predictor of victimisation” (Pease 1998). In relation to this, the fact is often mentioned that 4% of people suffer 44% of crime. Pease (1998) mentions results of the British Crime Survey, carried out between 1982-1992. The figures show property crimes and violent crimes whose victims are residents. The average of the data demonstrated that in terms of property crime, 10% of respondents suffered one case of property crime, and the number of these cases acounted for 32% of the total property crime. In the same vein, 2% of respondents suffered 4(or more)-fold victimisation. However, considering the total volume of property crime, the number of cases accounted for as much as 41%. In the case of violent crime, 5% of respondents experienced one case, and this number represented 25% of the total number of cases. In the case 4(or-more)-fold victimisation, 1% of respondents became victims. However, the number of cases accounted for as much as 59% of the total volume.

As regards commercial victimisation (victimisations of retail and manufacturing business), 11% of businesses were victims of 76% of crime; 9% of businesses suffered 92% of threat and intimidation; 3% of businesses suffered 81% of violent crime (Wood et al. 1997).

Two phenomena explain the concept of repeat victimisation: event dependence and risk heterogeneity (also referred to as “boost account” and “flag account”, respectively). Event dependence pertains to offenders. Gathering information about their target with each offence, they repeatedly victimise it. In other words, these actions boost their knowledge of the given place. Risk heterogeneity relates to the targets. Crime occurs in this place, but not necessarily commited by identical offenders. The place is thus flagged as a likely target. As a result, “[w]here the effect is a result of a flag account, it is the right time and place because at that place the time is always right. Where it results from a boost explanation, the time is right because an earlier event has made it right” (Pease 1998). For the purpose of taking next steps, the police need to distinguish between these explanations.

A comprehensive explanation of the phenomenon is provided by Ericsson (1995). He found that 76% of burglars admitted to returning on the crime scene repetitively, stating reasons such as little potential threat, previous knowledge of the premises, an easy access, or simply stealing of other property, either left at the house or stolen and replaced by the house owners.

Repeat offenders generally have specific qualities (Pease 1998). In the case of robbers, for istance, they are often more active, deliberate, often beginning to commit crime at an early age, they are more likely to hold a gun or to have committed a robbery where someone was injured. Such offenders have longer criminal records and they are more likely to have been in prison before, sentenced for upwards of five years. They also frequently plan their robberies and a more likely to wear a disguise.

The aim of the analysis of repeat victimisation is to identify individuals, property and places exposed to an increased threat of victimisation. Attention is generally paid to detecting burglaries. Crime is a predictor of further crime, at the level of both time and individuals (Pease 1998). Three factors are used to understand victimisation of an area: *incidence*, the number of offences per person/household that could be potentially victimised; *prevalence*, the number of individuals/households where victimisation occurs; *concentration*, the number of victimisations per individual/household.

Pease (1998) mentions the following advantages of concentrating on repeat victimisation. Should police forces focus on repeat victimisation, they will automatically concentrate their effort on areas of highest crime, without the need for any supplementary decisions. Also, if focusing on repeats, they will also focus on individuals with the highest probability of becoming crime victims in the future. The time frame of repeats also shows that resources can be focused temporally as well as spatially. Another benefit is that victim support and crime prevention are part of the process, two roles approached separately in the past. Also, since the targets are victimised by the same perpetrator, clearance of serial crimes and property recovery is more probable than in the case the events were seen as independent. As a result, prevention and detection are explicitly linked. Identification of repeat-victimisation patterns can also serve as means of targeting prolific offenders, who are more inclined to this behaviour.

Originally, discussions were held on the topic of crime displacement. Research suggests that such displacement is never total (Hesseling 1994), i.e. that crime gradually declines. What also occurs is a positive influence extending the boundaries of the original area. This phenomenon is referred to as “diffusion of benefits”.

6.2.4. Risk terrain modeling

Risk terrain modelling is a set of techniques aiming to identify geographic features which contribute to an increased risk of crime (e.g. some amenities or types of streets) and which generate crime predictions based on the distance from these features.

From the police perspective, the outcome of risk-terrain modelling is at the same qualitative level as hotspots. These strategic analyses highlight areas with an increased probability of crime. From the viewpoint of analysis, however, these are two different methods. While hotspots are based on identification of statistically significant areas where places with a high occurrence of crime are captured, risk terrain modelling is based on classification where it is geographic conditions that pose the threat.

Heuristic approach: Risk Terrain Modelling

Risk terrain modelling is a straightforwad apprach to the assessment of factors contributing to an increased risk of crime.

In this method, analysts create a grid over the analysed area. Afterwards, a test is carried out on the statistical relation between the presence of certain geospatial features in the individual grid-cells (comprising geospatial features included in GIS data layers) and the occurrence of crime in these cells. The model utilises features with a positive correlation to crime. The method then calculates the number of selected features present in each cell. Cells with the highest amount of features contributing to crime are then marked as a probable hotspot.

Figure 8 demonstrates an RTM outcome for the part of Shreveport, Louisiana, USA. The data layers used include information about the presence of individuals on probation or parole, whether an offence has been committed over the past six months, whether an offence has been committed over the past fourteen days, whether vandalism or anti-social behaviour has been reported over the past six months and whether high-risk facilities are found in the area (bars, restaurants, gas stations, malls, etc.). The more factors are found in the given cell, the darker its colour on the map is (Perry 2013).

Figure 8: RTM output for Shrevenport, USA

Source: Perry 2013

The example of Irvington, New Jersey (Caplan, Kennedy and Miller 2011) demonstrates the use of spatial analysis to localise risk terrain with shootings. The data comprises gang member residences, type of facility (bars, strip clubs and liquor stores), and information about the arrest with respect to the possession of illicit substances. By transferring of the coordinates into the grid, it was defined which cells present the highest threat of shooting on the basis of data from the past six months. This model was then used for another six-month period for validation. The result was that, when compared with ordinary retrospective modelling, the GIS approach was more appropriate. Retrospective modelling assumes that crime locations over the past six months are most likely to be crime locations in the following six months also.

Statistical approach to risk terrain modelling

The statistical approach to risk terrain modelling comprises two main stages. In the first stage, the algorithm compares distances between general criminal activity and the relevant types of geospatial features. Then, the distances between specific crimes and the nearest geospatial features of the specific types are observed. In the second stage, the algorithm evaluates the similarity of the individual points in the grid to crime scenes, with respect to the distance from geospatial features. Points whose distance to the geospatial features resembles the distance from the crime scenes are regarded high-risk. Supposing a high occurrence of robberries within 50 metres from some bars in the city, an area of 50 metres from any bar in the city would be regarded as high-risk.

Signature Analyst, developed by DigitalGlobe, is a tool which utilises this approach. Figure 9 presents output of this software, depicting predictions of stolen handbags in Washington, D. C. The range of colours, from yellow to red, shows areas considered statistically similar to purse-snatching locations (black points) in June-July 2008. To colour a sufficient amount of areas with potential snatchings in the future, high sensitivity of the algorithm was set. As shown later, all handbags in August-September 2008 were snatched in areas captured in the map (Perry 2013).

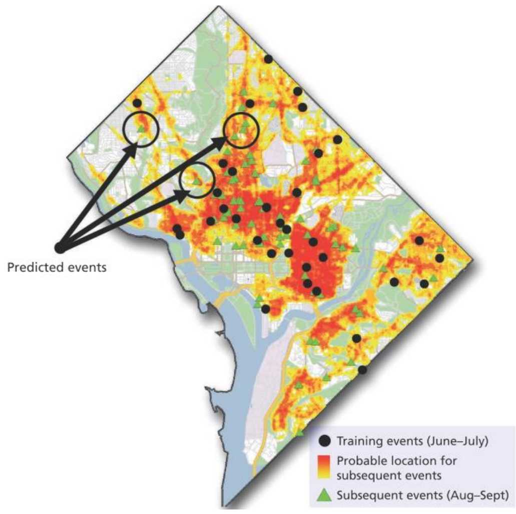

Figure 9: Using a risk terrain analysis tool to predict purse snatching risk

Source: Perry 2013

Risk terrain modelling brings to considerable advantages. Firstly, these methods are predictive in the sense that they predict risks on the basis of geographic traits rather than deriving historical information. Practically, this means that these methods are capable of predicting new high-risk areas on the basis of the knowledge of other contemporary high-risk areas. The idea is that despite the absence of crime in the newly predicted areas, they bear resemblance to the areas considered high-risk. Secondly, these tools illustrate the geospatial phenomena the model used for the prediction. It is also possible to generate predictions and identify risks with a small amount of data on incidents.

6.2.5. Geographic profiling

Geographic profiling is an analytical method which determines areas with the highest probability of unidentified perpetrators to occur on the basis of an analysis of areas where this individual commits crime. This method stems from the idea that offenders can target specific victims merely due to a geographic location. In the vast majority of perpetrators, it is the surrounding area of their place of living. In some cases, still, it can be another place (for example workplace or former place of living). This method enables localisation of both mentioned types.

Geographic profiling is mostly used in serial crimes considered to have been committed by one perpetrator. It was developed to identify serial murderers, rapists and arsonists. These days, it is also used in identifying robbers and burglars.

Each crime scene provides information about the perpetrator’s spatial perception. Multiple places render more information and create a better geographic profile. Some predictive tools attempt to forecast next crime scene of the serial offender. Geographic profiling, by contrast, to localise the perpetrator’s whereabouts.

Geographic profiling draws from a number of theoretical and analytical concepts (Chainey & Ratcliffe 2005):

- *Rational Choice Theory* explains offenders' behaviour on the basis of the assumption that perpetrators act rationally in the actions they perform. Therefore, when planning their criminal activity, they, for instance, balance the potential "profit" with the possibility of being captured.
- *Routine Activity Theory* works on the assumption that three conditions must be met to commit a crime, "a potential **offender** has to find an appropriate **target** with an absence of a suitable **guardian**".
- *Mental map* is a cognitive image of one's surroundings developed through experiences, travel routes, referential points and centres of activity. Places where people feel safe are generally saved in mental maps, and the same applies in offenders. The more time offenders spend in an area, the more confident they become and the more this area spreads. It is therefore likely that perpetrators commit crime in areas where they live or they have extensive knowledge about (where they were raised, where they lived, where they work, etc.).
- *Journey to crime* indicates the distance to the crime scene. This distance is based on the idea that every individual exerts a minimum effort to complete any tasks. As a result, perpetrators are also assumed to commit crime in the vicinity of their whereabouts.

Another important factor is also the distance between perpetrator's whereabouts from his/her target, referred to as **distance-decay effect**. Offenders are limited in their movement to a certain extent. Were they to commit crime in the vicinity of their whereabouts, they would expose themselves to an increased risk of being recognised. On the other hand, offenders usually strive to exert minimal effort in their actions. As a results, they create buffer zones, committing crime near their borders.

On the other hand, offenders usually strive to exert minimum effort in their actions. Consequently, they create a buffer zone, offending near its border. With the distance from the border increasing, crime occurrence of the given perpetrator declines exponentially.

Practically, these concepts are applied in the software CrimeStat (see Section 7.5), Rigel and Dragnet.

Rigel utilises mathematical models which include the offender's movement, behavioural patterns and the distance to the crime scene. It also includes the model for calculating the relationship between crime scenes and the perpetrator's whereabouts. Calculating of probability is a four-stage process. Firstly, on the basis of serial crime acts, offender's active area is defined through a buffer. Secondly, the distances between the individual offences are calculated. Thirdly, these distances are used as independent variables in a function evaluating the distance of the individual spots inside and outside the defined zone. For longer distances, this value is either lower (should the point be located outside the buffer) or higher (should it be located inside). Lastly, these values are added, with each point assigned a certain score. The higher the score, the higher the probability of it being the offender's whereabouts.

Dragnet is another piece of software that uses Canter's model. David Canter is a psychologist at the University of Liverpool, who participated in numerous investigations as an advisor in psychological profiling. This model uses principles of environmental psychology, which analyses the relationship between environment and human behaviour. It is a series of statistical methods, improved with an increasing database of perpetrators.

Although different programs use different types of distance functions in modelling geographic space associated with serial crime, the general output is substantially identical. The application creates a grid in a certain area, followed by counting probability of offender's activity in each cell according to spatial relationships to crime. Some systems visualise this network using a 3D diagram, where *x* and *y* represent coordinates and the *z-axis* presents the probability of crime occurrence in each cell. Law-enforcement agencies are experienced in the use of these tools when giving preference to suspects and tip-offs, when establishing strategies in patrolling and observation as well as other actions related to investigation for a closer focus on offenders.

Geographic profiling utilises the principle of inferring spatial traits of an offender. However, for a basic analysis of geographic profiling, no special software needs to be owned.

6.2.6. Data mining

Data mining, also referred to as *knowledge discovery*, is a method of acquiring hidden, useful information from a usually vast amount of data ("Big Data"[3]). It is analytical processing of data from a variety of angles, summarising useful information that could be used for higher revenues and other purposes.

In the beginning, work with data mining meant finding correlations in huge data sets. These days data mining uses a broad range of methods, algorithms and ways of work which enable finding potentially useful, often crucial information, hidden factors and inconspicuous correlations between phenomena in large volumes of data. Data mining is a tool that supports decision making, predictions of development, identification of extraordinary incidents and diagnoses. Its main aims is to extract relevant data from a large volume of data in a short time and as effectively as possible (Berka 2003).

In the time of an exponential rise of publically available data every minute, information is becoming the main commodity, and data mining increasingly important. Important and indispensable mainly for firms and companies which implement the acquired information into their processes, from elementary operations to top management.

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[3] Gartner (2011) defines big data as data sets of a size beyond the capability to capture, administer and proces data with commonly used software tools in a reasonable time.

Stages of data mining

Data-mining process can be divided into several phases, which are basically standardised in accordance with the methodological process for all areas of expertise. One of the most known methods is CRISP-DM (CRoss-Industry Standard Process for Data Mining) and SEMMA (Sample, Explore, Modify, Model, Assess). Methodologies divide the process into six basic steps connected to one another in the manner illustrated in the figure below (CRISP-DM, 2000).

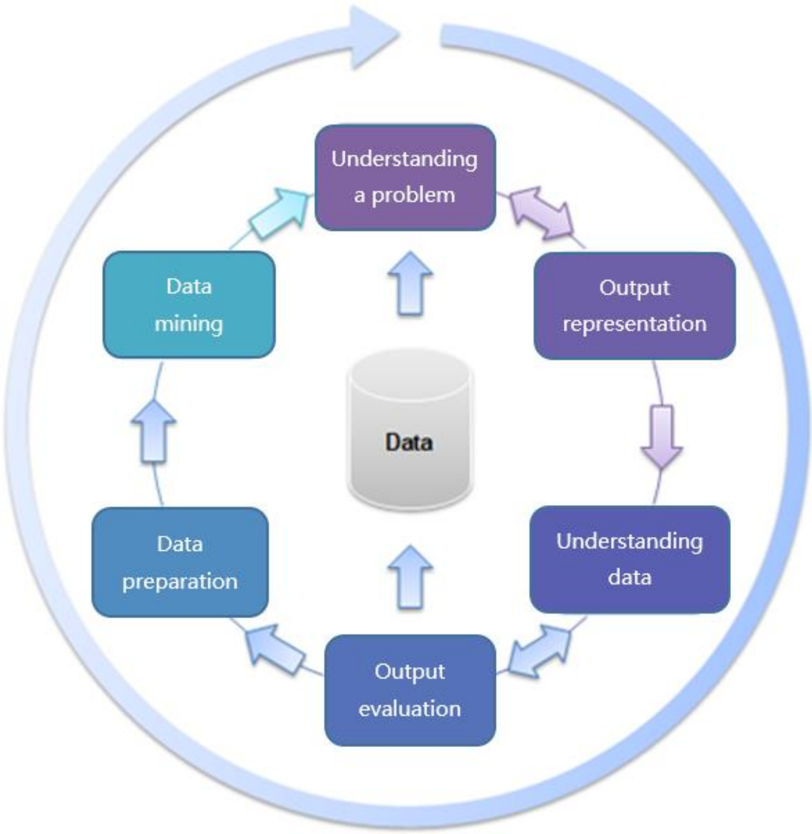

Figure 10: Stages of data mining and their relations

Source: ACCENDO – Science and Research Centre 2014

Business understanding:

A company working on a project needs to understand customer's demands. Similarly, data mining can't dispense with understanding the phenomenon intended to be observed in the data. It is therefore appropriate to propose and create a plan for tackling the issue in question. (CRISP-DM, 2000)

Data understanding:

In this phase, data needs to be analysed and explored for the sake of defining primary hypotheses or significance. In the course of further processing, this primary knowledge can be either confirmed or disproved, defining other solutions (CRISP-DM 2000).

Data preparation

In case of a high number of data sources, data needs to be integrated. That means that should one use data from at least two sources, each of which differs in the structure of files, or even format. The data therefore needs to be unified, or adjusted in accordance with the requirements of statistical and analytical methods and tools used. This process is, however, dependent on the comprehension of data. In case of misunderstanding the data, it can be integrated wrongly, causing damage to the source information and resulting in an incorrect outcome (CRISP-DM 2000).

Data mining:

Testing and selection of appropriate methods, alternatively setting of parameters of methods, for tackling the defined problem. The outcome of this step is a selection of several generated solutions, evaluated in the following step (CRISP-DM 2000).

Evaluation:

Phase of final evaluation and selection of acquired models according to various properties, and verification of the solutions generated with the models used (CRISP-DM 2000).

Representation of output:

It is the last step of data mining. However, the process does not end, but begins to repeat cyclically (as illustrated above). Data and relations change over time, and the user of the results wants to re-implement them in any given period. This is why system needs to be sufficiently robust and regularly updated. Also, its models need to be verified, otherwise the data-mining process could result in a loss of its quality with new data (CRISP-DM, 2000).

Currently, data mining is used by both large companies and small enterprises. This is not only due to the availability of data, but also availability of software, from commercial programs (SPSS, Statgraphic, Clementine, WEKA, Oracle Data Mining) to open source tools (R-projekt).

Data-mining programs analyse relations and patterns in saved data. Number of analytical programs using statistical analyses and methods can be used for this purpose. These methods include logistic regression analysis, cluster analysis, association rules, neural networks, decision trees, discriminant function analysis, correspondence analysis, principal component analysis, etc. Basic description of these functions is provided below.

Logistic regression analysis

Analysis representing a predictive model with a qualitative variable. Compared to linear regression, logistic regression is advantageous in predicting probability whether an event did or did not occur. Logistic regression can be applied on a multi-categorial variable (MELOUN et al. 2005).

Cluster analyses

The aim of this method is to obtain optimal clusters, when observations or objects in each cluster are similar, but the clusters vary. This method provides a way of gaining knowledge about the structure of data. Cluster analyses are used in identifying patterns in data (RENCHER 2002).

Association rules

Association rules disclose hidden associations among specific values of categoric variables in large data files. These rules enable identifying items with associations. This method is often used in analysing shopping baskets in e-shops (NISBET et al. 2009).

Neural networks

Neural networks belong to the category of artificial intelligence, which use predictive modelling to generate predictions. It is a method usable in numerous fields. Neural networks simulate the human nervous system and gradually gain experience and learn, resulting in changing weights in the model (RAHMAN, 2008).

Decision trees

Decision trees are used in terms of both qualitative and quantitative data. They serve to divide heterogeneous data into small groups of homogeneous data (Berry, 2004).

Discriminant function analysis

This technique can be divided into two types. The first evaluates the difference between pre-defined sets of objects, the second divides objects into groups by characteristic features. Object are further classified by the level of similarity (MELOUN et al. 2005).

Correspondence analysis

A technique used to compare relations between categories of variables in contingency tables. The advantage of this analysis is a graphic visualisation of connections in the individual categories (RENCHER 2002).

Principal component analysis

It is used as a tool for evaluation and identification of abnormalities in data files. Used mainly in survey analysis of data, it can also be used to analyse relations of mutually dependent variables in a certain set (HEBÁK et al. 2007). The aim of this analysis is to reduce the file dimensionality with maintaining information from the original data set, improving the quality of the analysis without a significant loss of data (LAVINE, 2000).

6.3. DATA ANALYSIS IN POLICING

The following section provides an expert view on the methods of policing, which are based on the analysis of data. This view stems from applied research of specialists of the University College London, who have been dealing with this issue, in conjunction with the police, extensively.

6.3.1. Predictive policing and the role of analysis[4]

Effective contemporary policing is currently following three approaches: *intelligence-led policing*, *problem-oriented policing* and *evidence-based policing*.

Intelligence-led policing (ILP) involves using intelligence to inform police decision-making, rather than a purely responsive police strategy. For example, tackling the problem of repeat offenders (using intelligence) rather than just *responding* or *reacting* to offenders. ILP involves systematic analysis, through the generation of intelligence products, to identify patterns, with a focus towards developing analysis on people (offenders and victims) and places (locations, buildings, and facilities). ILP also involves the sharing of information and collaborative work with partner agencies, such as local government, the fire service, corrections service and health service (e.g., to tackle drug and alcohol misuse, and public safety issues associated with mental health).

Problem-oriented policing (POP) involves ensuring that any crime or public safety issue that is causing concern is properly understood, with a focus towards dealing with its causes, rather than just reacting to individual events. POP involves being *crime specific* by breaking the problem apart into smaller and more manageable pieces, influencing decision-making with good analysis, recognising the importance of the immediate situation, temptations and opportunities in determining offending behaviour and vulnerability, thinking through how a given response will work, and then measuring response impact.

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[4] *Spencer Chainey – Director of Department of Geographical Information Science, University College London*

Evidence-based policing (EBP) primarily involves determining *what works*. In practice it involves the generation of evidence and the use of evidence. By *evidence*, this does not refer to evidence from a crime scene to assist a prosecution, but *evidence* in the scientific sense that explains how a particular initiative works and its impact. Generating evidence involves conducting empirical research that uses robust evaluations of police activity. Using evidence involves drawing from robust scientific evidence on the outcomes of police work to guide police activity. EBP can involve the generation and use of evidence on specific crime problems (e.g., burglary), on improving practices (e.g., hotspot policing), improving programmes (e.g., Neighbourhood Watch), and improving policies (e.g., offender rehabilitation). EBP not only involves applying *what works*, but also requires police decision-makers determining how it works (i.e. conceived, implemented, and sustained) in order to shed light on why it worked, and a thorough understanding of the problem to ensure that ‘what works’ is translated into the context into which it is to be applied. In turn, this can help police-decision makers understand what is *likely* to work (particularly if there is limited evidence-base).

At the heart of ILP, POP and EBP is analysis. Without good analysis evidence can not be generated or critically reviewed, problems can not be properly understood, and police decision-making cannot be guided by an interpretation of the intelligence that is gathered. Analysis involves a set of systematic processes that aims to identify and interpret patterns and correlations between crime data and other relevant information sources (i.e. to determine ‘What is going on? and ‘What is likely to happen in the future?’). Analysis should also be used for the purpose of supporting decision-making that informs and prioritises the design and allocation of police activity and crime prevention responses (i.e. identifying what can be done to tackle the crime issues?). Analysis also involves supporting the best use of limited resources available for tackling crime and improving public safety, providing an objective means of identifying and understanding crime problems, and taking advantage of the volumes of information that are collected by the police and other agencies. Analysis should endeavour to provide the *“right information … to the right people at the right time”.*

Crime and intelligence analysis should though also be produced in line with the different types of service responses that are required for police and public safety interventions. Good policing and effective crime reduction involves three types of service responses. In the first instance, services should be designed that offer an **immediate, operational response**. For example, the targeting of police resources on the next patrol shift. Secondly, services should be designed to support **near to medium-term, situational responses**. For example, working with other local agencies to address opportunities for committing crime. And thirdly, services should be designed to support **long-term, strategic responses**. For example, addressing endemic causes through regeneration schemes and changes in policy. Thinking about police and service responses in this way helps us to then think about the outputs we should consider generating for the purposes of crime prediction. That is, rather than thinking about crime prediction as solely supporting an immediate, operational police response, crime prediction should also support service responses that are aligned to prevent situational opportunities for crime to occur and support strategic policy that helps address endemic causes of crime. To date, predictive policing has been solely oriented towards supporting operational police responses. In addition, it is anticipated that in order to predict different stages of the future (i.e. the immediate, near to medium-term, and long-term) is likely to require each prediction to require different data and different analytical or modelling techniques.

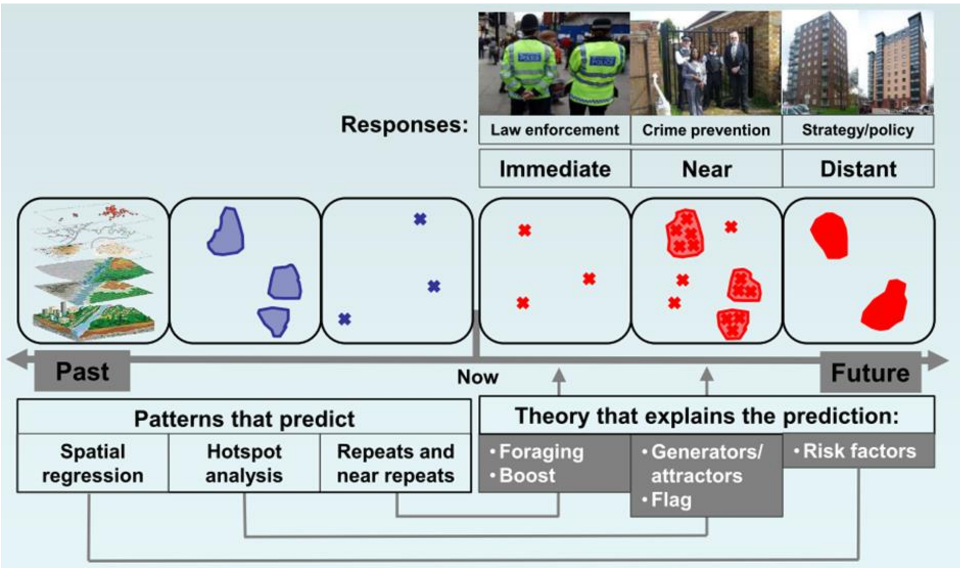


Figure 11: Time frames of predictions and adequate responses

Source: Spencer Chainey, University College London 2015

Previous research has shown how the spatial attributes of recent offences can be very effective in predicting where individual crimes may occur in the immediate future. The ability to be able to make these predictions of crime in the immediate future is based on the well-researched and frequently empirically observed spatial and temporal patterns of repeat and near repeat victimisation. However, the effectiveness of this prospective approach for predicting where crime is likely to occur decays as the temporal horizon extends – it is effective at predicting the immediate future, but beyond this timeframe the accuracy in the predictions begin to reduce. Once crime patterns begin to form into hotspots, the places where crimes previously formed hotspots appear to provide more accurate spatial crime predictions than using just the patterning principles of repeats and near repeats. A third temporal frame for predicting spatial patterns of crime is the more distant, long-term future. Through the spatial modelling of crime patterns against variables that are hypothesised to explain the spatial distribution of crime, the relationship with these explanatory variables can be quantified and used to inform the direction of strategic policy and predict how crime levels may change as a result.

To date, the attention to spatial crime prediction (so called predictive policing) has been towards using single, all-encompassing techniques to produce predictions. Often, little thought is given to how the currency of data may influence these predictions and to whether these predictions are more suitable for the immediate future (i.e. the next day), the near future (i.e., the next week or month) or are better at providing a long-term forecast (i.e., for several months and beyond). Little thought has also been given to whether the technique of choice is equally suitable for providing accurate predictions for all types of crime. It is suggested that it is not sufficient to consider that a single spatial analysis technique will be accurate for predicting where crime is likely to occur for all crime types and for all periods of the future.

To help illustrate this, I use a weather forecasting analogy. Data on current and very recent weather conditions are perhaps the best predictors of what the weather is likely to be like in the immediate future. To forecast what the weather may be like next month, data in addition to recent conditions would be used. To forecast what the weather may be like next year, data other than that on recent conditions and from just the last month would be used. Similarly, the analytical technique or model that is used to forecast what the weather may be like tomorrow is different to the technique or model used to forecast the weather outlook for next month, with another different technique or model being used to forecast what the weather may be like next year. Using this analogy for crime, it would appear unsuitable to use a single technique, with little thought given to the input data, to determine accurate spatial predictions of crime for different periods of the future. Therefore, a temporal framework is suggested for spatial crime prediction – the crime prediction framework. The crime prediction framework consists of three temporal prediction periods – predictions for the immediate future, predictions for the near future and predictions for the distant future.

To predict the immediate future, the prospective mapping technique (based on the patterning principles of repeat and near repeat victimisation) should be used. These types of predictions for the immediate future are most likely suited to targeting police patrols in those areas where incidents are predicted, using the patrols' high visibility to deter any further offending, utilising stop and search on known offenders who are suspected to have recently committed incidents, and speaking to people who live or frequent this area, encouraging them to carry out practical crime prevention activity that will minimise their risk of victimisation. The immediate activity should also involve minimising the heightened risk of victimisation to the person or other target that has recently been victimised, and utilising offender supervision resources to help disrupt and deter the activity of those suspected to be involved in the commission of crime in this area.

For the purpose of predicting the near future, the crime prediction framework involves the use of hotspot mapping using the Gi* statistic. After hotspots have been identified, further analysis would need to be conducted on these hotspots to determine the favourable geographic conditions that cause crime to concentrate at these locations. Police and other agency activity should therefore be focused on addressing these favourable and enduring conditions that make crime particularly conducive in this area.

For the purpose of predicting the distant future and long-term change, the crime prediction framework should involve the use of geographically weighted regression analysis of crime, against a hypothesised set of explanatory variables. The variables that are significantly correlated in this type of modelling and that can be explained in clear theoretical terms would inform the direction of strategic interventions. Activity that is focused on addressing the influence these variables have on crime (where the relationship is significantly positive) and improving the influence these variables have on crime (where the relationship is significantly negative) would help bring long-term reductions in crime that focus on addressing the underlying norms that influence crime levels.

The crime prediction framework helps to direct a realistic response structure for reducing crime in the areas where it is predicted to occur – in the immediate, near and more distant temporal terms. In order to determine the types of response most suitable, a clear theoretical explanation for the patterns needs to be provided. These theoretical explanations also need to be sensitive and aligned to the different temporal response arrangements of different agencies – where the focus on police services is to respond quickly with tactics, while for other agencies some further planning may be required to organise the response activity. The crime prediction framework points towards the theoretical principles that explain these spatial patterns and the types of service response that would be most suitable. To identify and predict spatial patterns of crime, different techniques are required, using different types of input data. The framework also points towards the input data that are required and the spatial analysis techniques that are most suitable for each time frame. It is hoped, therefore, that with wide promotion, the adoption of the crime prediction framework will further improve how police and public safety agencies respond to and reduce crime.

7. SOFTWARE TOOLS

Despite the existence of a large number of other programs besides those listed (such as QGIS, R Project, MapInfo, Grass, Statgraphic), the section provides information about the most frequently mentioned predictive, analytical tools and GIS software, used in the given cases. The section concentrates on the description of the individual product series on offer and their functionalities. It therefore should by no means be considered a subjective selection of tools.

The product information was obtained mainly during meetings with organisations that use the software. Alternatively, internal materials of given companies were used. The section does not aim to promote selected products and/or companies, but to render the list of tools available on the Czech and foreign market.

Based on the users' experience, selection of a technological solution is highly individual, tuned on the basis of any company's needs. All implementations in question took place on the basis of consultations with given companies, which prepared a specific solution in accordance with the client's technical equipment.

Crime-predictions tools	Traditional data-analysis tools
HunchLab (Azavea)	**ArcGIS (ESRI)**
CrimeView Dashboard (Omega Group)	**IBM SPSS (IBM)**
PredPol (PredPol)	**CrimeStat (National Institute of Justice)**
Near-Repeat Calculator (Temple University)	**GeoTime (Uncharted)**
PRECOBS	**ORACLE**

Table 3: Tools analysed in terms of the study

Source: ACCENDO – Science and Research Centre 2015

7.1. HUNCHLAB

HunchLab (ver. 2.0, 2015) is a predictive tool developed by the Azavea company (www.azavea.com), which assists the police in an effective use of resources in tackling crime. The predictive model Hunchlab involves a number of criminologic theories and operations with data, which lead to an unambiguous outcome indicative of the critical areas. The system automatically determines the way information about commited crimes, time cycles, weather and locations which are typically crime scenece, should be aggregated and used in order to generate a prediction. The system is essentially independent and can be controlled without any special knowledge of statistical and analytical methods.

Predictions of crime occurrence operate on the basis of an algorithm, where criminogenic data is entered, containing different time frames, depending on the purpose of the prediction, specific critical locations (such as bars, stops, whereabouts of known offenders) and crime patterns, which are always specific of a given type of crime. The use of predictions is dependent upon an effectively functional model.

Prediction models are created in the following steps:

1) generation of training examples,
2) enriching by variable inputs,
3) building up of the model proper,
4) evaluation of accuracy,
5) selection of the best functional model.

7.1.1. Data

There exist certain requirements on the quality of data used in predictions. It has to be consistent within a territory in terms of the following points.

Geographic range

If data coming from an area predicted by HunchLab typically used in buffer of one kilometre can be provided, also external influences can be included. Crime occurs irrespective of administrative borders, which is why such supplementary data should be involved in predictions.

Format

Supported are data inputs in vector formats of dot, line and polygon layers. Raster data are adjusted to an optimal resolution prior to the generation of predictions.

Time data

Data containing time usually enters the system as CSV files. For instance, schools which operate at a specific time are recorded as 1, and schools which are closed are represented as 0. Meteorological data have to contain historical time series from numerous seasons, also containing a forecast for at least the following 48 hours. Season, day of the week, hour, phase of the moon and the times of sunset and sunrise is data generated automatically from calendar.

Terrain model, demographic data, weather forecast and the base map Open Street Map are delivered with HunchLab. It can be assumed, however, that in some European countries, specific conditions will be applied with respect to data availability.

Historical criminogenic data of a five-year period are divided into hourly sequences during analyses. The result is hundreds of millions "time-space cells", which enter predictions. Further, processes and methods are used, such as hotspot analyses, regression methods, data mining, near-repeat victimisation or risk-terrain modelling.

Predictions are based on:

1) time series of criminogenic data,
2) repeat victimisation,
3) risk-terrain modelling – the distance and density of selected geographic elements (dots, lines, polygons),
4) distribution of police forces, potential offenders and potential victims
5) socio-economic indicators (demographic data),
6) time cycles (day of a year, of a week, daytime),
7) repeated events (holidays, cultural and sporting events…),
8) weather (temperature, precipitations…).

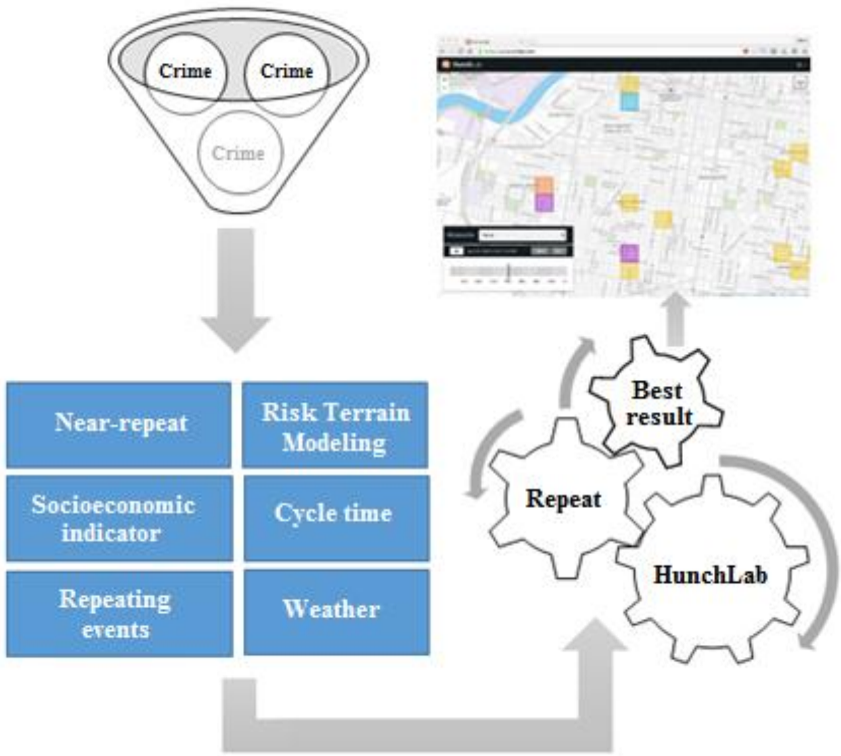


Figure 12: Predictive model HunchLab (structure)

Source: The Omega Group 2015

The algorithm is set to adapt to conditions defined specifically for each police force based on particular conditions of a jurisdiction and on the structure and quality of data available. During the development of the model, three basic factors are taken into account, which determine the modelling and prediction of crime:

1) Priorities of the organisation which will use the product, defined by the needs and knowledge about crime it would like to attain.

2) Practical use of studies and criminology.

3) Specific data of an organisation.

Each area predictions are generated for has different conditions from the viewpoint of input. HunchLab therefore approaches each model on an individual basis. Data entering the algorithm is attributed different weights, and in the development of a model its progress is defined. Some inputs can be omitted should a situation require this. The following images (Figure 14, Figure 15) illustrate a different structure of predictive models for various American cities using Hunchlab. Each city uses different models also from the perspective of individual crimes. Figure 14 shows aggravated assaults, and Figure 15 vehicle thefts.

Crime Models

Label	Severity Weight	Patrol Efficacy	Patrol Weight	Relative Weight
Homicide	8,649,216	1%	86,492.2	53.9
Aggravated Assault	87,238	5%	4,361.9	2.7
Robbery	67,277	20%	13,455.4	8.4
Motor Vehicle Theft	9,079	50%	4,539.5	2.8
Theft from Vehicle	2,139	75%	1,604.3	1.0
Burglary Residential	13,096	25%	3,274.0	2.0
Gun-related Crimes	100,000	15%	15,000.0	9.4

Figure 13: Preparation of a predictive model using weights

Source: Azavea 2015

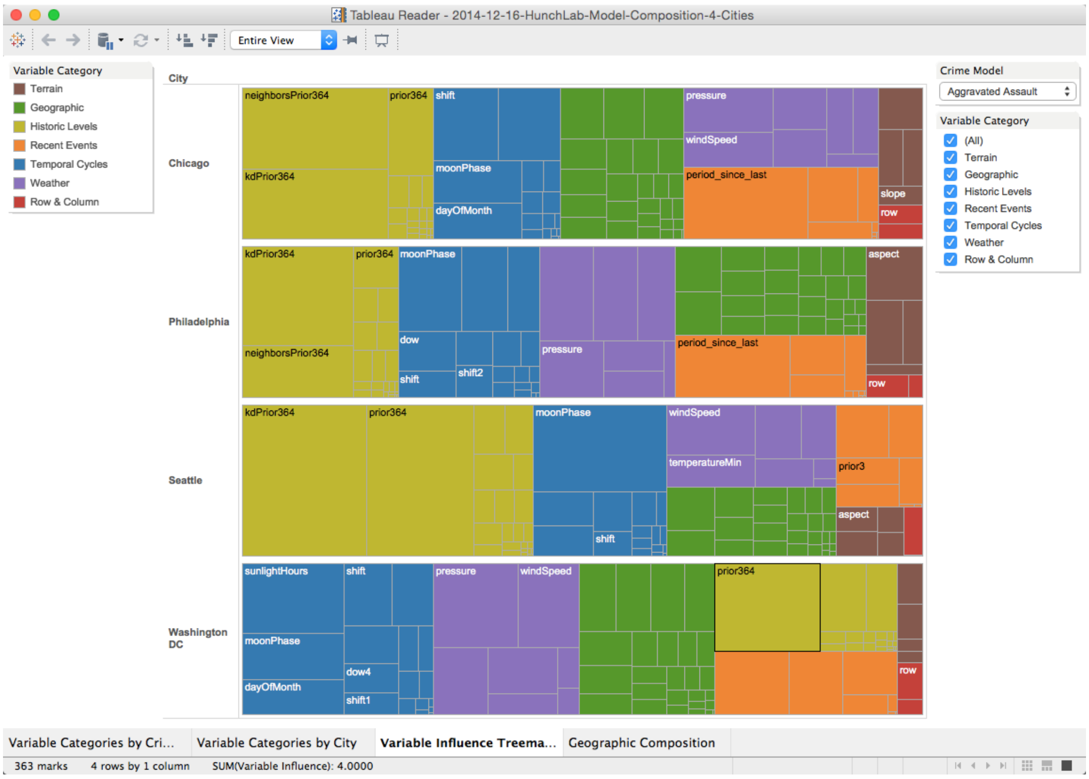


Figure 14: HunchLab – aggravated assaults

Source: Azavea 2015

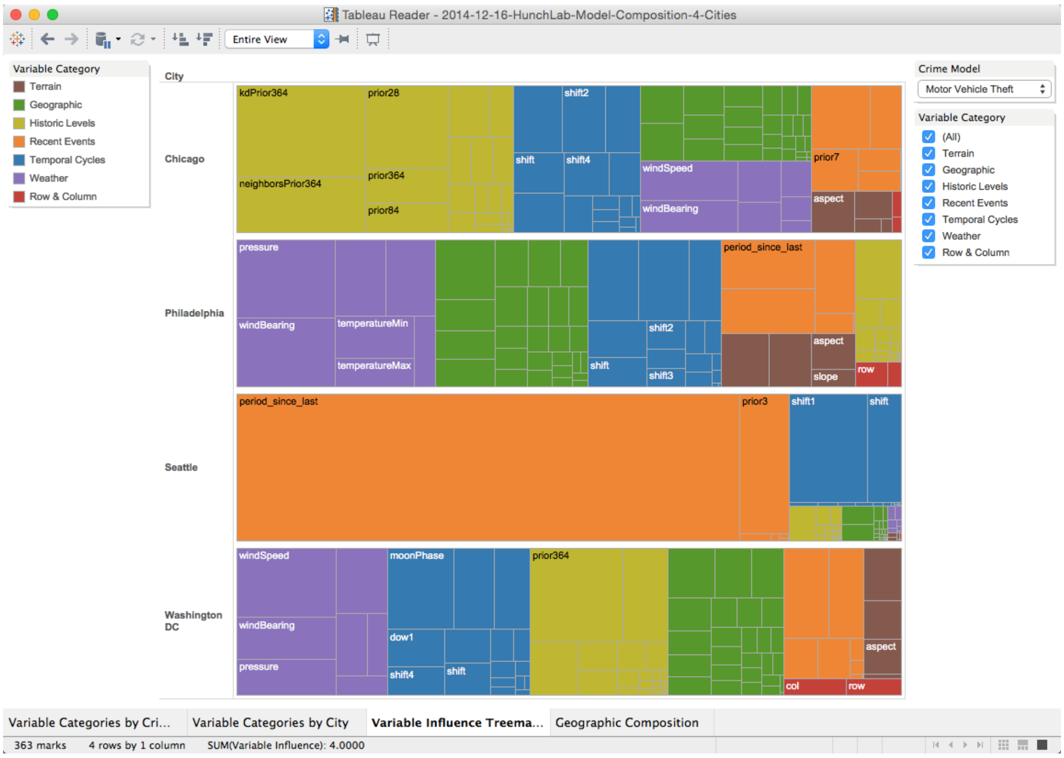


Figure 15: HunchLab – vehicle thefts

Source: Azavea 2015

Hardware and software requirements

The basic form of the application is offered as a SaaS solution (Software as a service), hosted on Amazon Web Service. It is the primary company strategy. Users thus access the system via a web browser. Yearly subscription enables an unlimited number of users and devices for the access.

The application does not require any specific database. Crime-rata data have to be geocoded with basic attributes, such as the date and time of the accident, classification and a unique identifier. This data is handed over in the CSV format via AI HunchLab environment.

Web-browser and operating-system requirements:

- Chrome – Windows XP and later, Mac OS, Linux
- Firefox – Windows XP and later, Mac OS, Linux
- Internet Explorer – Windows 7 and later

7.1.2. Results of predictions

The expected results of predictions are visualised in squares, each of the real size 150x150 metres, and set in an optional time frame of 1, 2 or 4 hours, with further user settings. The result of the calculation determines the probability of a crime occuring in a particular time within a cell. Cells with the highest probability are evaluated as high-risk, and therefore advised to be patrolled. In each cell, information about the extent of the individual types of crimes is visualised. It depends on the police officers' consideration what preventative measures they will apply.

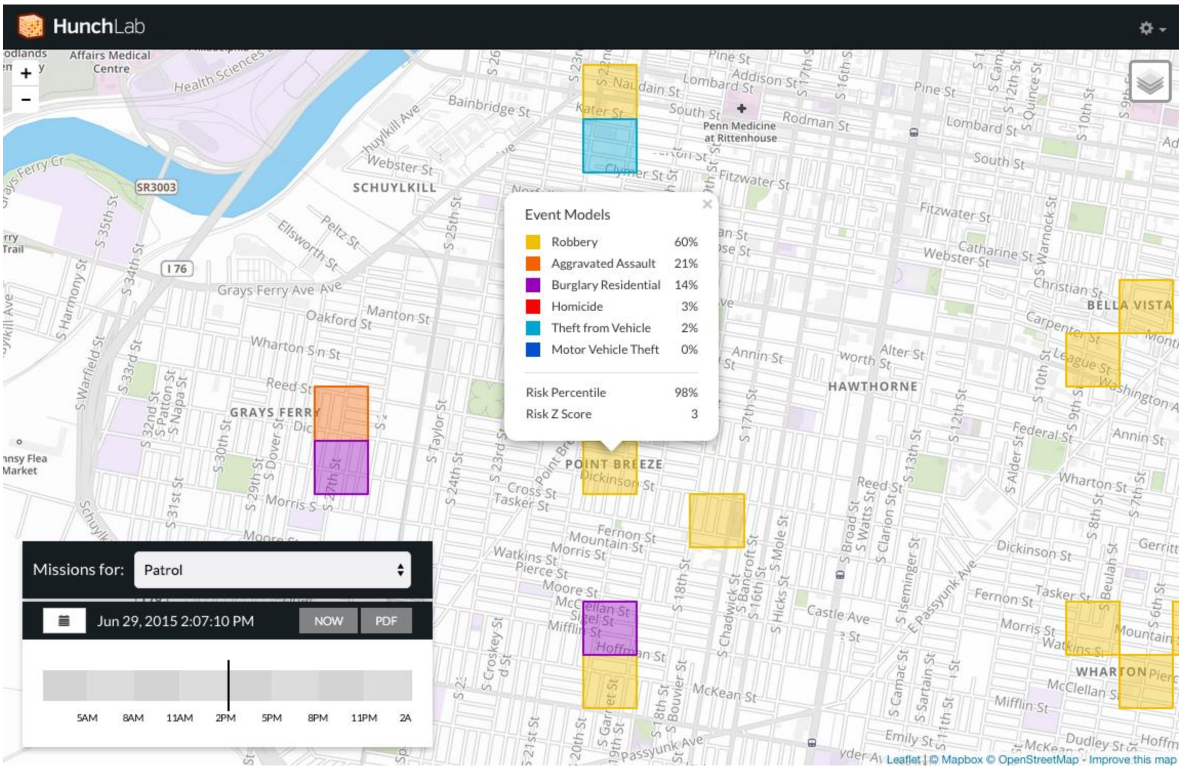


Figure 16: Hunchlab with predicted cells

Source: Azavea 2015

The predictive model HunchLab is used by the following product, CrimeView Dashboard, as well.

7.2. CRIMEVIEW DASHBOARD

CrimeView Dashboard (CV Dashboard 2015) is a software tool developed by Omega Group (www.theomegagroup.com), which integrates criminogenic data into analytical abilities. Development of this system began in 1992, as a more user-friendly version of the used tools. The solution was a transformation of Omega tools, which were used by fire brigades, the police and by educational institutions. At that time, these were mere marketing tools. At the beginning, it was a desktop tool used by clerks inexperienced in operating GIS. To render processing and localisation of data more time- and work-efficient, more straightforward generations of this tool were developed.

This system is a product from the CrimeView portfolio. It provides police forces with the possibility to identify crime patterns, analyse the state of crime and manage police forces and assess their performance. Patrol officers can be directed with the application **NEARme Mobile**, uploaded on their mobile devices and therefore available in the field. Other tools from the CrimeView family is CV Desktop, offering analytical functions and missions, which makes it an alternative to CV Dashboard. Also, **CV Predictive Missions**, which enables creating missions to prevent crime, **CV Advanced** Reporting, used to generate reports for the purposes of both police officers and police management, and the application **crimemapping.com**, a mapping portal for sharing criminogenic data with the public, which enables filtering of different types of offences in a selected time frame and territory.

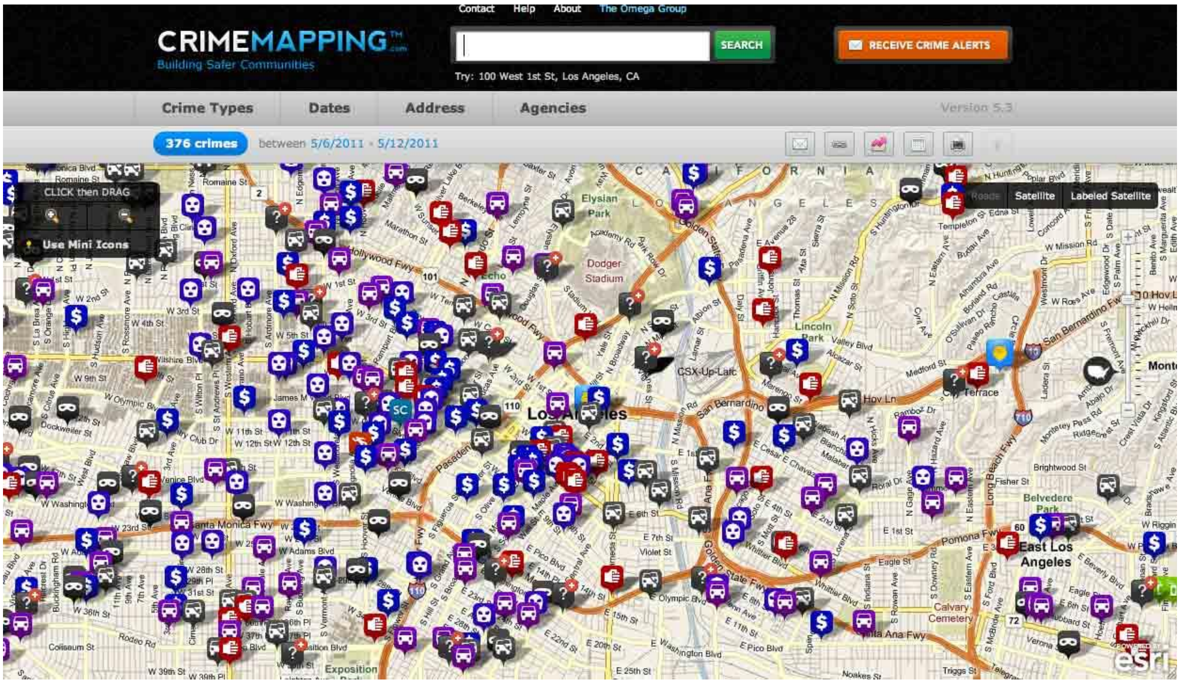


Figure 17: crimemapping.com

Source: Gislounge 2015

To generate analyses, **CV Dashboard** makes use of the access to police databases and other sources of data. Using available data, the system creates interactive reports, which are further spread to police management as a source of information, or to designated police officers in the streets as guidelines and materials for their actions. These reports can be generated directly by the user, or automatically, using pre-defined criteria. There are extensive options of setting, not only from the viewpoint of analysis functionality, but also setting of compositions and combinations of different functional windows. Apart from the generation of reports, other functions can be utilised, for instance:

1) generation of spatial data analyses
2) selection of data according to offence, place and time
3) comparison of data from various periods
4) phone call data analysis
5) geographic profiling
6) searching from information about offenders, viewing crime registers
7) register of stolen vehicles

8) locations of stolen vehicles and their finding

9) interactive mapping windows

10) measuring

11) indicating situations using dots, lines and polygons

12) viewing and generating statistics

13) export and sharing of data and reports.

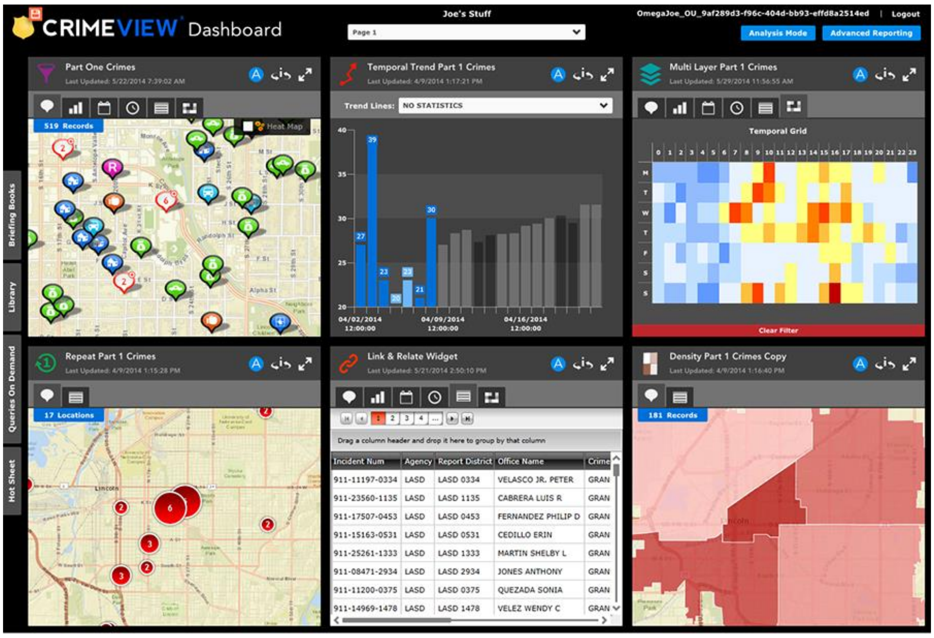


Figure 18: CrimeView Dashboard

Source: Trimble Public Safety 2015

Figure 19: CrimeView Dashboard 2

Source: The Omega group 2015

Hardware and software requirements

Hardware/server requirements vary depending on the implemented solution and system operations. The system operates on the Windows Server 2008 platform or later.

Requirements on the end user: Windows, Intel Core Duo, or Intel i-Series 1.8 GHz or faster, 2 GB RAM, 100/1000Mb network interface controller, operating system Windows XP SP3, Vista, 7, 8. Microsoft Silverlight 5, Adobe Flash Player 10.

7.2.1. Predictive missions

CV Dashboard can be equipped with module for predictive missions. Having analysed data about specific conditions and focused on a particular issue, the system generates predictions of crimes which could take place at a given time in a given place. In combination with integrated analytical tools, which help police officers to analyse the given issue in the given time or time period, predictive missions are a tool for an effective management of police patrols, investigation or strategic and tactical tasks.

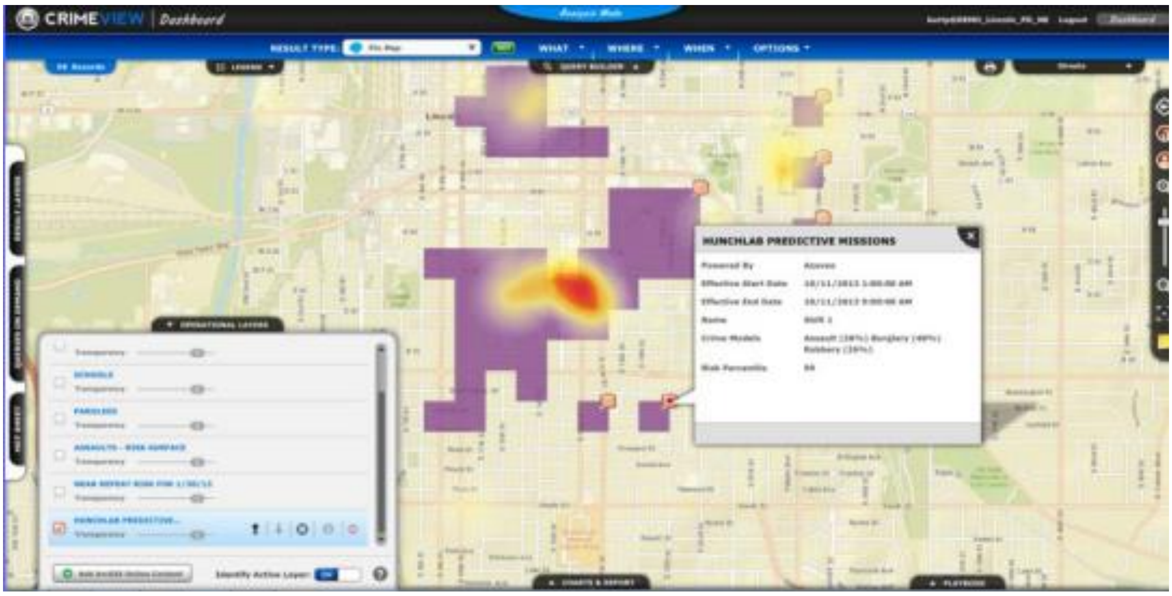


Figure 20: Predictive missions in CrimeView Dashboard

Source: The Omega Group 2015

In terms of predictions, Omega Group launched cooperation with the company Azavea. The predictive model is therefore based on HunchLab, which is also described in this section.

Connected with models that can be integrated in this tool, CrimeView Dashboard is a complex solution with a functionality necessary for managing police forces, generating analyses and doing ordinary tasks, all of which are carried out with the use of separate software tools. It therefore brings about an effective solution which can individually be adjusted to particular needs. Currently, CV Dashboard is being implemented in several hundred organisations, and CV Desktop is used by approximately 140 organisations.

7.3. PREDPOL

PredPol – Predictive Policing (2015, www.predpol.com) – is the name of a company located in the USA which developed a program of the same title and used for predicting specific types of incidents (crimes against property, drug-related crimes, gang activity, gun-related crimes, but also traffic accidents). The system was developed in collaboration with the University of California, Santa Clara University and University of California Irvine and also police analysts and officers from Los Angeles Police Department and Santa Cruz Police Department.

For generating predictions, this program uses an algorithm based on statistical models. PredPol focuses on mutual connections between places and historical events. In the area of crime, it analyses the relations between past offences and the places where these offences took place. Applying mathematical models, it predicts where and when other crimes are probable to occur. Besides statistics with the history of crime, this model also operates with factors relating mainly to the places of crimes (whether crime repeats in short intervals; whether repeat victimisation is typical of this place; the environment of the given spot), to which offenders' behavioural patterns are added.

Crime occurrence in the past is the basis for calculating the probability of crime occurrence at present, and in the future. The final product is arrived at mainly on the bases of three sources of data: **when** and **where** an offence took place and what **type** of offence it was.

Thus any personal data, such as names or races, is eliminated. A specific description of the algorithm is not available to users, whose opinions vary as to how the system works and what secondary data enters the process.

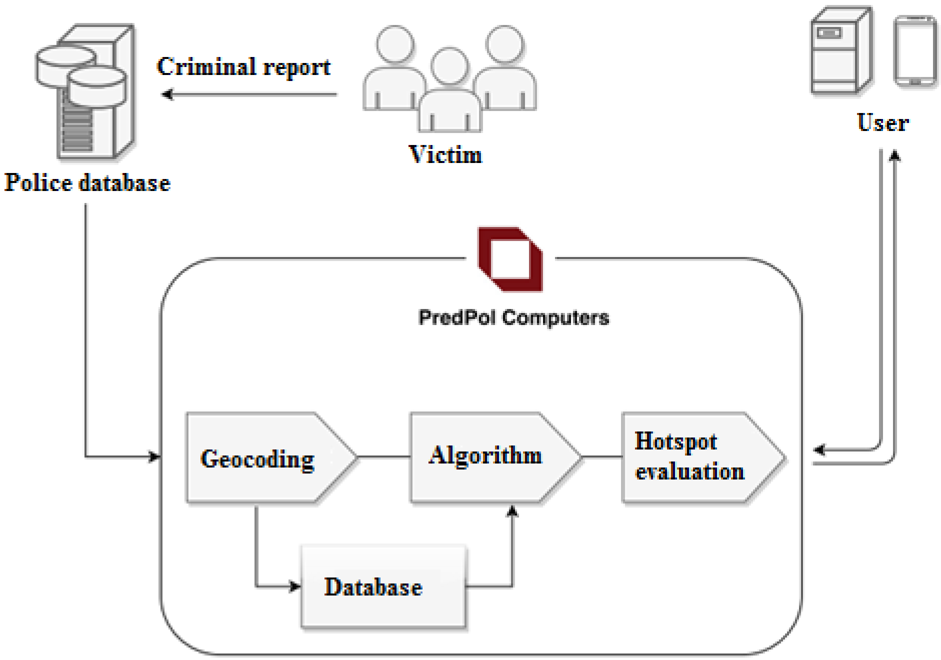


Figure 21: PredPol prediction process

Source: PredPol 2015

Based on settings, the algorithm generates visual predictions in a grid over the map of the given area. The individual squares of the map represent a real area of the size of 500x500 feet (approximately 150x150 metres). The colour of the given square indicates the probability of a given type of crime within the area and in the given time frame in the future. However, information acquired from the predictions need to be interpreted by police analysts, whose opinion influence the decision-making as regards the aplication of police resources.

Figure 22: User interface PredPol

Source: PredPol 2015

To carry out analyses in hindsight, PredPol also developed an additional future called *Radar*, which is a “business analytics” tool. This shows the development and the level of accuracy of PredPol in terms of individual jurisdictions. The resulting figures then show either the impact of predictions on the total crime rate as a year-to-year comparison (Total Crimes), or the impact on local crime rate, i.e. the selected square and adjacent squares (Hit Score).

PredPol is mostly located in a remote cloud. The administrator of the system is therefore the provider. All companies using PredPol use security features, such as safety protocols or biometric scanning, to save their data safely.

Hardware and software requirements

Users access the system via web browser, similarly to HunchLab. No PredPol system requirements are known.

7.4. NEAR-REPEAT CALCULATOR

Near-Repeat Calculator (NRC), version 1.3 is a non-commercial software developed at Temple Univesity (Philadelphia, USA, www.cla.temple.edu). It generates estimates of crime probability based on distances and time frames in terms of recently committed offences. The outcome are tables which show an increased percentual probability for various distances (in metres or feet) and times (in days), beginning with repeated crime over 24 hours since the offence happened, followed by a progress in distance and time.

NRC is an independent program which uses historical data for calculating probability rate. This data needs to be typed in by the user in the form of coordinates *x* and *y* for the crime scene, along with the date of committing the act. The outcome of the program is a CSV file (or alternatively HTML). Depending on the level of statistical significance, the results are marked either in brown (0.05) or red (0.01). The resulting output can be used in creating maps using other specialised software tools, such as ArcMap by ESRI.

Knowledge of crime analysis is required to operate the program, as the users have to uderstand the context of their work as well as of the program. Also, the ability to generate input files in an appropriate format is necessary. Output messages of the program are intuitively comprehensible and ordered in a table.

The results of the program can help law enforcement agencies better grasp the behavioural pattern of *near-repeat*, but also associated risks, resulting in implementing appropriate preventive responses.

NRC has an in-built minimal time resolution of 24 hours. Although this does not pose any limitations in most cases, the frame does not enable users to differentiate between offences happening on the following day and a series of crimes committed in short distances and within a short period of time (e.g. three burglaries on the same street over a one-hour period). In a single moment, NRC can work with one type of crime only.

NRC outcomes help law enforcement agencies to decipher potentially victimised targets. The police thus have a tool that can help them to organise their preventative activities more efficiently. It was used also by the army to analyse the probability of occurrence of landmines in war conflict areas (Wong et al. 2014).

Hardware and software requirements

The software works in the operating system Windows XP (or higher). As regards hardware requirements, the software does not have high requirements.

7.5. CRIMESTAT

CrimeStat (www.icpsr.umich.edu) is an application developed for the operating system Windows. It focuses on spatial statistics. The application carries out analyses of data on places where crime occurred, which provides information about both incidents and the number of events in the individual zones. CrimeStat connects with most desktop GIS programs. From records of criminal activities (or other types of police data), it carries out calculations a creates several types of map layers. The program contains more than 100 spatial statistical tasks, including the identification of spatial distribution, hotspot or analyses of behaviour of serial-crime perpetrators.

Since the version CrimeStat III, a module has been in use which enables analysts to model routes in a given territory. This model proved that routes in bank robberies begin in poor, less populated districts. Generally, bank robberies are more frequent in banks close to a perpetrator’s whereabouts. Models have viewed probable routes to banks and probable routes of escape, considering increased patrolling after the robbery.

CrimeStat IV also alters the ordinary model of distance from the crime scene (geographic profiling), feeding in information about other perpetrators committing identical crimes on identical places as the perpetrator whose profile analysts are attempting to create. The model was also supplied with implementation of geographic information, such as the definition of poor areas or the distance of districts from the city centre.

Crime is an appropriate tool for tactical and strategical analyses of crime. Besides being free of charge, its advantage is the connection of various methods of spatial analyses in one application that works with several GIS tools (Levine 2015).

Hardware and software requirements

The application works in the operating system Windows XP (or higher). Optimal configuration is 1 GB RAM and processor 1.6 MHz. It is recommended to operate the system with ArcGIS or MapInfo Professional.

7.6. ArcGIS

ArcGIS (www.arcgis.com/features) is a range of products developed by ESRI. The whole system comprises a number of parts (Figure 23). The following subsections provide description of selected products with a wide usage, among others, also in criminogenic analyses.

Figure 23: ArcGIS product range

Source: ARCDATA PRAHA 2014

7.6.1. ArcGIS for Desktop

ArcGIS for Desktop version 10.3 provides a set of tools for work with spatial information. The software is available in three licence levels: Basic, Standard and Advanced, which differ in their extent of functionality (ArcGIS for Desktop, 2012).

- **Basic** is used mainly for visualising and analysing GIS data and for generating map output. It contains elementary tools for generation, administration and editing of data.

- **Standard** aims at those users who intend to make full use of geodatabases and tools for editing spatial data, to adjust and administer vector data formats and to carry out checks of data topology.

- **Advanced** focuses on experts who want to exploit the potential of the GIS and to generate professional maps and other output. It includes tools used to boost productivity of work with geographic data.

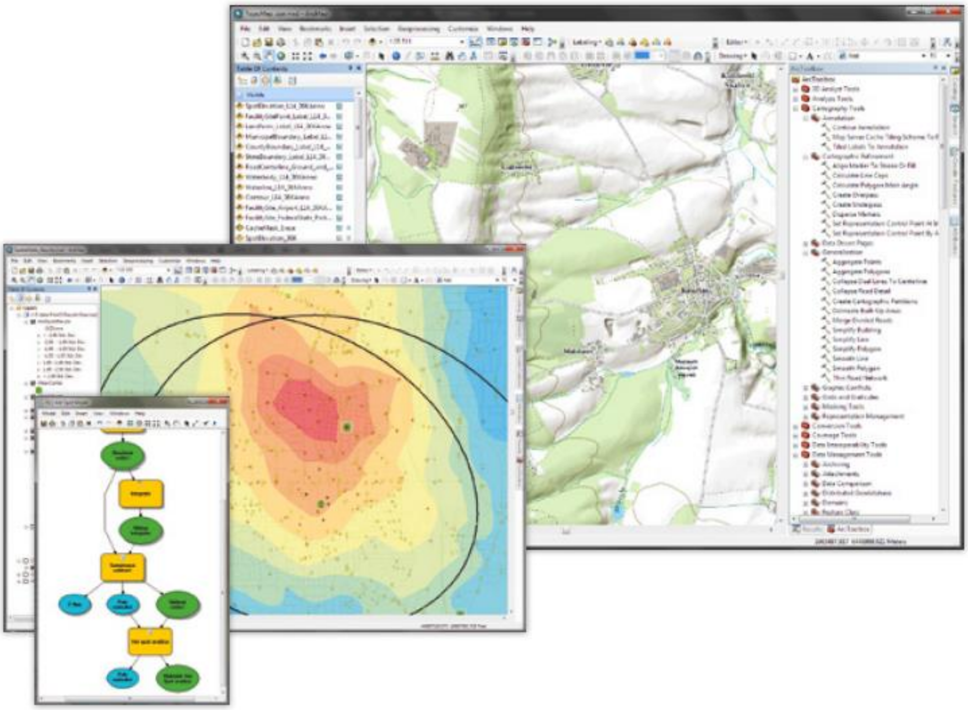


Figure 24: ArcGIS for Desktop

Source: ARCDATA PRAHA 2012

Components of ArcGIS for Desktop

- ArcMap which enables creating maps, visualising data, making queries, carrying out analyses, creating map compositions and printing out the final maps.
- ArcCatalog offers tools for administration, creation and organisation of supported data.
- Administration and analysis of geographic data is carried out by a set of applications located in the user interface ArcToolbox.

ArcGIS for Desktop can be modified according to the requirements of a given organisation. Simple adjustments can be made in graphic programming environment ModelBuilder, advanced processes can be carried out through the programming language Python. By use of it, ArcGIS functions can be accessed and thus involved in complex calculations, or automatise data administration. ArcGIS for Desktop also supports programming languages .NET (Visual Basic .NET and C#), Java, Visual C++ (ArcGIS for Desktop, 2012).

Capabilities of ArcGIS for Desktop can also be extended with specialised extensions (such as ArcGIS Spatial Analyst, ArcGIS 3D Analyst, ArcGIS Data Interoperability). Due to a large number of extensions, the following list provides selected extentsions relevant to the topic of this paper (Nadstavby pro ArcGIS, 2012).

System requirements

- CPU: *2,2 GHz, Intel Pentium 4, Intel Core Duo nebo Xeon*
- RAM: *2 GB (recommended 4 GB), in case of using Personal ArcSDE for MS SQL Server Express 4 GB RAM is necessary*
- GPU: *64 MB RAM (recommended 256 MB or higher), OpenGL 2.0*
- HDD: *3 GB*
- Operating system: *Microsoft Windows 2003/XP/Vista/7/8/8.1*

7.6.2. Selected extensions for ArcGIS

Crime Analyst

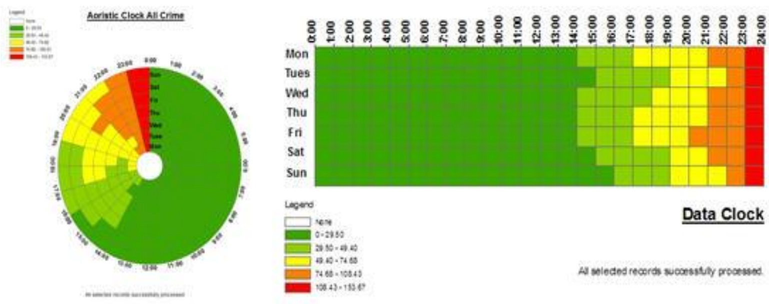


Figure 25: Crime Analyst output

Source: ESRI 2015

One extention of ArcGIS is Crime Analyst version 2. This extension helps police forces to gather, combine, visualise, and share information about crime. Crime Analyst enables obtaining in-depth information about analysed places, such as visualisation through data clock, which integrate concrete data and are able to idetify behavioural patterns in both time and space. Crime Analyst can also be integrated into corporate networks and intranets. Complementary tools of this tool for Model Builder enable automation of routine analyses.

Network Analyst

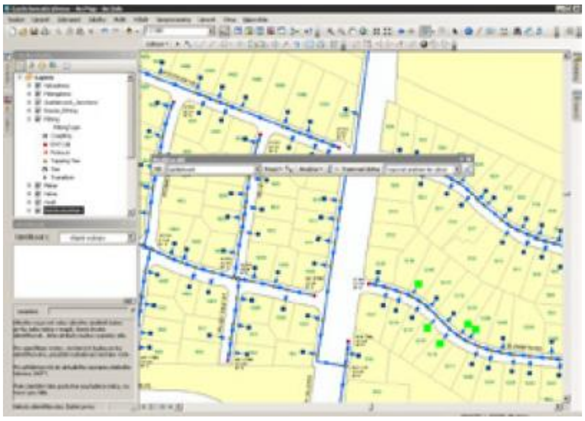


Figure 26: Network Analyst output

Source: ARCDATA PRAHA 2014

ArcGIS Network Analyst is an extension which allows carrying out spatial analyses related to a movement within a network. It utilises a specific data model which can easily create networks from data in GIS and to carry out a network analysis. It is also possible to dynamically simulate real conditions in the network (traffic limitations, speed limits, weight limits, changing traffic conditions over a day or week, and other conditions) (Nadstavby pro ArcGIS, 2012). Network Analyst extension can be, for example, used in a situation at an operating centre when vehicles which can respond most promptly to a situation need to be identified.

Spatial Analyst

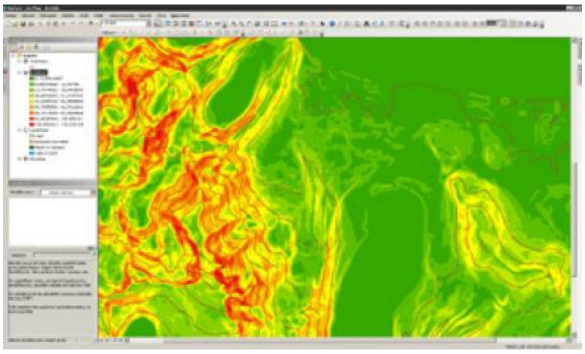


Figure 27: Spatial Analyst output

Source: ARCDATA PRAHA 2014

ArcGIS Spatial Analyst uses data that describes aspects changing in a continuous manner, such as altitude, incline, temperature, pressure, precipitations or pollution. It creates a raster layer through interpolating values measured in discrete points of the analysed area. In crime, for instance, behavioural patterns in space and time can be analysed, and the consequent information can be provided to law enforcement. This extension can also work with classified rasters (e.g. raster expressing the way soil should be used), or to create such rasters (by converting it from a vector format, or by categorisation of continuous data). Spatial analyst tools can also be used in Python scripts, and thus include them in complex calculations, where “fuzzy logic” can be used (Nadstavby pro ArcGIS, 2012).

Tracking Analyst

ArcGIS Tracking Analyst observes GIS data and its changes over time. ArcGIS can process temporal data in its elementary version. Tracking Analyst, however, brings extended tools for visualisation and tracking. Users can set which data should be viewed, visualise the changes in time and analyse time-specific data.

Tracking Analyst can also be used to view data obtained via special software Tracking Server in the environment of ArcGIS for Desktop. The movement of vehicles, for instance, can be tracked in real time (Nadstavby pro ArcGIS, 2012).

7.6.3. ArcGIS Server

ArcGIS for Server is a complex tool for obtaining, administering and analysing spatial data and its visualisation. It secures the administration of central data store, provision of tools and publication of datacentric services and advanced application services. It also offers tools for the development of mobile and web applications, with the options to edit, analyse and visualise data (ArcGIS for Server, 2012).

ArcGIS for Server is adjusted to be integrated in the current IT infrastructure of the given organisation. The integration into information systems (e.g. ERP, CRM) is enabled by the support of the SOA (service oriented architecture) standard by SOAP and REST protocols and standard in GIS (OGC) as well as IT (W3C) (ArcGIS for Server, 2012).

ArcGIS for Server is an open platform for the development of custom applications and services using technologies Java, .NET, JavaScript, HTML5, Microsoft Silverlight and Adobe Flex. It can also be integrated into applications based on technology Microsoft Sharepoint (ArcGIS for Server, 2012).

The application of GIS on a server enables cetralised usage of functions in heterogeneous interfaces of web, mobile and desktop applications. These can be adjusted to the customers needs and numbers in terms of volume and functionality (ArcGIS for Server, 2012).

ArcGIS is available in three levels of functionality: Basic, Standard and Advanced, and in two levels of server capacity: Workgroup and Enterprise. For administration geographic data in relational databases, ArcSDE technology is included in all levels (ArcGIS for Server, 2012).

Enterprise

- Unlimited simultaneous connections to the multi-user geodatabase.
- The size of the database is only limited by the used RDBMS.
- Unlimited number of CPU cores.

Workgroup

- Not more than ten simultaneous connections to the multi-user geodatabase.
- Not more than 10 GB of data in the geodatabase (limit of the used SQL Server Express 2008 R2).
- Not more than four CPU cores.

	Basic	Standard	Advanced
Multi-user geodatabase	YES	YES	YES
Data replication via web	YES	YES	YES
Web services GIS geodata service	Geodata service	YES	YES
Web mapping applications	YES	YES	YES
Application for tablets and smartphones	YES	YES	YES
Data editing via web	-	YES	YES
Image services	-	YES	YES
Geoprocessing	-	YES	YES
Advanced geoprocessing	-	extension	YES
Data processing in real time	-	extension	extension

Table 4: Functionalities of each level

Source: ARCDATA PRAHA 2012

7.7. GEOTIME

GeoTime, version 5 (www.geotime.com) is an independent tool for spatio-temporal data analysis. It contains in-built queries for analysing imported sets of data, which include events with specific data on movement in time and space. Events can be viewed as either dots in 3D space, or as sequences composed of events and places.

Data is visualised in an imaginary 3D cube, where axes *x* and *y* show spatial position, whilst axis *z* represents time. By combing these three axes, it is possible to track development in both time and space. The figure below captures the life of a Buddhist monk from the 17th century, Ouyi Zhixu. He lived from 1599 till 1655, which is the range visible on the blue scale on the left hand side of the window, which is simultaneously the complete range of the data file. The visible time frame is set for a five-year period, and the figure illustrates the events that took place between the years 1618 and 1623, visible on the blue scale in more detail. By moving vertically up/down the scale, the 3D visualisation is dynamically changed.

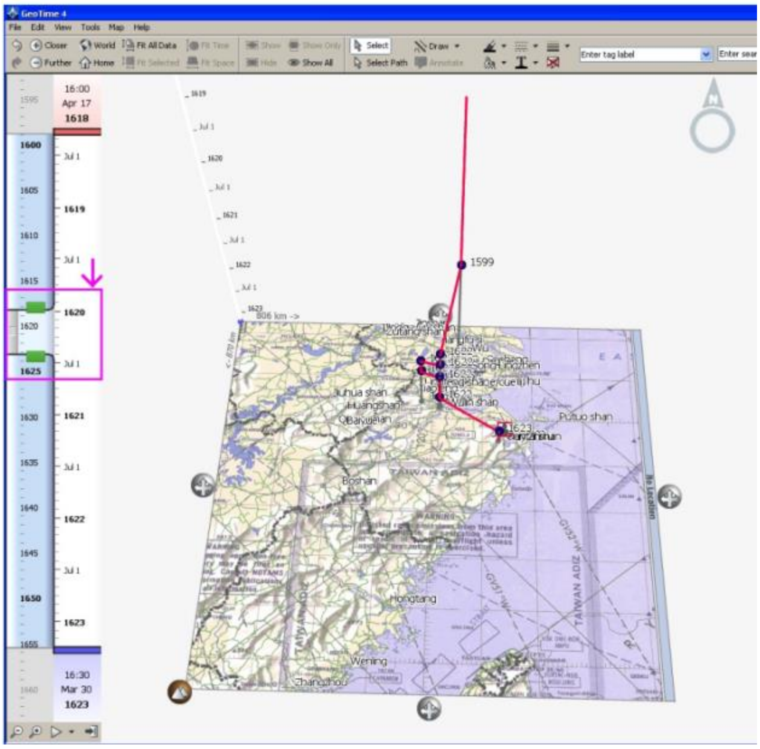


Figure 28: GeoTime

Source: GeoTime 2015

GeoTime is not designed to create and integrate authentic analytical algorithms. Instead, it includes general analytical tools.

An important feature of ths program is *Story*. The principle of this module is based on the “narrative theory” (Fisher & Walter 2004), i.e. people are basically story tellers and their natural ability is the assessment of the coherence, level of detail and structure of the stories. From an analyst’s viewpoint, story is a form of communication to verify the feasibility of certain features or motives. Stories provide a unique opportunity to present events which do not have to be necessarily linear in time. In timelines, nevertheless, events are ordered in an order pertaining to the topic. Narrators can work with listeners’ attention in time, in order to provide a closer context.

Story is an important abstract tool that analysts use to conceptualise threat and grasp patterns. It is a system capable of defining spatio-temporal patterns and of inserting aspects of narration to increase the analytical meaning. Visualisation of spatio-temporal events uses narration, hypertext visualisations, visual notes and revealing patterns to create an environment for analytical research and communication. It thus helps analysts identify, extract, order and present stories within data. This system enables analysts to work at the level of story with abstracted data on a higher level, such as behaviour and events, while being constantly connected to empirical data.

Story is built into a spatio-temporal frame of GeoTime, which aims to improve the perception and understanding of the movement of entities, events, relations and interactions in time and spatial context (Eccles, R. et al. 2007). GeoTime presents basic aspects of a story: events, people, objects, places and relations. Due to its ability to view these aspects in time and space, it is a suitable platform for building representations and interactions with stories. Analysis of observation in time and geography is a common task that often operates with multiple separate views. The aim of GeoTime is to enable analysis using connected information in time and space inside of a single, highly interctive 3D view. Owing to this view, analysts increasingly understand relations and behaviour (Kapler & Wright 2005).

Developers of the software attempted to apply stories from the very beginning. Prototype of the program included tools for detecting identical patterns, which should facilitate discovering of a story. Its interpretation then should add links, i.e. to visualise events in time and space which stimulate analysis and help tell a story. For the sake of a deeper analysis, attributes to cater for own interpretations of different phenomena were also integrated.

Hardware and software requirements

Minimum software requirements are operating system Windows 7 or 8/8.1, processor 1.6 GHz Intel Core i3 (dual-core), 2 GB RAM. GeoTime does not include any topographic surveys, but uses the ones from the following programs: ESRI ArcGIS, EsriTOC (in the case of the 32-bit version of GeoTime), Web Map Service or GeoTime Offline Map Pack (has to be purchased).

7.8. IBM SPSS

IBM SPSS is a tool for statistical data analysis, based on the statistical software IBM SPSS Statistics, version 21 (www-01.ibm.com), used for reporting, analyses and direct support for decision making, business analytics, both for strategic decisions and for operative management. It can be connected to any database and is used in both one-off analyses and ongoing process monitoring; it provides a description of a situation and support to repeated or regular decision making (Acrea 2015).

The integrated base of the analytical process is the software IBM SPSS Statistics Base, providing the functionality for data access, administration and analysis, editing, reporting and management of interactive and batch processing. It contains elementary methods of one- and multi-dimensional statistics. It connects other additional modules and programs from IBM SPSS Statistics, which introduces advanced, special methods into the system and such processes that enable all stages of the analytical process, from planning, through data-collection, data analysis, to deployment (IBM SPSS Statistics Base 2015).

System requirements

System requirements differ according to the system and hardware platform used. For more specific information, see www.ibm.com/spss/requirements.

7.8.1. Modules of IBM SPSS Statistics

Individual modules of the version IBM SPSS 21 are described below (IBM SPSS Statistics Base 2015).

Statistics Base: the basis of the whole system – data loading from different formats and by means of ODBC, data export to different formats, operations with files, operations with data (selection of cases, weighting, aggregation, identification of duplicity), data transformation, basic statistical reviews and tables, data viewed in maps, advanced statistical methods and processes (T-tests, ANOVA, correlation and regression analysis, smoothing, non-parametric tests, factor analysis, discriminant analysis, cluster analysis, reliability analysis, multidimensional scaling ALSCAL, multiple responses, and others), statistical graphs, simple editing of results (graphs and tables), export of results, pasting programs using syntax including macros and scripts.

Custom Tables: interactive creation of complex tables.

Regression: advanced multidimensional regression-based models (binary logistic regression, multidimensional logistic regression, nonlinear regression models with and without marginal conditions, method of weighted least squares, two-level method of least squares).

Advanced Statistics: mathematic-statistic modelling of relations: a general multidimensional linear model, methods of modelling the relation between categorised variables and methods of life-expectancy analysis.

Decision Trees: creation, verification and application of classification trees.

Categories: analysis of multidimensional categorised data, including graphic depiction of relations (optimal scaling, perception maps, different techniques of dimensionality reduction, categorical regression analysis).

Conjoint: analysis of product or service properties on the basis of customer preferences, recommendation of a suitable combination of attributes.

Complex Samples: tool for work with complex selections, from planning to analyses. Correct statistical inferences, including complex models (gernal linear model, logistic regression).

Forecasting: methods for analysing time series.

Exact Tests: analysis of small data files or minor groups of cases with accurate levels of significance.

Missing values: analysis of missing values – structure, summary, patterns, inferences of missing observations.

Neural Networks: disclosure of complex structure of relations in data through neural networks.

Data Preparation: improvement of the data-validation process and simplification of time-consuming processes during manual checks. A simple identification of suspicious or erratic cases, variables and values in data, detection of extreme values, observation of the structure of missing values, and other processes enable obtaining more accurate results.

7.8.2. IBM SPSS Modeler

IBM SPSS Modeler is a software tool used in the process of finding-obtaining-using information. The program deals with, for instance, the predicted behaviour of customers and risks, customer preferences, searching for fraudulent behaviour, creation of models for facilitating everyday decision-making processes, or for a better preparation for future events (IBM SPSS Modeler Professional 2015). The software uses CRISP-DM methodology.

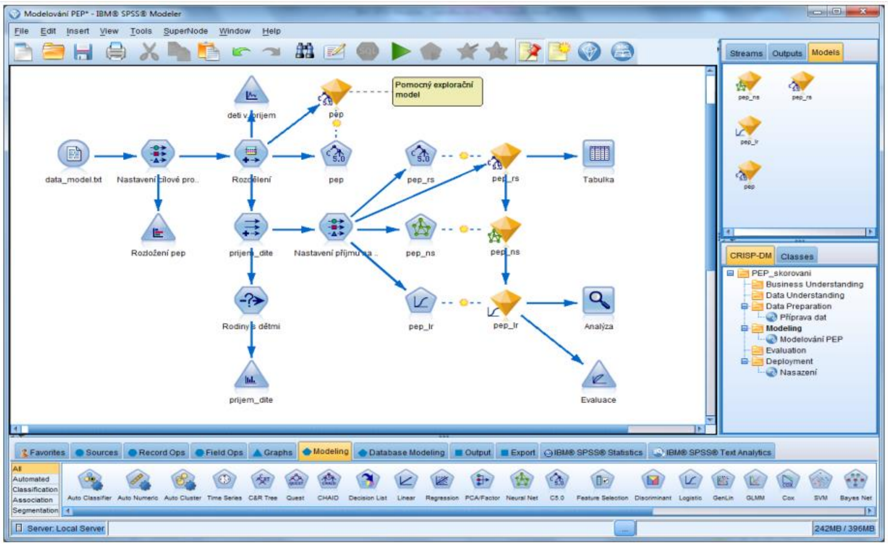


Figure 29: SPSS Modeler

Source: Acrea 2015

All types of databases (IBM InfoSphere, Microsoft SQL Server, Oracle and IBM Netezza), table, data files (such as IBM SPSS Statistics, SAS and Excel files), text files, sources from Web 2.0 (e.g. RSS), IBM SPSS Data Collection, IBM Cognos Business Intelligence, from systems with IBM Classic Federation server and zDB2 pro z/OS are easily accessible from the graphic interface (IBM SPSS Modeler Professional 2015).

Regular automation of the solution

After predictive analyses were created and their relevance verified, the next step is automation of the whole process and connection of the data analyses to the current processes. For this, a server variety of a data-mining tool, and components ensuring automation and deployment of the current systems (Acrea 2015).

IBM SPSS Modeler Server Professional (IBM SPSS Modeler Professional 2015)

- Modelling algorithms in the IBM InfoSphere database: Apriori, clustering, decision trees, logistic regression, naïve Bayes classifiers, regression models, identification of associations in sequences and time series
- Modelling algorithms in the IBM Netezza database: Bayes networks, naïve Bayes classifiers, decision and regression trees, hierarchicl clustering, K-means clustering, general linear models, principal component analysis and time series
- Modelling algorithms for the Microsoft SQL Server databas: Apriori, clustering, decision trees, linear regressions, naïve Bayes classifiers, neural networks, sequential clustering and time series
- Modelling algorithms for the Oracle databas: adaptive Bayes networks, naïve Bayes classifiers, Apriori, artificial intelligence, decision trees, generalised linear model, K-means, minimum description length, factorisation of positive semi-definite matrices, O-Cluster, support vector machine
- Access to modelling tools in databases
- Paralel activation of flows and models
- Safe transfer of sensitive data between the client and the server using secure sockets layer coding
- Export of transformations and selections to SQL, executed in the database through SQL Pushback

IBM SPSS Collaboration & Deployment Services (IBM SPSS C&DS) is a software platform which enables administration of analytical outcomes and automation of processes generating analytical assets. IBM SPSS Collaboration & Deployment Services is an application that enables sharing and using analytical conclusions and processes throughout an organisation. It offers a centralised, secured and audited storage of analytical output. Available are advanced tools for management of analytical processes, including automatic saving and sending to end users. Individual components of IBM SPSS C&DS are interconnected and extend the basic functionality of the central data store (Acrea 2015).

7.9. ORACLE

Oracle is one of the major developers of relational databases, tools for database development and administration, or systems of customer relationship management. It offers an optimimised, fully integrated package of commercial hardware and software. Due to an extensive range of products, a selected case from the army is provided, which was also presented at the first workshop in Prague (2014) by the company representative, Mr Bert Oltmans.

In the military context, the Oracle Event Processing (OEP) application is used. It can find geographic information about enemy positions, evaluate this data and identify the probability of attack. Based on this information, it can alert units which are capable of an adequate response in real time.

This software has been practically used in Africa, for example, when terrorists strove to get hold of a tanker. Data was processed in real time, with a focus on observing suspect behaviour in a given area. This mission served also as a sample of detection suspect individuals in real time, prevention from crime, or usage of spatial mapping.

OEP enables acquisition of data from various sources in real time, increasing its value in larger volumes. The application continuously processes incoming flows of information and executes predefined commands. For both prompt processing across situations and data sources and display of the flow of events, directed graphs are used.

In the context of public administration, Geo-Data Warehouse and Location Intelligence were used. The aim was to mine information from hidden correlations of data. As a solution suitable for analysis and adaptation of the given model, decision trees were used (Figure 30).

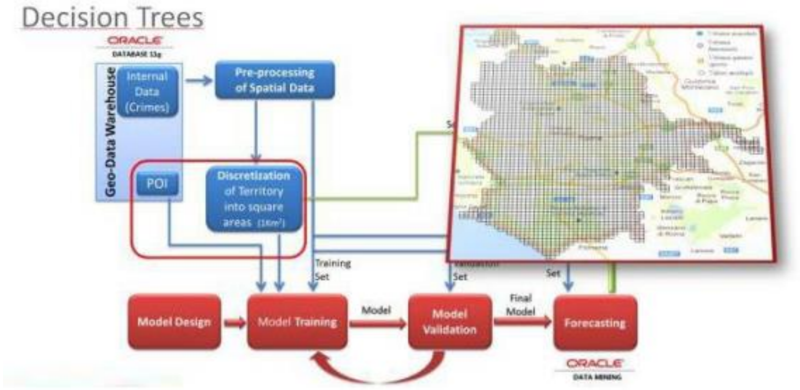


Figure 30: Decision trees

Source: Oracle Corporation 2014

The given area was divided into cells of the size 1 km^2 each. On the basis of observation, a map was created (Figure 31), which allowed for a more effective planning of the police. It was also confirmed that crime predictions should not be based solely on historical data, but also on the location of the points of interest in an area.

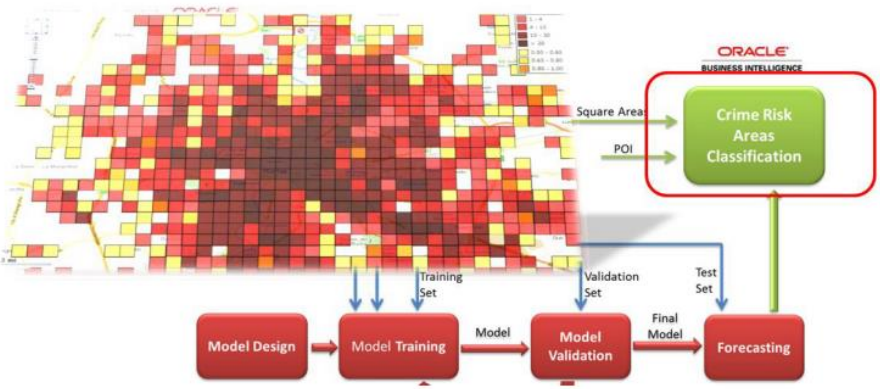


Figure 31: Decision trees – a map

Source: Oracle Corporation 2014

7.10. PRECOBS

PRECOBS (Pre-Crime Observation System) was developed by the German Institute for Pattern-based Prediction Technique (www.ifmpt.de) in 2011. The system[5] operates on the basis of pattern-recognition of near repeats. The processed outcomes make use of data acquired from specific areas of crime. The program processes information crucial for recognising specific offender profiles. Users thus obtain information whether it relates to individual offences or serial crime, whether it is an occasional or a repeated offender, or whether the offender acted on the spur of the moment or in an organised manner (IfmPt 2015).

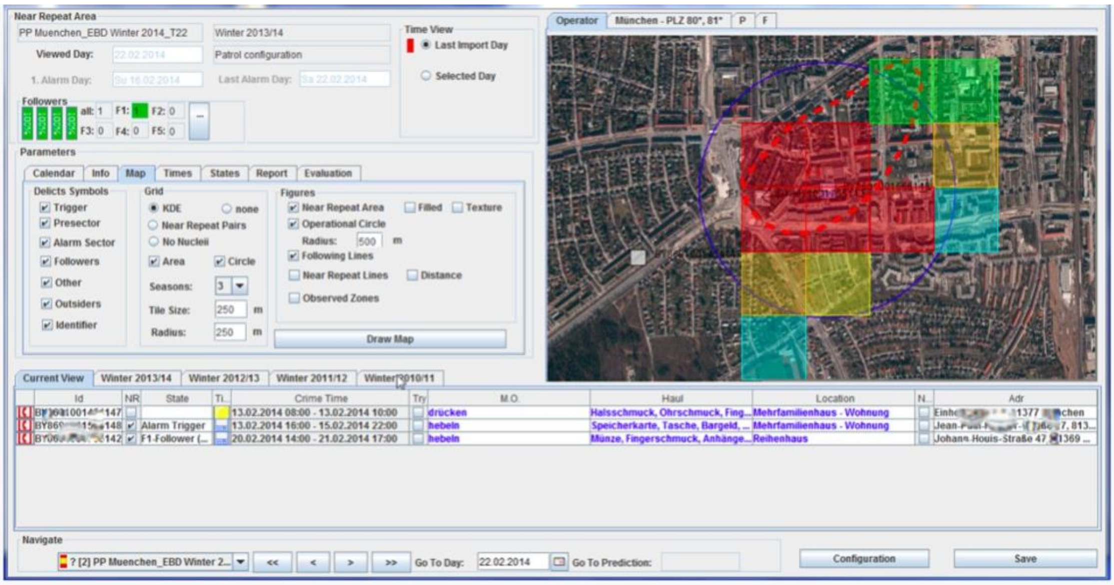


Figure 32: PRECOBS user interface

Source: IfmPt 2015

The program identifies areas with repeat crime, which are indicated as "near-repeat affin". This provides the basis for automated prediction of repeated crime. Materials for the police include data about time and place, which enables planning suitable counter measures. As PRECOBS processes the latest data, it generates predictions which police forces can use for both operating and preventative purposes (IfmPt 2015).

[5] More detailed description of PRECOBS functions has not been provided.

8. EXAMPLES FROM THE INDIVIDUAL COUNTRIES

8.1. CZECH REPUBLIC

8.1.1. Initial situation (focused on the National Police Force)

The competence of the National Police Force is defined by the Act 273/2008. Its role is to protect the safety of people and property, defend public order, prevent crime, abide by the penal code, and other tasks of internal order and security authorised by the Law.

It plays a role also in analysing security situation. Besides an ongoing analysis of territories of the country, the National Police Force, in accordance with the Crime Prevention Strategy in the Czech Republic for years 2012-2015, will newly focus on identification of particular selected continual security issues within each territory, their analysis and suggested solutions.

In-depth criminological analyses enable long-term, mid-term and daily operative decisions based on models driven by real data, which accurately describe a current, evolving situation and relations between the detected data. Approach based on analysis and prediction facilitates the organisation of police forces, resulting in a more efficient deployment of financial, personal and material resources.

In addition to this, the National Police Force will continue its collaboration with municipalities and municipal police forces via regular communication, joint planning of resources, sharing of information and potential analytical outcomes, joint solving of identified threats and mutual support (Crime Prevention Strategy in the Czech Republic for years 2012-2015).

8.1.2. Structure of the National Police Force

The National Police Force is controlled by the Ministry of the Interior. It comprises the Police Presidium, squads with nationwide jurisdiction, regional police directorates and squads established in terms of regional directorates. The Law establishes 14 regional police directorates, which are further divided into territorial divisions, or alternatively city directorates (81). Fundamental squads of the National Police Force are district police departments (544), and the Criminal Police Force.

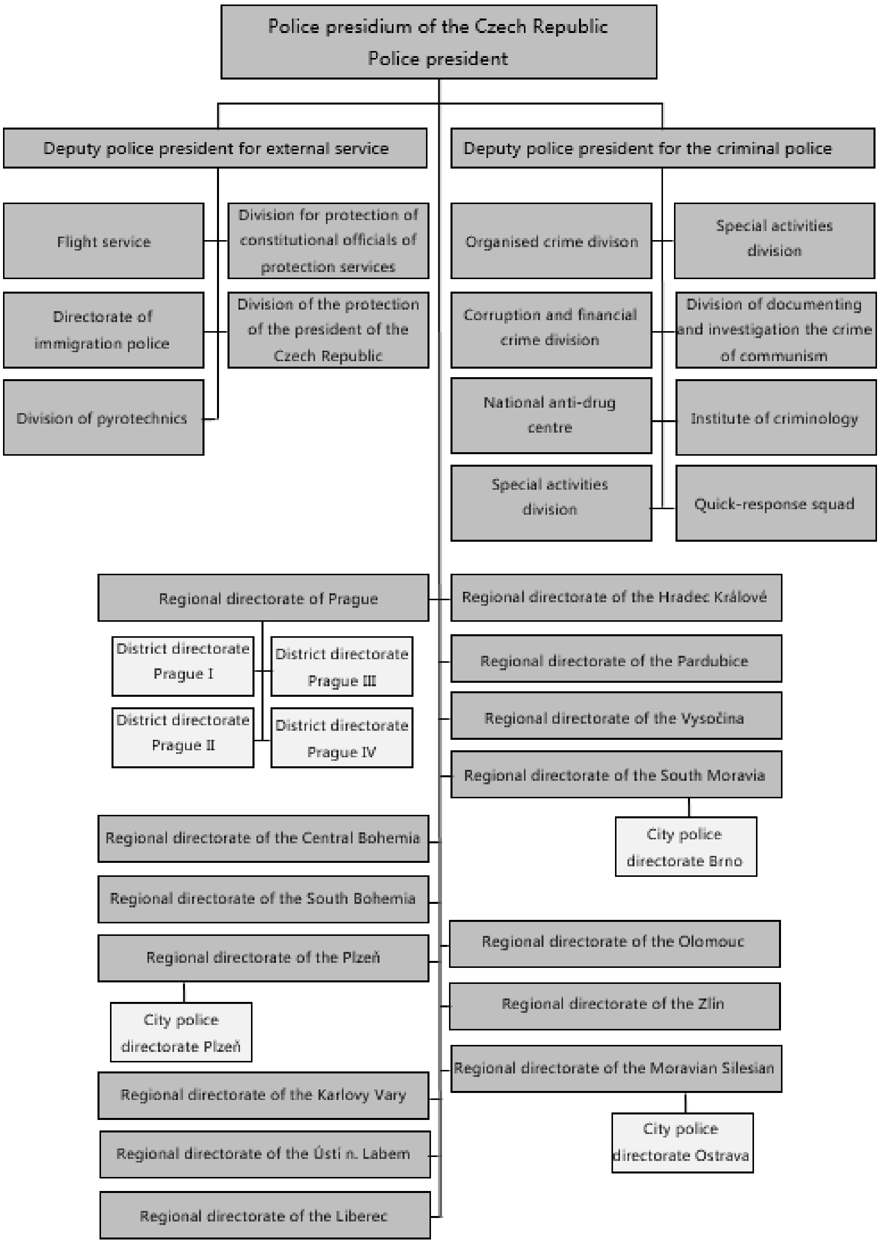


Figure 33: Structure of the Police

Source: National Police Force 2015

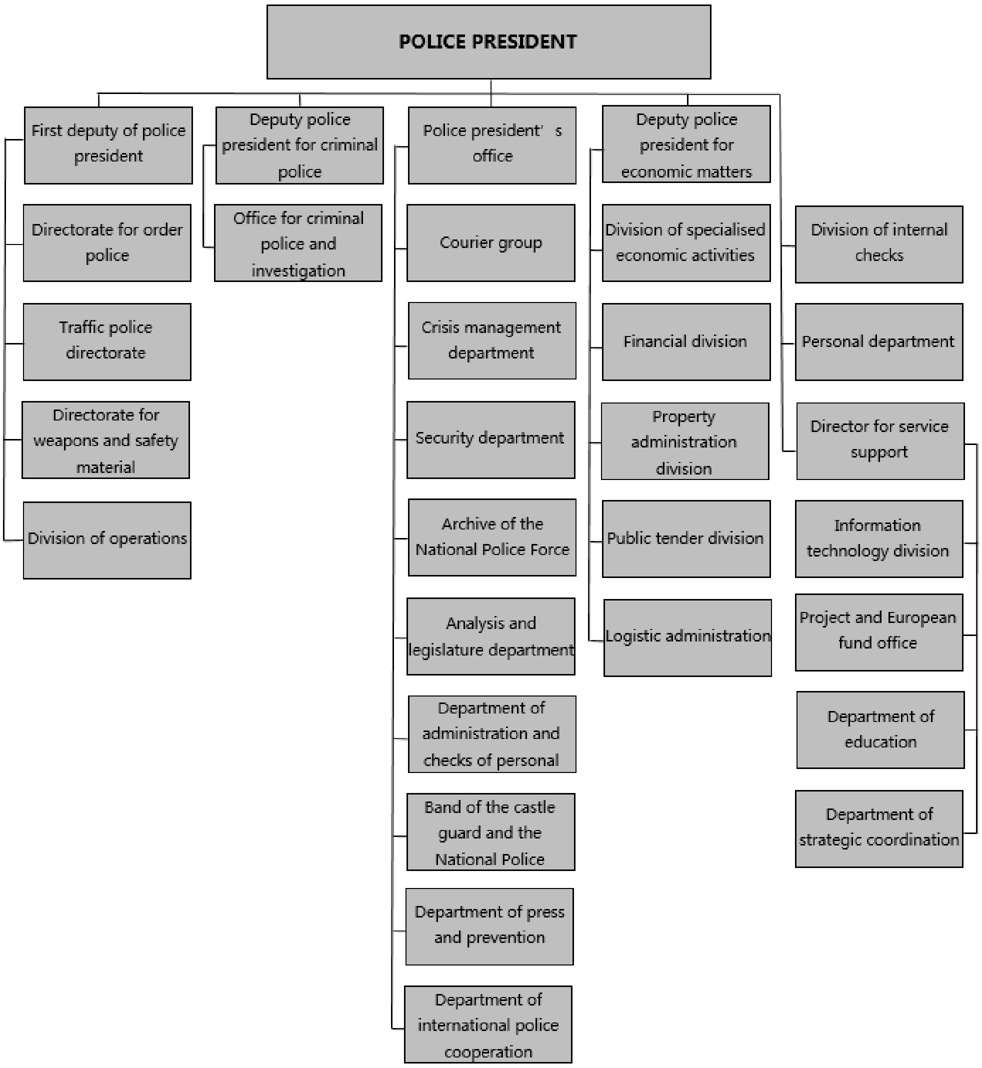


Figure 34: Sturcture of the Police Presidium of the Czech Republic

Source: National Police Force 2015

The National Police Force is controlled by the Police Presidium, headed by the police president, who defines the goals of development, concepts of organisation and management, and determines the tasks of the individual services. The Police Presidium controls both squads with national jurisdiction as well as regional police directorates. The former are established by the minister of the interior on the basis of a police president's proposal. The latter are established by the Law.

Regional police directorates have a defined jurisdiction. They serve the public within a defined territory and constitute independent organisational units of the state. In fulfilling their tasks, they freely work with financial resources from the government budget. Other subordinate territorial squads may be active within regional directorates.

Squads with national jurisdiction fulfil specific and highly specialised tasks throughout the country. Some provide a specific service to other police squads, others specialise in, for instance, organised crime, corruption, or serious financial crimes. They also tackle drug offences or are in charge of the president's or other government representatives' protection.

Each part of the territory thus belongs to a fundamental squad, territorial division, regional directorate. In special cases, squads with national jurisdiction, alternatively squads of the Police Presidium, are territory-bound (e.g. extensive crime activity, international elements, organised crime) (The National Police Force 2010).

The organisation of work in the National Police Force is defined by an approved system, similar across all territories with minor exceptions. The *Sample Organisation of Work Positions* is the document on planned numbers of positions, which is used as the basis for creation real volumes of officers and employees on given work positions. This document is drawn up by the Police Presidium.

The organisation in question is updated on an annual basis, when the number of official work positions changes. However, ongoing changes can take place on a quarterly basis, when salary classes are adjusted; still, total numbers remain unchanged. Proposals on changes are submitted via regional directorate to the Police Presidium, which approves the changes, and regional directorate carries the changes out. This ensures a unified work structure and performance.

8.1.3. Analytical activities in the National Police Force

A unified work structure of positions dealing with analytical activities is defined in the framework of the National Police Force. In some cases, these activities are merged with IT support or cybercrime. For illustration, at the level of territorial divisions, the average analyst-officer ratio is 1:100, in the region it is 1:50.

Analysts at the National Police Force generally hold a university degree and have undergone specialised training – a crime intelligence analyses course. What follows is a continuous methodogological and specialised training. Analytical tools are also marginally used by commanders of the fundamental divisions of the

National Police Force, this is, nevertheless, rather an option. The most frequent analytical output is statistical data on offences and their clearance, which also serves as a commanders' means of work evaluation or comparison with other divisions.

Positions dealing with analyses are divided as follows:

- *Territorial division*: the framework of the territorial division, specifically the department of cases analyses (groups), provides positions consisting of three areas of expertise, the first being cybercrime, which deals with crimes perpetrated by means of the Internet. The next one is IT support. The third part of the case analyses groups are analysts. Their work is defined internally by the Police Presidium. Generally, 1-5 individuals are concerned with analytical operations at the territorial-division level.
- *Regional directorate*: structured in a way similar to territorial division, therefore comprising the department of crime analyses with identical positions. Regional analysts' scope is defined by the jurisdiction of the regional Crime Police Force (serious felonies). Generally, 10-20 workers deal with analytical work systematically at the level of regional directorate.
- At the central level, analytics division has been established (within the structure of the Crime Police Force), with approximately 30 workers.

Aside from these analytical departments, two divisions carry out analytical work; in those cases; nevertheless, it is not their main work duty. It mainly applies to crisis-management divisions, service directorates at the Police Presidium, and, alternatively, specialised organised-crime squads with national jurisdiction.

Analysts' job duties are also adjusted to regional specificities or current needs of the managing staff. Marked differences in job duties can be observed between analysts in statutory cities and regional cities, compared to other smaller cities/towns. This is due to different numbers associated with higher crime rates in large cities. A notable issue is the scatter of tools used, as their incompatibility obstructs the analytical work.

Analytical police operations are mainly focused on data on felonies (answers to seven crime-related questions: what, who, where, when, how, what with, why + the damage). Operations with registers are approved by the National Police Force Act 273/2008.

The basic data source for analytical work is the criminal-proceedings register (*evidence trestního řízení, ETŘ*). This system contains comprehensive data on recognised perpetrators, felonies, selected misdemeanours and traces from these offences.

This backbone information system has replaced the operating and tactical register (*operativně taktická evidence, OTE*), which was thereby extended with other data. It concerns, for example, geographic data on the spots of committed acts, recorded in coordinates. The National Police Force uses more than 60 IT systems, which, nevertheless, are mutually incompatible at times.

As regards the use of supplementary data, the police gather no other crime data, such as socio-demographic data, localisation of the points of interest from the socio-pathological perspective.

Data on crime is collected on the basis of reporting an offence, which is followed by writing a report and searching the crime scene. This data is then fed into the criminal-proceedings register at the police station. In some cases (e.g. traffic accidents), this data is saved in off-line applications immediately at the place of committing the act, which is followed by an upload to the information system. Data on localisation of the offence are saved in the mapping environment at the police station. Still, accurate geographic data on crime in coordinates have been recorded since as recently as 2014. Before that, accurate places of committing an offence were localised using address, but also a more detailed location, such as points of reference. It is assumed that geographic data will be increasingly comparable with other data and that analytical outputs will allow for an enhanced interpretation in the future.

8.1.4. GIS of the National Police Force

Due to its wide range of activities, imposed by the current legislature, the National Police Force presents a suitable environment for applied geoinformation, where geographic support needs to be tackled from different perspectives. By no means can police maps replace local knowledge. However, they can considerably facilitate work of numerous users within the National Police Force and its divisions. Consequently, a decision was made about the implementation of geographic system of the National Police Force in 2007.

So as to coordinate the spread of GIS functionalities of the National Police Force system and its connection to current information systems, a task force was established, in accordance with the order of the police president from April 25, 2014.

The head of the task force was ordered to take the following steps:

- to submit proposals for further development and use of GIS to the police president
- to submit a report on the task-force activity with an evaluation of the implementation process and other GIS-system services for a discussion on a yearly basis
- summon and communicate with specialists from other squads and organisation units, or other experts to discuss separate activities.

Due to the current composition of the team (4 members, year 2015), analogous and digital materials and tools needs to be as effective as possible for all individual organisational units of the National Police Force. What is at the beginning of the process is the creation of the *police basemap*, composed of hundreds of thematic layers. Consequently, the National Police Force is informed about the content of the map, saving financial resources used for updates for other purposes. The work on the *police basemap* is still in progress.

The shift to digital technologies and dynamic development of the information system resulted in the National Police Force neglecting the usual need to create police maps. Although the vast majority of information is directly – and often accurately – linked to time and position, IT systems of the National Police Force recorded this data quite inaccurately. Items of territories were optional in crime registers. Localisation was often filled in loosely, leading to writing down wrong information, undecipherable abbreviations or data difficult to localise (e.g. "SHELL gas station, D1 highway").

Automatically localisable areas represented a mere minority in these records. Still, the quality of crime spatial data acquired during reporting on offences radically improved in 2014. These days, the National Police Force has up-to-date data available with coordinates and adequate geoinformation tools for registering purposes.

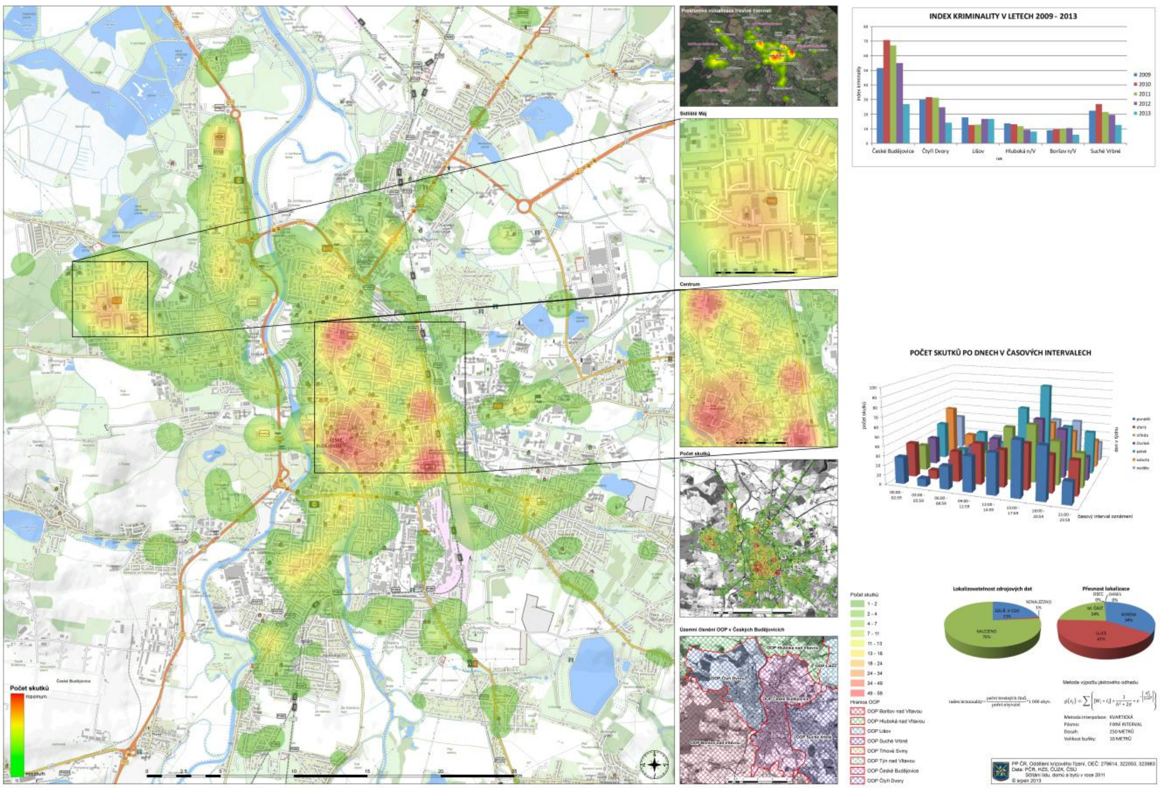


Figure 35: Registered crime in years 2009-2013 in the area of České Budějovice

Source: National Police Force 2013

Another issue perceived by the National Police Force is the shortage of authorised spatial information from abroad. At this juncture, the National Police Force is limited to open resources available in the public domain in this area. In the early 2015, the areas around the border with the neighbouring countries within the perimeter of 80 kilometres from the Czech national border were defined. Due to this, the basis of the maps has been consolidated in most application of the National Police Force over the past two years. In the final stage of consolidation, the bases of the maps will be unified in applications operating off-line in squads with national jurisdiction.

Inspired by partners from abroad, the National Police Force has successfully improved the quality of spatial data, created new tools for its workers that can be actively used within the National Police Force over the past years.

In the current composition (four full-time employees), the team work as a single unit for the needs of the whole National Police Force. In April 2015, the police management approved the proposal on new GIS workplaces organisation. The present team may be extended by seven workers operating at regional directorates.

Presently, more than 1300 single users work in the GIS environment of the National Police Force every day. These new technologies aim to become a common part of routine police work at all levels.

Legislative limits

Among the most discussed topics on analytical work and crime mapping is mainly the provision of data on offences to other parties, and the cooperation between the National Police Force and City Police Forces.

The National Police Force is well aware of the fact that crime mapping has a big potential for a close cooperation with the public. The National Police Force is currently unwilling to supply all anonymised data on spots of offences.

Police GIS departments are not authorised to negotiate about requirements (the Information Access Act 106/1999). Currently, comprehensive exports of crimes within territories can not be shared. In accordance with the current legislature, it would be necessary to assess each case individually whether the information can be provided. Another undeniable fact is that as yet no rules have been laid down in terms of the Ministry of the Interior as to in which form this information should be provided. Most of this information is tactical for the National Police Force, some even sensitive. According to the current legislature, it is not possible to disclose information about investigated cases, which is without any doubt justifiable. Currently, the National Police Force can therefore provide a detailed picture about the crime in the Czech Republic to the public. The police, however, understand the public need and try to address it actively. Owing to the initiative of the National Police Force, the government has approved a Geo-info-strategy (government resolution from October 8th 2014 no. 815), amended with strategic tasks of the Ministry of the Interior and the National Police Force of the Czech Republic in the area of geoinformatics.

The collaboration between City Police Forces (municipalities) and the National Police Force derives from Section 16, the National Police Force Act 273/2008. Its goal is to define a joint procedure in defining local tasks in public order. These agreements on mutual cooperation for the sake of defining a joint process in securing local issues enable establishing conditions in data provision. The extent of provided data is undefined legally, which results to a variety of interpretations in the transfer of information. The National Police Force generally provides information about perpetrators and offences for statistical purposes only. Details (coordinates) about places where crime has been committed, perpetrators or victims are not provided.

Cooperation between the National Police Force and city police forces in data provision from IT systems is defined in the Municipal Police Force Act 553/1991. Section 11a of this Act authorises City (Municipal, for that matter) Police Force to share information from IT systems. These pieces of information, however, lead to identifying people and things. Consequently, the Law fails to empower Municipal Police Forces to obtain answers from IT systems of the National Police Force and the Ministry of the Interior.

A current discussion is held among experts whether municipal police forces (municipalities) should be authorised to gain information on crime.

8.1.5. Kolín

The following information was acquired through two specialised workshops held in terms of the project, where police representatives presented the implemented solution. It was also consulted in person with representatives of the task force “Bezpečný Kolín” (*Safe Kolín*).

Main sources of information:	Personal meeting held on May 5th, 2015 at the regional division of the National Police Force in Kolín Proceedings from the first workshop, held on December 11th-12th, 2014 Proceedings from the second workshop, held on June 10th-11th, 2015
Parties involved:	Director of the regional directorate of the police of the central-Bohemian region Head of the territorial division of the National Police Force Kolín Director of the City Police Force Kolín

Information about the city/region

Source: ESRI, basemap ArcGIS Online 2015

The regional city of Kolín is situated in the lowlands on the banks of the river Elbe in Central Bohemia. According to the Czech Statistical Office, 30.946 residents inhabited the area of 35km^2 as of January 2015. The city is located on two key railway transit tracks, which makes it an important node of a national significance. From the viewpoint of road transit, the city has a direct connection with Prague via an express way of an approximate length of 60km. Being situated on the river Elbe, ship haulage is also a significant factor; specifically, a port and a lock. The major employer, providing jobs to more than three thousand people, is automotive industry. Operating a thermal and a hydroelectric power station, its significance also lies in the field of energy (Město Kolín 2015).

Information about the organisation

The city is divided into 10 parts in four cadastral territories. Policing within this therritory is carried out by the City Police Force and the National Police Force, in particular the Kolín territorial division, which is further divided into six district departments: Kolín, Český Brod, Kostelec nad Černými lesy, Kouřim, Pečky, Týnec nad Labem. The city of Kolín, the City Police Force and the National Police Force are involved in the *Safe Kolín* project, whose aim is to reduce crime-rates in the city through cooperation of the afore-mentioned subjects.

Kolín comprises 42 City-Police-Force officers and 53 officers in the district department. As regards the city security, Kolín has had marked crime-rates. For the sake of illustration, 1881 felonies were committed in 2013, as opposed to neighbouring cities of Kutná Hora and Nymburk with 547 and 874 felonies, respectively. One significant factor impacting on these figures is the spread of social housing, several gambling houses, industrial zone wth 5000 employees recruited from both the Czech Republic and abroad. Another contributory factor is a notably high number of drug addicts.

Initial situation

The security situation in the city resulted in the foundation of the task force *Safe Kolín* in late 2013, with the following vision:

The National Police Force in conjunction with the City of Kolín and other partners join forces in their determined effort to reduce crime-rates significantly in order to contribute to a better quality of life of the city folks.

Permanent members of the task force are, among others, the mayor, head of the territorial division of the National Police Force Kolín, director of the City Police Force, crime-prevention manager, head of the health-care and social-affairs division of the City Authority, and head of probation and mediation service.

The vision has been shaped by specific goals:

- **Safe streets** – a programme based on the collaboration of units of the National Police Force (traffic, public order, serious crimes) with the City Police Force:
    - The territory has been divided for the purposes of more efficient patrolling of the City Police Force and the district department, with clearly defined beats with the presence of the City Police Force or the district department, which ensures a more extensive coverage of multiple areas at the same time in times of emergency.
    - Enhanced presence in areas with identified risks (see *safe places*).
    - Regular checks in social houses, gambling houses, night bars and pawn shops.
- **Safe places** – the railway and the bus station, the city shopping mall, carparks, social houses, department store, spots with frequent occurrence of syringes.
- **Zero tolerance** – of drugs and offences.
    - Creation of the police team “Kolín”
    - Continuously increasing crime-rates caused that officers of the district department Kolín were inundated with paperwork, having to deal with vast amounts of reports, consequently having limited time to investigate perpetrators thoroughly. Due to a low clearance-rate, the city was becoming a sitting duck for perpetrators of mainly crimes against property.
    - In early 2014, a decision was made to found a special police group “Kolín”, composed of the national and local police force, as well as Criminal Police Force. The group undertakes to investigate drug-related and property-related crime in the city of Kolín. Currently, the police also patrol in locations with an increased crime-rate.

  - So far, this specialised group has tracked down more then 50 offenders engaged in serial property-related and drug-related crime.

- **Creation of the websites "Safe Kolín"** to inform citizens about criminal offences and use their participation in crime reduction.

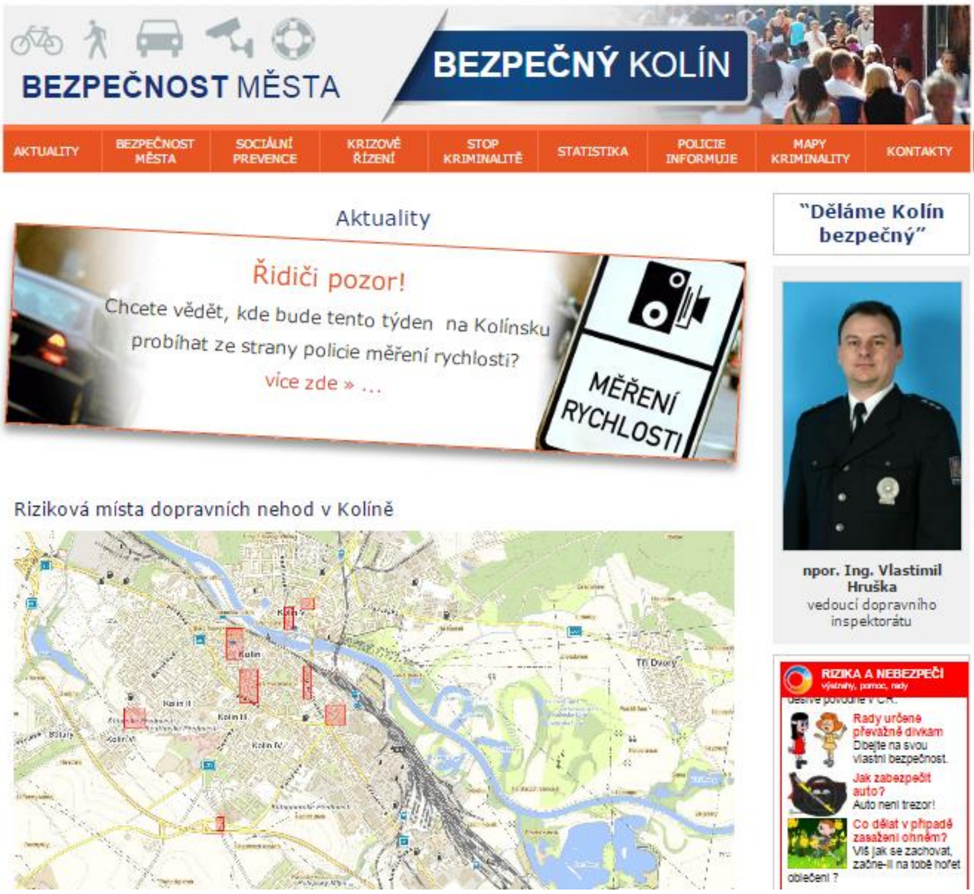


Figure 36: Screen of the websites "Safe Kolín"

Source: Bezpečný Kolín 2015

- **Preventative measures taken by the City Police Force**
  - Beat policing
  - Suggestion box in each beat
  - Sessions at primary schools and kindergatens
  - Presentations for the elderly and the disabled
  - CCTV adjustment

  - Officers' surveillance of pedestrian crossings
  - Preventative police presence around schools
- **City CCTV**
  - Built in 1998, currently undergoing extensive adjustment, comprising 25 points, to be expanded in the future.

Projects undertaken

Since January 1st 2015, the pilot project, which aims to eradicate "street crime", mainly thefts and break-ins, has been running in the Kolín county.

The pilot project should review the current legislation pertaining to data sharing from information systems of state administration and self-government. Individual institutions of state administration hold important, valuable information, which, however, are not shared further. The IT system of the Labour office is a case in point, having a thorough overview of socially vulnerable citizens within its jurisdiction (where they live, how many children they have, whether they are on social benefits, who and when returned was released from prison). From the perspective of security, these are precious pieces of information which could be effectively used in crime mapping.

Case study / application

First and foremost, the police strive to monitor the movement of risky individuals around the city. This is why they carry out regular controls in social houses and scrap-metal collecting facilities. Patrols of the National or City Police Force are almost constantly present at the railway or bus station (one of the main entrances to the city), where they execute thorough controls.

Checking facilities buying scrap metals, the police in conjunction with the labour office investigate whether the persons collectingn metal applied for social benefits, whether they reported this financial income, amounting to as much as CZK30,000 in some individuals. Until 2015, 63 cases were disclosed with unreported income of CZK231,453. Consequently, since the beginning of 2015, a marked decline in stolen iron objects has been observed. Stolen gutters or sills were not reported in

Kolín altogether. Who represent a large group of individuals engaging in property crime are drug users. The police carry out controls of these individuals based on mapping analyses (places with the most frequent occurrence of these persons).

Patrol policing is located in places where property crime is concentrated. These are squares of approximately 200m^2 in size. These locations are defined through a geographic system developed by the National Police Force, which enables graphic visualisation of these hot spots on the basis of the input data. These places are then covered by district police officers, transportation authority and the City Police Force so as to avoid multiple presence and to cover as many of these spots as possible.

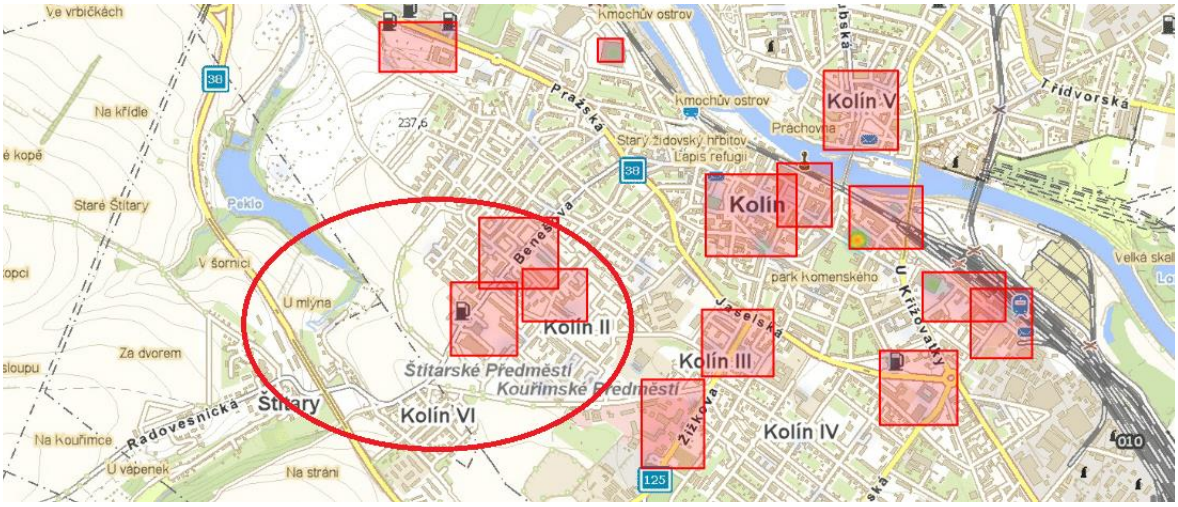


Figure 37: Concentraction of property crime

Source: National Police Force – Kolín division 2015

The utilised geographic system enables defining input criteria concerning:

- the period of visualising criminal activity (day, week, month, year),
- the ime when a crime was committed (alternatively time of day/night)
- the type of offense.

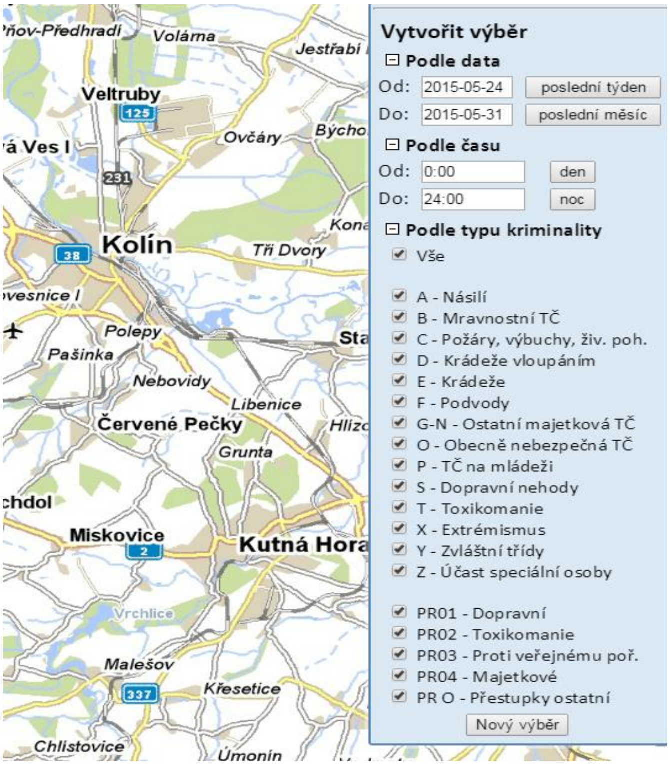


Figure 38: Screenshot of the geographic system used

Source: National Police Force – Kolín division 2015

On the basis of the selected criteria, officers can visualise a particular offense over a specific period of time on a map. Several forms of output can be created – depiction in points for particular crimes, hotspot mapping, visualisation of critical zones.

Figure 39: Hot spot

Source: National Police Force – Kolín division 2015

The police in Kolín are of the opinion that a citizen living in a specific place should be informed about offences in that area and therefore about potential future risks they might be exposed to. Hence the police decided to publish non-specific offences on the territory on the websites "Safe Kolín", which were established with this in mind, among others. What is also planned is publishing the map of Kolín with a defined area where specific offences will be visualised. The exact crime scene will be vague, having been blurred in a sector of approximately 200m^2 to avoid identification of the victim, hence secondary victimisation.

Another part of the websites lists the places where the police will be monitoring speed in a given week. This is based on the assumption that such places (mainly defined by frequent accidents) drivers will drive with caution the over the whole week, although the measuring will be carried out for approximately four hours every day due to limited resources.

The webistes also enable citizens to give anonymous input regarding offences, e.g. information about an offender or stolen goods. Simultaneously, citizens can draw attention to any offences they are concerned with in Kolín.

Practical usage

As of June 1st, 2015, the pilot project named "Simply Quick" should be launched in terms of the regional directorate of the Central-Bohemian region, territorial division of Kolín.

Its main goal is to transfer a maximum volume of an officer's workload into a fieldwork. A mobile device will enable an officer to identify a person, vehicle, object, to carry out investigation of a specific offence, to acquiant themselves with the daily schedule, to exchange information with the City Police Force.

Using a mobile device, officers will be able to carry out checks of individuals, vehicles, and thus feed this information into an information system, including the date, time and place of the check, which eliminates the time necessary for the administrative work resulting in a higher occurrence of patrollling. Identification of an object, whether it has not been reported as stolen, is carried out immediately via a mobile device, which reduces the time for checking.

Public meeting points at financial institutions, post offices, shopping malls, the labour office, etc., will be arranged for police officers to process such reports. This should affect police presence in the given critical area over specific time periods.

Mobile devices connected to crime maps enable officers to acquire information about work schedule of a given day, with delineated critical zones and times being visualised gradually for the police officer.

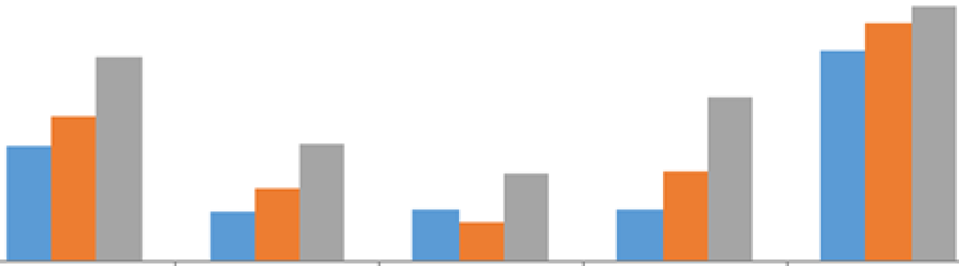
Also, the Kolín City Police Force is in possession a system which records crucial information of individual officers' activity (interviewed persons, vehicles, found syringes, information about offences, including property-related). This information can be shared and used by the local department.

Case study / application effects

Despite the short period over which the measures have been in effect, the preliminary outcome has had a positive response. Since the beginning of 2015:

- crime-rates have seen a decline by 39% compared with 2014, and by 50% compared with 2013,
- property-related crimes have dropped by 57% compared with 2014; which is by 68% compared with 2013,
- break-ins decreased by 56% in comparison with 2014, which is an 85% decrease compared with 2013,
- thefts have been reduced by 64% compared with 2014, which is 71% compared with 2013.

At the same time, police officers still use traditional methods connected with writing a report, searching the crime scene or investigation of an uknown felon. Along with the measures, a special group, consisitng of local members of the police who engage in investigating property- and drug-related crime in the city of Kolín only, has been founded. This resulted in a higher clearance of offences, by 13% compared with 2014, and by as much as 20% compared with 2013.



	Total clearance	Property crimes	Burglaries	Thefts	Violent crimes
year 2013	25,82%	10,86%	11,48%	11,30%	47,06%
year 2014	32,57%	16,31%	8,49%	20,00%	53,19%
year 2015	45,69%	26,24%	19,57%	36,92%	57,14%

Figure 40: Clearance rate in Kolín

Source: National Police Force – Kolín division 2015

Conclusion

The project aims to transfer the main workload, including office administrative tasks, into streets, while increasing work efficiency and comfort due to a prompter reaction or check. The final result is therefore a higher number of uniformed officers in the streets, which should improve the security in the area.

8.1.6. Uherské Hradiště

The following information draws mainly from the first specialised workshop held in terms of the project, where the mentioned representatives present the implemented solution. The described solution has also been consulted with police officers and the crime-prevention manager.

Main sources of information:	Personal meeting held on February 23rd 2015, city police force Proceedings from the first workshop held on December 10th, 11th 2014 Websites: http://analyza-bezpecnosti.tmapserver.cz
Persons involved:	Head of the City Police Force Uherské Hradiště GIS administrator, municipal authority Uherské Hradiště Crime prevention manager of Uherské Hradiště

Information about the city / region

Source: ESRI, basemap ArcGIS Online 2015

Uherské Hradiště is a county city in the Zlín region, where, according to the Czech Statistical Office, lived 25,287 inhabitants, as of January 1st 2015. The municipal statistics of the Czech Statistical Office states that the city area is 21.26 km^2 (2014). It is located in the region of Zlín and it is the natural centre of the traditional region of Slovácko. The city is composed of seven boroughs: Mařatice, Rybárny, Jarošov, Míkovice, Sady, Vésky and Štěpnice. Until 1990, still separate cities of Kunovice and Old Town belonged to Uherské Hradiště, both of which are located in its vicinity. Together these cities form an agglomeration with 37,677 inhabitants and 70 km^2 in size (ČSÚ, 2015).

The city is found in the vicinity of an important railway transit track, connecting the cities of Břeclav, Přerov, and Ostrava, continuing to Poland via the city of Bohumín. Unemployment-rate in this district is the lowest across the whole Zlín region. The city is an important industrial centre of South-Eastern Moravia. That is to a large part due to the agglomeration of the city with significant job opportunities. The city is the cultural centre of the whole region, with a number of sights. The amount of cultural and sport events plays a role in an increasing occurrence of vandalism, which is one of the main areas the City Police Force focuses on (Město Uherské Hradiště 2015).

Information about the organisation

The City Police Force Uherské Hradiště was established in 1992 by a binding ordinance and currently consists of 23 patrol officers and two civil employees (Město Uherské Hradiště 2015). For the purposes of the City Police Force tasks, the city is divided into independent areas, in particular: A1 – the city centre, A2 – Náměstí republiky and the surrounding areas, A3 – Štěpnice, Mojmír and the surrounding areas, A4 – Stará Tenice and Rybárny, A5 – Náměstí Míru and the surrounding areas, A6 – Sídliště Východ and the surrounding areas, A7 – Mařatice, Na Hliníku (housing estate), A8 – Jarošov, Kněžpolský les, P1, P2, P3 – Sady, Vésky, Míkovice.

The city uses CCTV, which consists of 19 surveillance spots (and three cameras for traffic and security) and which aims to reduce violence- and property-related offences. In conjunction with the health-care and social-service division and the health emergency service, the City Police Force carries out a project entitled “Signál v tísni” (*Emergency Signal*), whose target is to facilitate communication by making it more prompt and efficient among the units providing immediate response, thus reducing the danger individuals have found themselves in.

GIS used by the city (administered by the IT division) has been gradually utilised and spread since 2004 in the T-MAPY company’s environment. The first mapping portal for the City Police Force was launched in 2010. At that time, it operated with basic functions only and contained the positions of the City Police Force surveillance cameras and a division of the city into seven policing territories.

Initial situation

Due to the need to connect maps for the City Police Force with the then-current offence register, the mapping portal was finished and extended in two stages over the years 2011-2014.

On the basis of a Ministry of the Interior call to implement the Urban programme of crime prevention for 2011, the City Police Force obtained a subsidy for the pilot project on *E-analysis of Security* (*E-analýza bezpečnosti*). The main goals were:

- Visualisation of offences in a map.
- Decision-making support of the Uherské Hradiště City Police Force.
- Interconnection of IT systems at the city authority.
- Presentation of the City Police Force work to the public.

During the first stage, the officers noticed that some tasks the application should fulfil failed to be applied properly. As a result, project analysis was carried out in 2013, which was compared with a new call of the Ministry of the Interior, the Urban programme of crime prevention, which enabled completion of the whole system (2013-2014).

The personal structure of those involved in the project comprised:

- Officers, who were in charge of the mapping process and field data collection.
- Prevention manager, who serves as a methodological support (correct data, regular checks, corrections).
- GIS specialist, who administers the technical setting.
- Police commander, who uses the completed maps for patrol management.

Case study / application

First stage of the project

In terms of the *E-analysis of Security* project, the City Police Force officers locate an exact position of offences in the system at the police station. This data has been regularly uploaded in the mapping server in a text file since 2012. The whole set of values is updated every night.

Besides selected offences tackled by the City Police Force, data of the regional directorate of the Zlín region is fed in separately in a MS Excel format. Data of the National Police Force is provided, on the basis of a mutual agreement with the regional directorate.

Data in the map was visualised using the AJAX client (Asynchronous Javascript and XML) - *http://gis.mesto-uh.cz/tms/muuh_lm*. In this environment, users can see a detailed classification of offences according to the defined categories (see below).

Figure 41: Visualised offences

Source: City Police Force Uherské Hradiště 2012

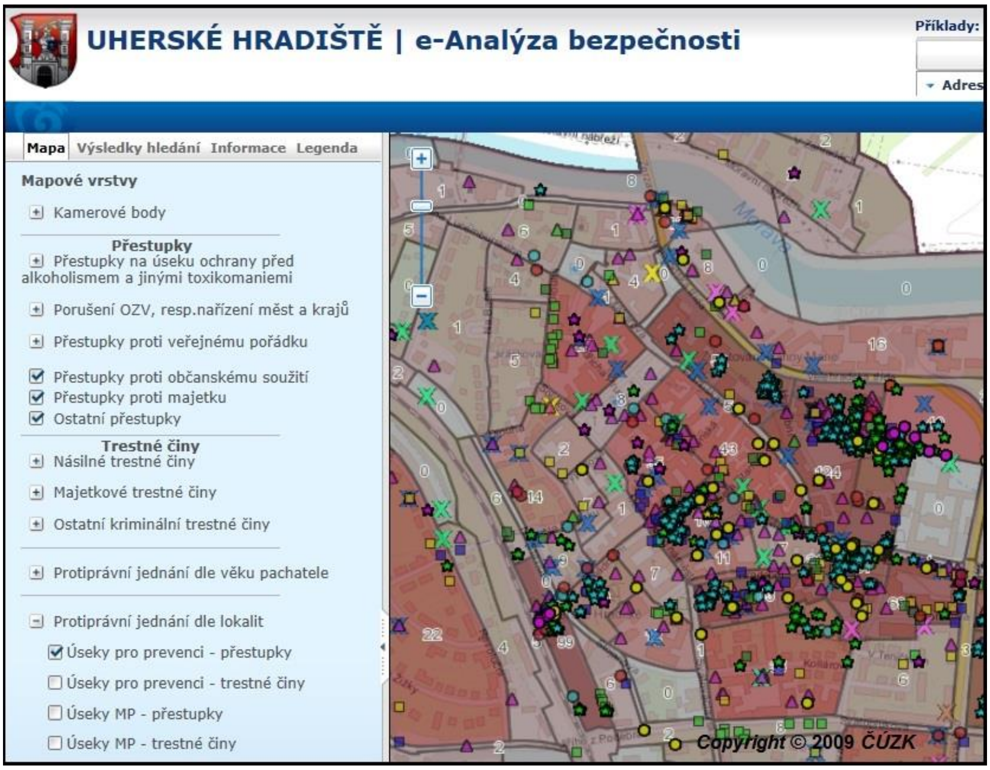


Figure 42: First version of the project “E-analysis of Security”

Source: City Police Force Uherské Hradiště 2012

In the mapping application, the city was divided into smaller areas, which enables observing statistic data on offences on the basis of a specific polygon (see below).

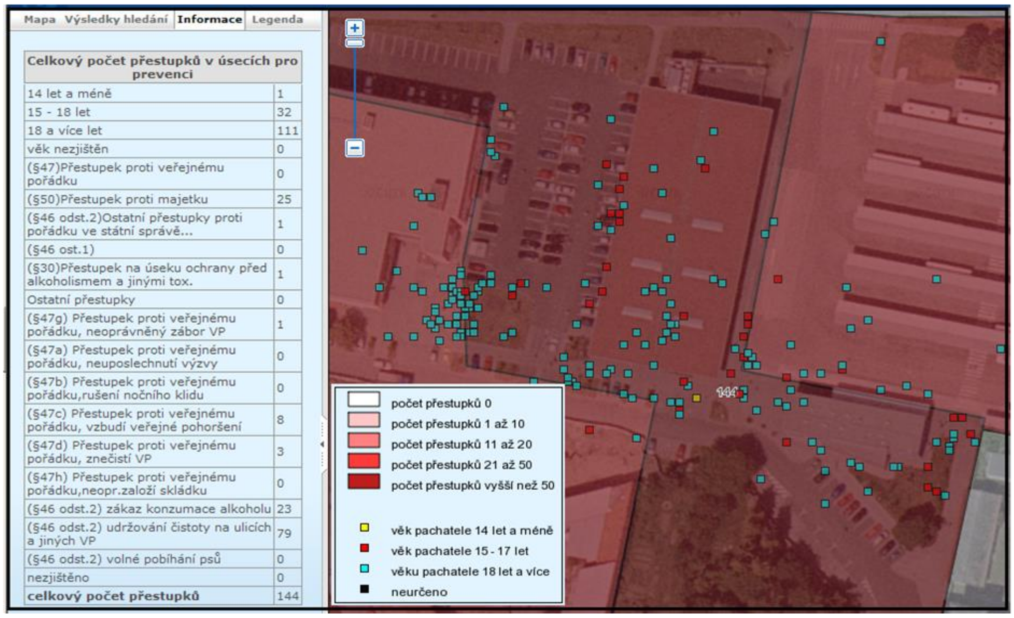


Figure 43: Misdemeanours by age, summary of statistical information

Source: City Police Force Uherské Hradiště 2012

Since the number of registered offences saw a significant increase, reading of the map became less transparent in some problematic areas. This is why a limit of 12 months was set up for visualisation in the map. It, however, caused that the user lost the ability to visualise data extending the period.

Another need that arose during the status-quo analysis was observation of selected areas in different time frames (e.g. defined areas where no alcohol consumption is officially allowed).

Second stage of the project

When the system was being completed, extensions, based on the mentioned demands of the police, were applied in a new environment concerning the way the data was visualised.

Firstly, a more user-friendly environment was designed. At the same time, output from the police database of offences was changed for the sake of an operative provision of data. Also, the option to visualise localised offences in the map was added in the register of the City Police Force. This function enables the officers to check the correctedness in the primary register.

Already-existing points of interest (CCTV) were extended with new points of interest, which are in a direct or indirect relation to street crime in Uherské Hradiště. Those points include supermarkets, facilities with gambling machines and with a degree of risk. These points can be updated on the basis of available data.

The new concept of the completed system also allows visualising data based on different parameters. The first is visualisation of offences, followed by the type of visualisation. Compared to the original version, the number of categories is reduced to five (*offences against public order, protection against alcohol- and illicit-substance-related activities, offences against property, interference with the local law, other offences)*, mainly due to a better clarity. However, specific information on the type of an offence is maintained and shown being clicked on the given point in *infobox*.

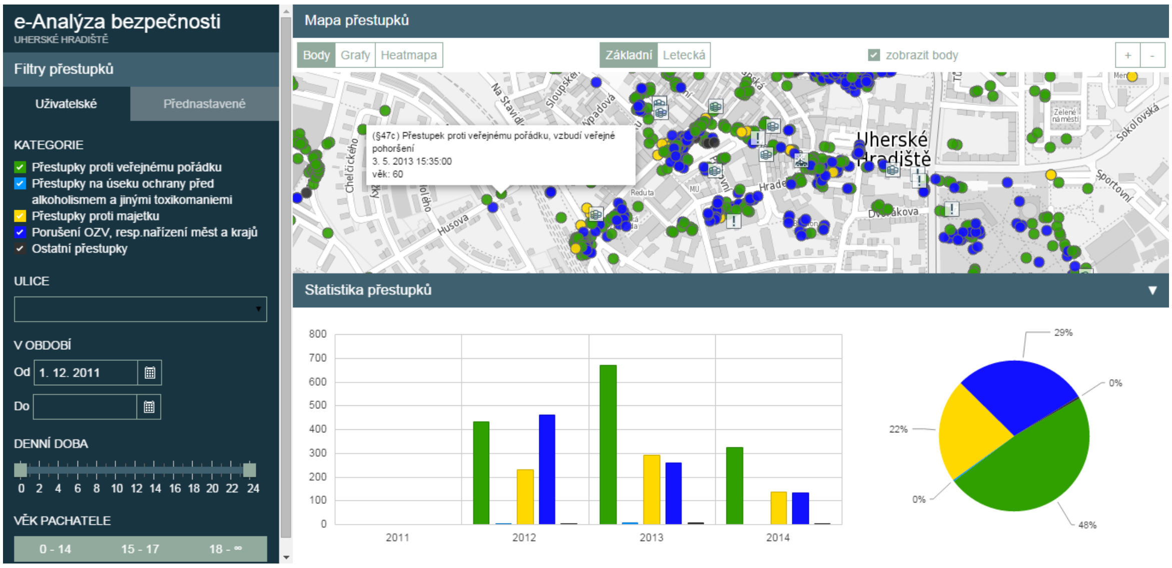


Figure 44: New version of “E-analysis of Security”

Source: City Police Force Uherské Hradiště 2015

The system shows different forms of visualisations of individual points/offences using colour points, graphs or a heat map, which shows clusters of points in hues of colours. Cluster analysis is a suitable form visualising street crime, which is a phenomenon occurring in an area.

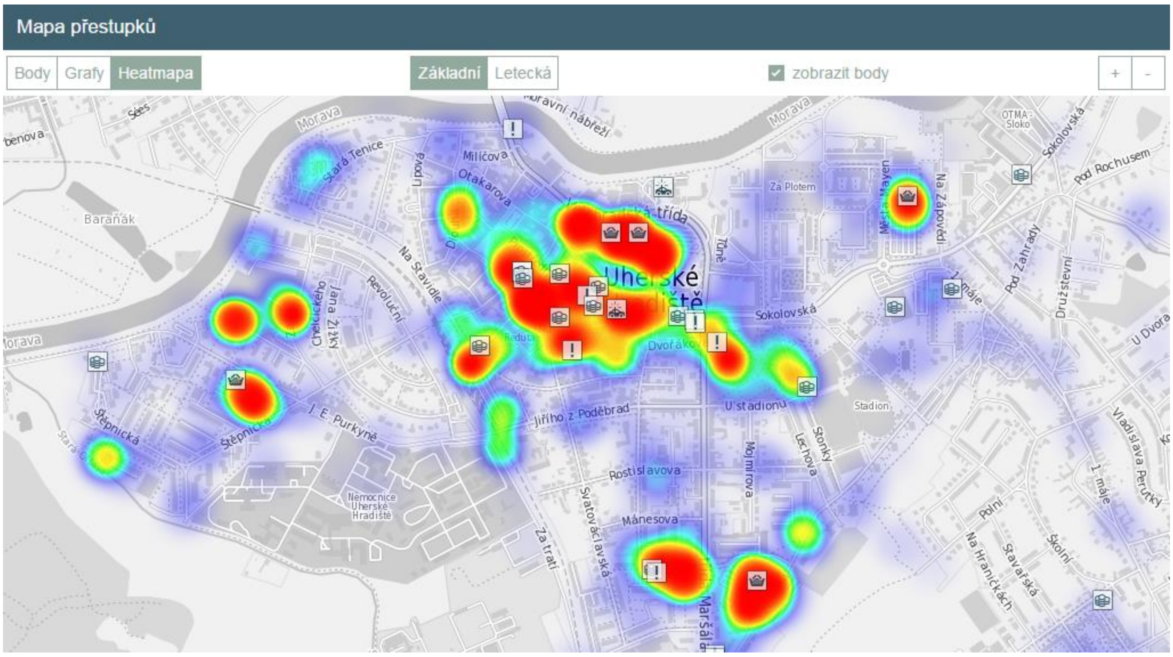


Figure 45: Heat map of street crime

Source: City Police Force Uherské Hradiště 2015

The system can also define temporal conditions for visualisation. Using the time of committing an offence, it is possible, for instance, to visualise criminal activity at nights. Users can also make use of predetermined areas where selected features can be observed. Based on these filters/parameters, the system generates a map with the required visualisation.

Another feature is the "offender's age", when the final volume of points can be specified by defining whether the offender is a minor, juvenile or adult. Beside the final map, the system also provides a statistic which reflects on the input parameters for a selection of points in a map.

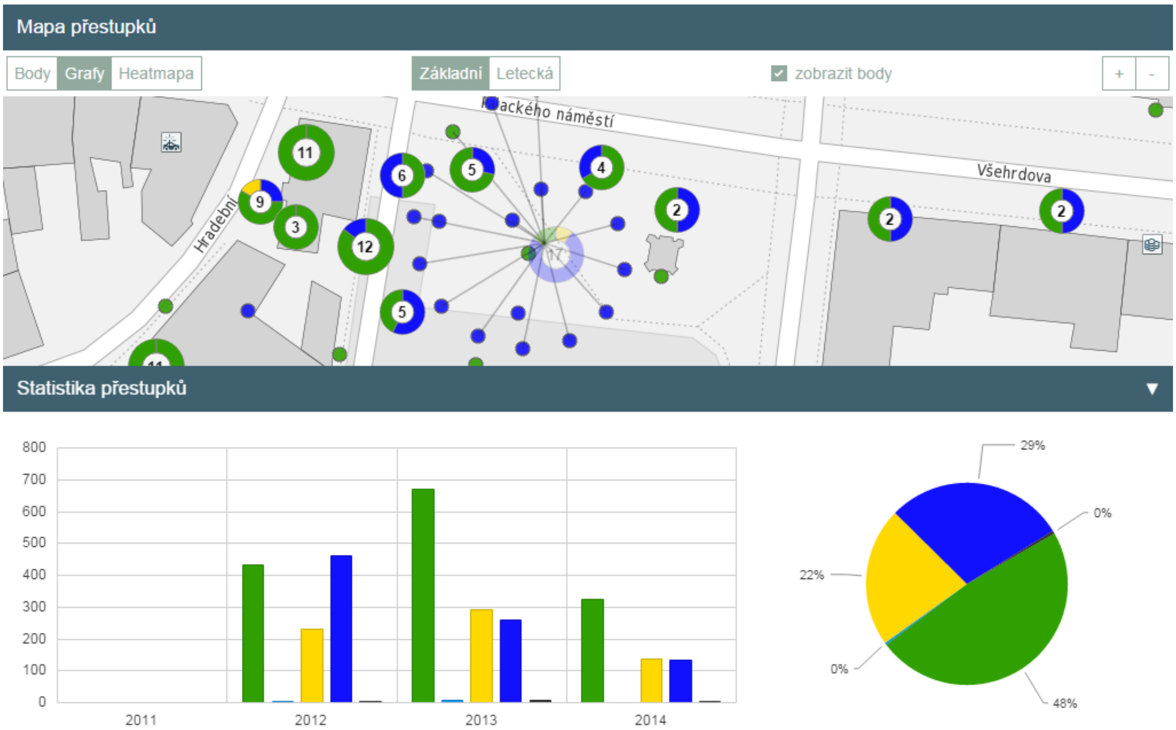


Figure 46: Statistics viewed along with a map

Source: City Police Force Uherské Hradiště 2015

Practical usage

In terms of the system implementation in the policing, the system and its application and functionality were introduced. The intuitively operated environment of the whole system made it unnecessary to carry out any specialised training. The only feature set was the level of access for individual users.

As regards legislative measures in implementation, no changes were necessary with the exception of an agreement with the National Police Force – the territorial division Uherské Hradiště concerning data exchange.

It is mainly the commander of the City Police Force who works with the mapping output, using these materials for planning purposes in conjunction with the National Police Force (the territorial division Uherské Hradiště). On a weekly basis, they coordinate resources in areas where the situation has deteriorated.

The expenses were covered from the Urban crime prevention programme (the Ministry of the Interior call). In 2011, the ministry provided a subsidy of CZK200,000 on the first stage, and the city expended CZK20,000. The second stage was subsidized with the same volume of money provided by the ministry, but the city supplied CZK100,000 from their resources. In the implementation of the solution in question, mainly current resources of the city were used, such as mapping server from the T-MAPY company, hardware, licenses, personal resources (GIS administrator).

An extending pilot project is to be executed in 2015, which will focus on testing of an application for the City Police Force in the field. Each shift will have a cell phone at their disposal, which should facilitate reporting offences in the system outside the police station.

Case study / application effects

The City Police Force does not observe to what extent the system contributed to crime reduction. The effectiveness is evaluated mainly on the basis of targeted patrols, which results in their higher visibility in problematic areas, thus increasing safety. The mapping portal also gives citizens the opportunity to have a novelty view on security in the city.

Emphasis is also put on mutual cooperation in data exchange with the National Police Force, which is based on an oral agreement but not legally binding. Therefore, should the management of the regional directorate of the Zlín region change, termination of the agreement with the City Police Force is imminent.

Summary

The project was carried out till the end of 2014 and launched in early 2015. With hindsight, it may be said that the database was created as well as a simple visualisation of data in a map during the first stage. The following stage focused on work with data and enhanced user-friendliness for both officers and the public.

The City Police Force Uherské Hradiště was one of the first law enforcement institutions to integrate crime mapping in their daily work and to provide public access to this information. What shows the benefits of this application is a number of prizes the city has been awarded for the system. The connection of the system of register and mapping shows a new view of the police work to the public.

8.1.7. Pardubice

The following information was obtained during a personal meeting with the director and the IS administrator, the City Police Force, which dealt with the usage of MP Manager developed by FT Technologies and the cooperation with the National Police Force.

Main sources of information:	Personal meeting held on March 9th 2015, at the City Police Force MP Manager manuals
Persons involved:	Head of the City Police Force Pardubice IS administrator of the City Police Force Pardubice

Information abou the city / region

Source: ESRI, basemap ArcGIS Online 2015

Pardubice, the regional city of the region of Pardubice, is situated in eastern Bohemia. According to data of the Czech Statistical Office, the size of the city is 82.7 km^2 with 89,693 inhabitants, as of January 1st 2015. It is the tenth most populated city in the Czech Republic, and along with the city of Hradec Králové, situated 20 km from this city, it is one of seven metropolitan areas of the country to implement integrated territorial investments (Město Pardubice 2015). This potential allocation of financial resources of the EU into this metropolitan area of Pardubice and Hradec Králové is one of the objectives of the cooperation of these cities.

The centre of the eastern Bohemian region is characterised by its convenient position of transport due to its connection to the D11 express highway, a one-hour train journey from Prague, an airport with mixed service, and 30 regular connections of public transport. The regional city is the industrial centre of the region of Pardubice, with particularly intensive branches of food industry, machinery, chemical industry and electrical engineering. Pardubice is also considered a cultural and sports centre, not only on the regional level (Město Pardubice 2015).

Basic Information about the organisation

Two law-enforcement agencies operate in the city: the National Police Force, represented by the Regional Directorate of the National Police Force Pardubice, and the City Police Force, whose directorate is located in the city centre. Both agencies cooperate closely with one another. For the purposes of the City Police Force, Pardubice is divided into four districts (1 – city centre, 2 – Polabiny, Ohrazenice, Rosice, 3 – Dubina, Pardubičky, 4 – Dukla, Svítkov). Based on the *Report on the Pardubice City Police Force activity for the year 2014* (Město Pardubice 2015), the agency employed a total of 95 officers and other 13 civil employees at the end of 2014. The City Police Force has several specialised departments, among which mounted police can be found.

Initial situation

Since 2014, City Police Force has been localising offences with smart phones and consequently producing crime maps used for a more effective scheduling of shifts, patrols and crime prediction in the city.

This operation is carried out by the MP Manager software, produced by the company FT Technologies. It is a system created for local law-enforcement agencies for organising their schedule defined by the Local Police Act 553/1991. MP manager is an online application used for the creation and administration of electronic information about event registered by the City Police Force.

The expected benefits are:

- increased work effectiveness
- savings in human resources
- planning of preventative measures
- more efficient disclosure of repetitive patterns
- online screening
- a complex information system along with online database
- localisation of events

- tracking down patrols
- processing of statistics and work schedules.

Projects undertaken

Cooperation of the City Police Force and the National Police force, based on coordination agreement, gives rise to crime mapping in Pardubice, which focuses on offences in individual territories. The aim is to facilitate coordination of both law-enforcement agencies, thus increasing higher safety in the city streets.

Regional directorate of the police is accessed to the MP Manager system, which has been used by the City Police Force since 2014. Due to this cooperation, operation officers of the regional directorate are aware of the position of both vehicles and individual officers of the City Police Force in the streets, which can be made use of in urgent cases. By contrast, the National Police Force provides anonymised data on locations of offences in Pardubice to the City Police Force. Besides this information, the system also provides a list of points of interest, such as bars or gambling houses. Data is updated by both the National and the City Police Force. At the same time, City-Police-Force officers have mobile devices (32 tablets and 60 smart phones) at their disposal for collecting data in the field.

Case study / application

The main feature of the software is that data is fed into the system by all officers, mainly patrols in the field, since these are most exposed to the events, be it offences or general situations. Part of the data transferred to the system are coordinates in the WGS84 system or photos/videos from the fieldwork. This data becomes immediately available for further process from both desktop computers and mobile devices. Localisation is also carried out using numbered poles of street light. These numbers serve as supplementary information to GPS localisation, which can be inaccurate at times.

Police officers also report all offences, not only those they investigate. As a result, the officers are acquainted with events happenning in the area but that have not been tackled, which may contribute to disclosing unreported crime.

Functions of MP Manager include:

- Feeding in information about events outside police station
- Verifying number plates in the online database of stolen motor vehicles, administered by the Ministry of the Interior of the Czech Republic
- Listing all types of situations
- Creating user groups and setting up their rights to access
- Entering and observing processes in real time
- Evaluating the work of individual officers statistically
- Registering issued tickets
- Searching based on specified parameters
- Creating datasets
- Accessing the system remotely (from business trips, home)
- Observing the users' steps at the system level.

Main part of the application for an officer in the field is the module "event administration". Among the basic items the application registers belong:

- The department dealing with a specific situation

Figure 47: MP Manager interface – selecting departments

Source: FT Technologies 2015

- Type of event, which defines whether a given situation is a felony, misdemenaour or another type of event. Each type is further specified. There is also the option to mark the event as extraordinary.

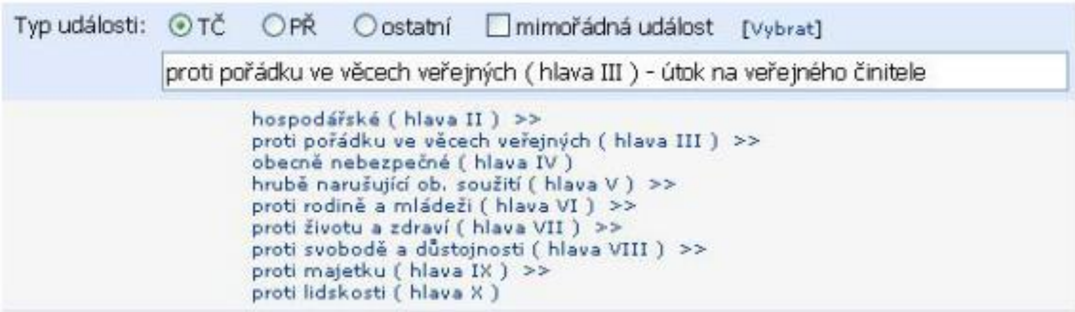


Figure 48: MP Manager interface – selectng types of incident

Source: FT Technologies 2015

- Authority used in dealing with the situation

Figure 49: MP Manager interface – selecting authorisations

Source: FT Technologies 2015

- The manner of solving a situation.

Figure 50: MP Manager interface – selecting way of solving a situation

Source: FT Technologies 2015

It is also possible to track down the route of all patrols, which can visualise whether an officer was moving and whether anything happened at a given time.

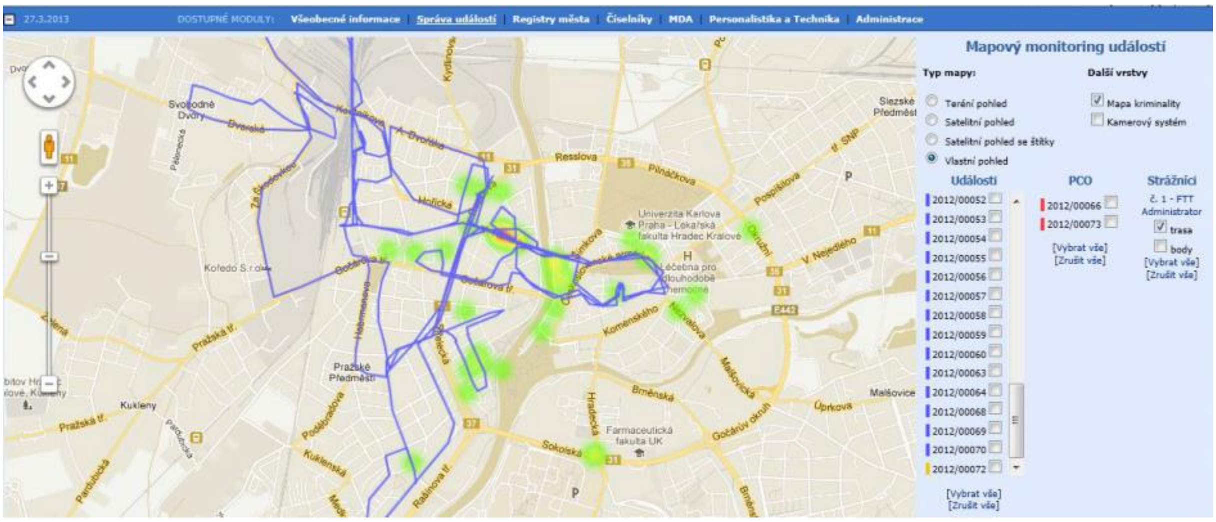


Figure 51: Officer's route

Source: FT Technologies 2015

MP Manager also enables creating certain types of crime predictions through visualisation of hot spots. Prediction is a function that makes use of police data acquired in the past. This data is calculated via algorithm developed in cooperation with a specialised facility of the Faculty of Natural Sciences with Palacký University in Olomouc. In predictive function, the application lists the following items: *name, filter, number of years back, number of predicted day, type of calculation, periodicity of automatic launch* and *description*. On the basis of available data, it is possible to assume that the principle is based mainly on statistical evaluation of historical data on crime.

However, these predictions can not be used due to shortage of historical data. Police officers can make use of data acquired from 2005 since; however, only of certain offences. Complete data is available only from the year 2014. Officers consider the process of mapping as a sort of prediction serving as a suitable material for decision-making – the *identification* of a problem.

On the other hand, MP Manager has a limited range of GIS functions/analyses (Heat maps only) and the work with maps is quite troublesome, mainly due to the fact that it fails to provide export of selected layers and mapping compositions. Operation officers are therefore forced to print screens and connect these in a graphic processor.

Figure 52: Heat mapy – concentration of homeless people in the city

Source: City Police Force Pardubice 2015

The administration of the City Police Force system is provided by the information-system administrator, who secures the access to databases along with the system supplier.

Practical usage

In terms of the implementation of the system, the application and its functionality were introduced in cooperation with the supplier. In the course of utilisation, trainings are carried out, focused mainly on proper entering of data into the database as no integrity limitations are in place. Also, levels of access to the system were set up for individual users by the administrator.

No legislative measures needed to be taken during the implementation, with the exception of the coordination agreement with the National Police Force and a minor change to the duties of officers in the city centre.

The maps, both the outputs and supporting materials, are to be primarily used by police management. This information is also vital for district mayors since it enables them to respond to and confront citizens’ complaints about the location and real position of patrols observed with the system. Moreover, the system enables the officers to scrutinise crime in the given area, resulting in more targeted preventative measures. Last but not least, the data is of political interest.

Concerning project funding, the implementation was included in the city budget (CZK480,000) in 2010. Due to the purchase of MP Manager server licence, everything was located on the server of the city hall, therefore no additional resources had to be expended on hardware. The licence is unlimited in with respect to the number of users. Operational costs of the system included quarterly fee of CZK20,000 and extra programming hours should the need arise, which can be transferred to another period.

Contributions of the case study / application

The main benefit is seen in the elimination of paperwork as officers spend more time in the streets. The aim is therefore a more efficient planning of resources: when, where and who should be dispatched, the number of patrols, time limits.

Another feat attained was the creation of an interconnected database of offences as a shared datasource of the National and the City Police Force.

Crime mapping has had a markedly positive feedback from the public.

Summary

The output simply shows where anti-social behaviour is most frequent or where used syringes are most often found by the officers. Other reports graphically depicts spots of the most frequent occurrence of public-order related offences. So the approaches provides a detailed, joint overview of offences and therefore objective information about the safety in the city streets and boroughs

Crime mapping has been gradually meeting the expectations of the police management, and Pardubice citizens can feel safer. This feeling should be even strengthened due to a project-related recruitment of new officers.

8.2. GREAT BRITAIN

Source: ESRI, basemap ArcGIS Online 2015

This subsection deals with examples from Great Britain which describe experience in crime mapping, analysis and prediction from **the Metropolitan Police London, Greater Manchester Police, Kent Police**, and **Cambridgeshire Police**. The subsection concludes by providing a description of a national solution of the **Home Office** to mapping and provision of information about crime to the public.

Main sources of information:

Personal meetings held on:
April 7th 2015 - Kent Police headquarters
April 8th 2015 - Metropolitan Police London
- Home Office
April 9th 2015 - Cambridgeshire Police Headquarters
April 10th 2015 - University College London
- Greater Manchester Police
Internal documents provided by the representatives of the visited organisations
Websites:
https://www.police.uk/metropolitan/00BK17N/crime/
https://www.police.uk/metropolitan/00BK17N/crime/stats/

Persons involved:

Commanders-in-chief of the individual police departments
IS administrators of the police
Director of the department of Geographical Information Science UCL
UCL university workers

8.2.1. London

The series of meetings in London began with the **Metropolitan Police London**, which has a long-standing tradition in analytical work using GIS tools. Apart from that, this institution also carries out projects leading to the implementation of the most suitable tool for predictive analysis for their conditions. Among other examples listed in this study, this approach is highly unique. Another organisation visited was **University College London – Department of Security and Crime Science**, which is a distinguished global academic institution specialising in applied criminological research. Studies by researchers from this the college serve as the basis of numerous processes, products and solutions in police forces all around the globe.

Information about the city/region

Source: ESRI, basemap ArcGIS Online 2015

London is the capital city of the United Kingdom of Great Britain and Northern Ireland. It spreads on an area of 1,572km^2 and its population is 8,538,689 (Office for National Statistics 2015). Including suburban areas, whose total density is more than 16 thousand km^2, the number of population is 14,031,830, which makes London the largest metropolitan area and one of the most populated areas in Europe (Eurostat 2014).

London population is ethnically diverse, with a large number of races and ethnic groups from the whole world. From the viewpoint of security, this constitutes a whole host of risks. The London area is characterised by a large population density and an outstanding traffic availability. The city is one of the most significant economic centres in the world and a business, residential and tourist centre of

Great Britain, visited by almost 30 million tourists every year (London Datastore 2015).

London is divided into 32 locally governed boroughs. City of London is an independent administrative unit, administered by a historical council called the Corporation of London. These local administrations and strategic planning is coordinated by the Greater London Authority. The Metropolitan Police London is responsible for police surveillance of the 32 boroughs, and the the City of London Police for the City of London (London 2015).

Information about the organisation

The Metropolitan Police London was established in 1829 and is one of the largest police forces in the world. There are 55 thousand members of staff, of whom 31 thousand police officers, 13 thousand employees, 2,600 supporting community police officers, and 5,100 voluntary officers with limited authority, who serve the city in terms of the Employer Supported Policing programme, sponsored by the Metropolitan Special Constabulary (Metropolitan Police 2015).

The Metropolitan Police London and the supporting units provide security for more than seven million London inhabitants and other millions of commuters to work and visitors in the central London (Metropolitan Police 2015).

Initial situation

Data of the Metropolitan Police London shows that London has the highest crime-rates compared to other areas in England. Almost 50% of reported crimes in London belong to the following categories: burglary, robbery, mugging, petty thefts, property crimes and vehicle-related offences (POLICE AND CRIME PLAN 2013-2016).

Crime mapping, spatial data analyses and other related tools are no uncommon operations in Metropolitan Police London. Specific types of spatial analyses and analyses of criminogenic data have been used for years. The team of analysts comprises nine specialists who deal with data analyses, commencing with cooperation on mapping and ending with the development of other supporting tools. They use Big Data in their work, striving to automatise this process while using systems of intelligence and other IT resources.

Inspiration and initial information the Metropolitan Police acquired in crime prediction and analysis was from Kent Constabulary using software developed by the PredPol company. At the beginning, when the police started seriously considering implementing predictive analysing into their work, this commercial software was considered to be purchased. However, they realised that giving preference to a single product without trying out others was an inappropriate step. Apart from this, a system that worked in the USA did not necessarily need to adaptable in the conditions of Great Britain.

Projects undertaken

The Metropolitan Police London decided to contact different companies to foster the intended project called “High Crime”. Since developers of modern analytical tools and crime predictions rarely publish details about algorithms and mechanisms of their products, 12 companies capable of providing a solution to given requirements of the police were contacted. Based on an evaluation of the provided task, three companies were chosen that came up with a predictive solution best suited to the conditions of the Metropolitan Police. The task comprised a number of specific requirements for functionality, such as the system of reports for different shifts. Not all companies were able to fulfil this task. Hence the project was launched with the **PredPol**, **HunchLab** and **Palantir** products.

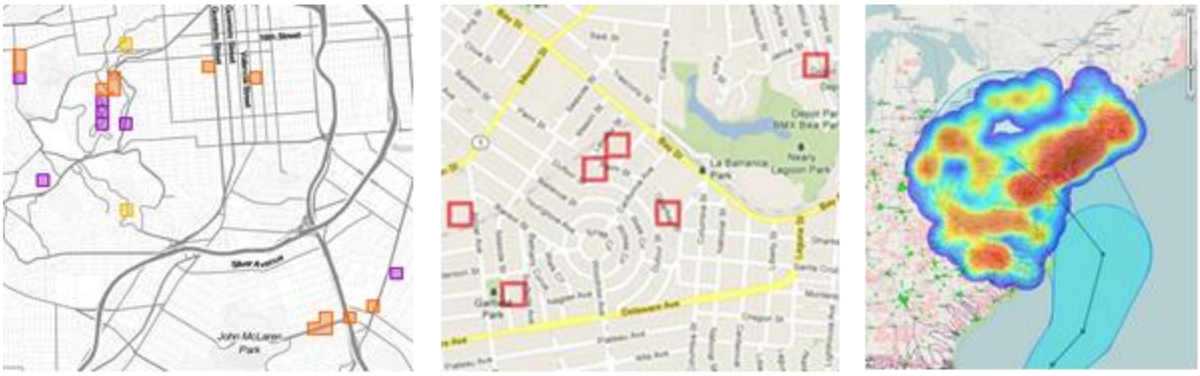


Figure 53: HunchLab, PredPol and Palantir output

Source: ACCENDO – Science and Research Centre 2015

As mentioned, the Metropolitan Police have a team of analysts who create materials for management, using tools for statistical data processing, spatial analysis and visualisation. The team thus comprises data analysts, GIS specialists and – due to the development of supplementary applications – is also supported by programmers.

Case study / application

All selected products are tools for analysis and creation of crime predictions which were implemented by police forces in a number of cities in the USA. Their algorithms are based on methods developed by prominent scholars in criminogenic analyses and modern mathematical and statistical methods. The High Crime Project was originally set to last 18 months. Complications, however, caused a delay in schedule. The testing period was consequently moved to July 2015, as opposed to the originally considered April. Currently (August 2015), no results are known about the testing period, nor about the availability of the results.

Testing of the selected products was divided into different boroughs of London. Due to an evaluation under way, precise assignment of products to boroughs is still classified. Based on the 18-month experience of the Metropolitan Police in terms of the High Crime project, current knowledge and processes are described.

The Metropolitan Police London and their units involved in the project and the following usage of the final product perceive predictions as a means to achieve situational awareness within a territory they are responsible for, to create a mutual synergy among patrols. The aim is to bring new technologies into fieldwork in order to inform the police officers about what types of crime and areas of cities they should pay increased attention.

The predictive models used work with information such as date, place, time and type of offence. This is referred to as *basic data*. In the course of the project, no other types of data were provided to the system developers by the Metropolitan Police. Depending on the possibilities of their software, commercial suppliers can also work with publically available data, such as weather conditions or demography, provided by the statistical office. However, it is often mentioned that system developers are reluctant to implement supplementary information in their software due to a negative impact on the final output. As regards the wider spectrum of data, the Metropolitan Police London made an exception in the case of hate crimes, which they would like to focus on in the future.

Used are also methods of geographic profiling, which the police use to evaluate serial offences and other related events.

The solution implemented in London considers three latest weeks of basic data, and predictions are made for 24-hour periods. However, as regards specific tasks, such as predictions of break-ins or violent offences, predictions are generated for each shift. Analysts consider data on offences over the past five years. Other patterns can also be observed, such as seasons or the time of day when the sun starts setting.

Algorithms are adjusted for different offences. Predictions are therefore more informative compared to hot spots, which enables the police to be at the right place at the right time, focusing not only to where they should be but also what they should do. Based on the outcomes, the police can operate in the defined areas, where they change their movement in specific time periods, usually every two hours, which would be impossible due to time constraints and limited resources with traditional analytical methods. Despite this planning of resources, it is stressed that even these modern processes and usage of tools is dependent upon the opinion of an experienced police officer.

Apart from the tested predictive tools, the police are considering using information acquired through social media by using tools for key-word searching and their combinations. Such tools are able to localise users' contributions with given content and thus to define potential rise of emergency situations. In numerous parts of the city, various communities are concentrated, and the police are striving to use their limited resources as effectively as possible by using this way. Due to social media, they can focus on these areas prior to any incidents as well as observe where an emergency situation is arising and to deploy additional forces.

Another type of technology used is CCTV. As there are thousands of surveillance cameras around the city of London, interactive mapping environment is a suitable form to monitor their locations using a single tool, be it a private or a public video camera. The system also provides supplementary information, including contact information of the camera owner. Spatial data of the cameras is held by local authorities and were transferred from table-based-data into the tested system. What is therefore apparent is cooperation with other actors within the territoriy, who can have a positive impact on the public safety.

In terms of research and development of new methods, the police cooperate with scholars who, however, are obliged to abide by strict safety conditions for work with data. A secured specialised database has been created for this cooperation with univerities for transferring and storing data.

Practical usage

Predictions allow commanders of shifts to move patrol officers to right places at the right time. Despite sophisticated predictive systems, field work and coordination require tactical preparedness of the forces. Formerly, hot spots and designated areas were checked by police officers, who wore high-visibility jackets. It was assumed that this prevention by visibility may result in reduction in crime. Active participation of the police focused on a specific target, however, is far more effective than what they wear. So as to focus on particular issues and effective prevenetion, teams of analysts began working on materials adjusted to specific demands.

The Metropolitan Police London are responsible for a spread area that is, due to its population density, so risky that an optimal way of tackling crime would be possible on only 2% of the total area of the city. For instance, 13.4% of burglarised residential areas are found in the 2% of areas in question. It is an active environment, which is connected with crime-rate in the vicinity. Therefore, an appropriate amount of resources has to be deployed in these areas, which is facilitated by the analytical approach. To evaluate the impact in these areas, it needs to be verified whether police officers were present in those places and for how long, along with defining whether there is a correlation between crime reduction and predictive tools. A tracking system is used to analyse officers' positions, which sends out a signal every five minutes in the case of personal radios, and every 45 seconds in the case of GPS, to record the position of a patrol, which is automatically indicated in a mapping appication. Operational officers thus can trace patrols' movement in time, or (using spatial processing of historical data) analyse their movement back in time, which enables them to evaluate the correlation between a patrol's presence and a reduction or an increase in crime in the given areas, and to come to particular conclusions.

The Metropolitan Police London are testing the system in conjunction with the Palantire company. The area of London can be observed by seven types of offences. It is also possible to observe the time frame when the peak crimes occur. Heat maps can be used on the seven defined offences. However, the police wanted to limit these seven types to three main areas only, which would be efficiency threshold from the viewpoint of resources. One operation realised was focused on violent offences in the streets of London.

The areas of focus are visualised on a grid with a defined size of one square: 250x250m. This size was selected as one police officer can go through this area in 15-20 minutes. Size of the square can be set, however. Based on experience, the Metropolitan Police London use the size 250x250m.

The tested system places high demands on intuitive controlling of the application. This does not concern predictive analyses only, but also a user-friendly visualisation of data and statistics, which will be used by commanders and operational officers of the Metropolitan Police. Using basic operations, they will be able to search information, define the search-radius in a selected area, also back in time. Therefore, they can create their own analyses during their ordinary activity, which should result in a more effective work. They will be able to create their own overview of the crime rate, without involving an analyst, who may concentrate on more specific tasks.

Case study / application effects

Since the High Crime project has not been finished yet, no evaluation of the results is available. Currently (August 2015) it is not known when the results will be published. Therefore, no specific contributions of the tested tools are described.

In terms of this project, police officers also drew from the experience of the Los Angeles Police Department. It is, however, necessary to realise that the Los Angeles Police had not carried out any traditional analyses prior to the implementation of predictive system, and the application of their system in their work was a major change and a milestone in their analytical work and spatial analyses. Since traditional analytical methods and spatial analyses were carried out in the Metropolitan Police London before, no dramatic changes took place and most probably will not take place as regards crime rates. Basically, it is possible to say that the predictive system in question brings results similar to the ordinary police work, but can additionally save analysts' time of their routine work.

Los Angeles Police Department enjoyed a considerable success in analysing and predicting crime, and similar results were shown in the work of the Metropolitan Police London. Politicians tend to bring up this matter who are willing to expend considerable amounts of money on predictive systems. Still, representatives of the Metropolitan Police London try to be considerate in this respect, explaining that local conditions and approaches towards investigating crimes in the USA differ widely from the United Kingdom.

Another challenge of the project group was to overcome the officers' distrust, who, showing misunderstanding, refused to work with the systems. This obstacle was overcome eventually, however. What was problematic was a certain cultural barrier of some officers, general cynicism and unwillingness to do other activities than they were used to doing, although they were deliberately allocated in selected areas.

Summary

The Metropolitan Police London believe that the project will have a positive effect, and police analysts will free their time which they could devote to specific analyses. The High Crime project gave rise to other activities which result in an enhanced patrol monitoring and automated gathering and processing of data on crime in real time. Spatial analyses facilitated profiling of selected problematic areas, and patrol commanders focus on specific tasks handed to officers.

Police officers in the streets keep their behaviour, as they are unaware of what is hidden behind predictive analyses and algorithms. This is not even their role. The aim is to answer the question whether crime prediction, i.e. outcomes of analyses, function in an operational setting. The question of the ex-post evaluation, which will be carried out in the mid- or late 2015, is also the financial burden of all three tested products and the return on investment, which will be an unavoidable part of the implementation process.

8.2.2. Greater Manchester

Meeting representatives of the Greater Manchester Police was productive mainly from the viewpoint of a unique solution. To reduce crime, the police carried out a research project which led to an implemenation of methods with positive results without virtually any financial costs.

Information about the city/region

Source: ESRI, basemap ArcGIS Online 2015

The population of 2,723,479 (Eurostat 2014) makes Greater Manchester the 18th most populated metropolitan area in Europe. It is a metropolitan county of Great Britain situated in the north-eastern part of England. Due to its size, 1,276 km^2, it is one of the smallest counties, which in relation to the large population results in a high population density of more than 2,130 inhabitants per 1 km^2.

One district of this county is **Trafford**, with its population of 232,458 (Office for National Statistics 2014). It is found in the south of the county, neighbouring the cities of Manchester and Salford. The city has a relatively high number of population of Asian descent (5.4%, according to the 2011 UK census). Trafford comprises the towns of Altrincham, Partington, Sale, Stretford and Urmston, and is connected to the Manchester metropolitan transport line, which provides a good connection to the regional centre by both public and private means of transport. Towns of the district are an important part for Greater Manchester as a whole, regarding both work opportunities (low unemployment rate) and leisure time (Trafford Council 2015).

Information about the organisation

The areas of Manchester and Trafford are protected by the Greater Manchester Police, which is divided into 11 divisions, one of which is focused on Trafford. As to December 2014, this division employed more than 370 police officers and other employees (Greater Manchester Police 2015.

Initial situation

Trafford is a demographically diverse area. From the crime perspective, it is one of the most problematic areas in the jurisdiction of the Greater Manchester Police. The mixture of population from various social groups is one cause of high crime rate and a very high rate of property crime.

In 2010, the Greater Mancheste Police decided to apply new measures in fighting crime by cooperating with experts on crime, whose research results the force commanders decided to implement. Prominent scientists from London UCL Department of Security and Crime Science were contacted. This launched a project focused on a specific offence: burglaries.

Projects undertaken

Innovative approach using scientific knowledge is based on predictive analysis and the understanding of where a particular crime takes place, followed by a preventative action. The key method applied is Near-Repeat Victimisation, which takes into account the probability of crime occurrence in a given place in a specific time frame, with dependence on the time of a prior crime. Research shows that within three weeks and the distance of 400 metres from the prior crime scene, there is a high probability of reoffending. This concerns targets found in the vicinity of the original target which are victimised shortly after the original offence. (For more information about this theory, see 6.2.3.)

Figure 54: Near-Repeat Victimization principle

Source: Greater Manchester Police, 2015

In this situation, the police had to focus on the prerequisites for crime. Therefore, special maps were created which visualised prior thefts in Trafford. Apart from mapping of these historical events, this approach aims to predict locations where crime will occur in the future and, consequently, to allocate resources in order to minimise the risk. The maps were created with the use of the *Near-Repeat Calculator* and visualisation tools. Firstly, round buffers were created around the formerly located burglaries of 400m in radius. In relation to the time from the specific incident, each circle was automatically changing colours accordingly. For instance, a blue circle indicated that the place was burglarised three weeks ago, a yellow circle two weeks ago, and a red circle indicated the incident occurred over the past week. Intersections of red and yellow buffers show locations with the highest occurrence probability. Also, a temporal aspect was included in the maps, i.e. the supposed most exposed daytime and day of the week to a burglary. These specialised maps were created three times every day, and the data used in the analyses were no older than three days before their use. The police worked with data on offences only. They also had georeferenced socio-demographic data at their disposal, which, however, were not made use of in this project.

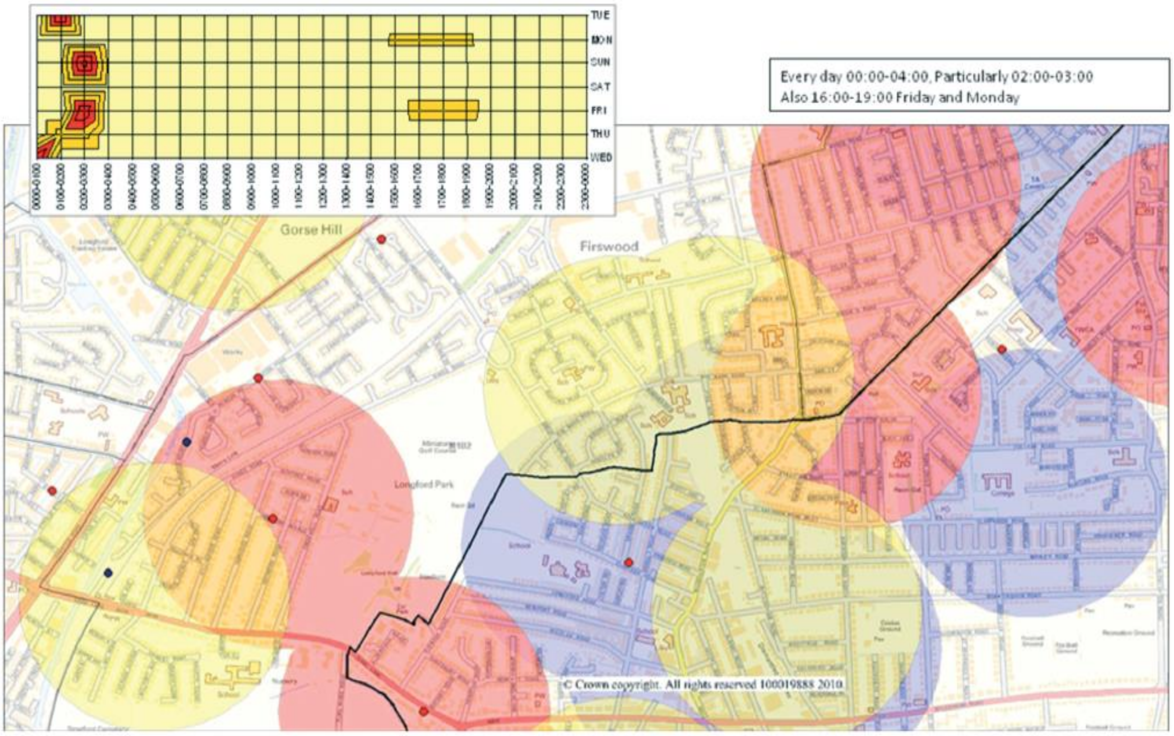


Figure 55: Analysis using buffers

Source: Greater Manchester Police 2015

Case study / application

A vital part of the application of scientific knowledge, analyses and prepared maps was their practical usage. These materials were distributed to police teams, and officers were ordered to spend most of their shifts in the critical zones, paying attention to burglaries and aspects leading to them. It was set as a primary goal, which is also supported by the engagement of air police forces, which could identify potential threats from the air, providing further support to officers in the streets. Other partners involved in this activity were, among others, social services, driving-school instructors or fire departments, who were asked to carry out frequent observations in the critical areas in terms of their usual duty in the streets of Trafford. The output was provided also to authorities, schools, for the sake of information and enhanced prevention.

In 2011, the project was evaluated by specialists from the University College London, which was followed by a number of recommendations based on the feedback. A 4% probability of burglary was found, which increases to 18% were the house to have been burglarised already. Premises burglarised twice stand a

33% probability to be re-burglarised. In premises that have been burglarised three times, the probability rises to 44%, and five times to 50%. These figures clearly show the pattern and the threat of revictimisation of houses and their vicinity.

Practical usage

Using spatial data analyses, the police located 61 address points in Trafford with a high risk of revictimisation. In these areas, patrols were strengthened and GPS tracking system applied. What was necessary was to hold police officers responsible for the given area and track their movement. It may have happened that a police officer was patrolling on one place where, at the time when he/she was being allocated to another area, a crime was being commited. The question of responsibility is, nevertheless, why the operational officer had not replaced the police officer in question. The officers' movement can also be traced in a mapping application, evaluating whether they spent a necessary amount of time in the critical area. After the outcome had been evaluated, shortcomings were found and street patrolling optimalised.

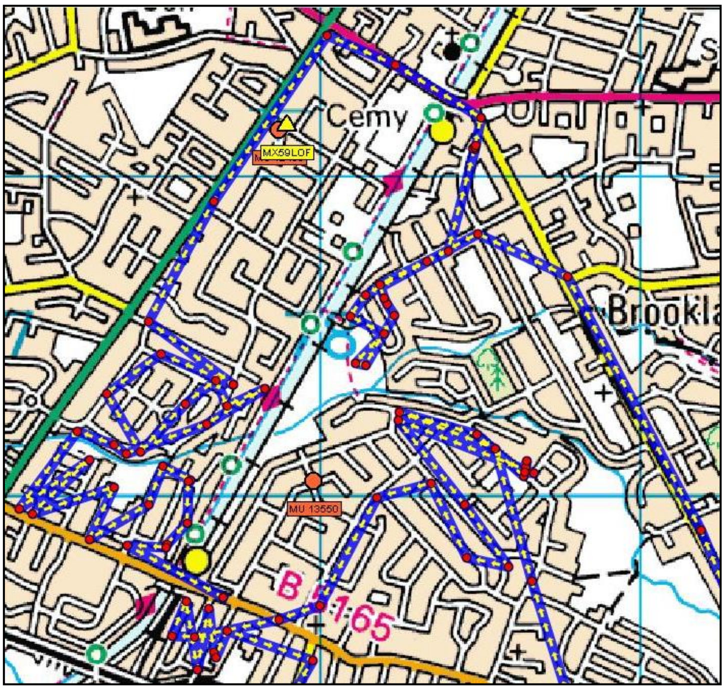


Figure 56: Tracking police officers

Source: Greater Manchester Police 2015

The police presence in the streets is not the only measure that has been newly implemented in the police work on the basis of the suggestions by specialists from the University College London. In connection to burglaries, preventative measures also included a method called “cocooning”, which is based on a personal visit to surrounding houses in the area of the initial crime. It is a standardised format of police work. The visit takes place soon after two houses in the surrounding area were burglarised. In the upcoming 24 hours, officers visit five addresses behind the house in question, ten houses in the neighbourhood across the road, and eight houses adjacent to the house in question on both sides.

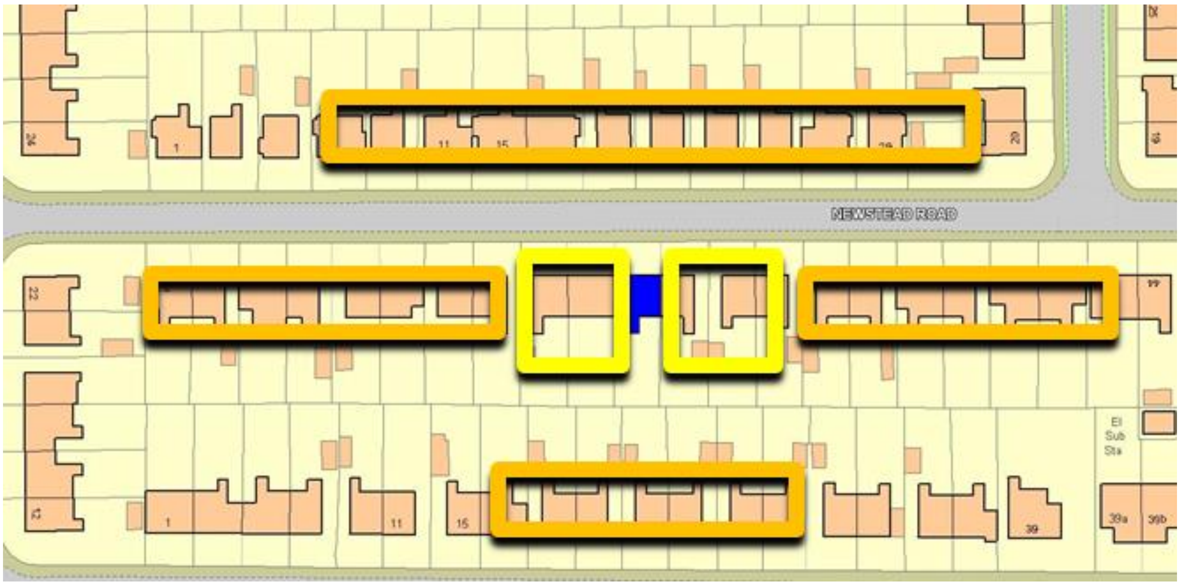


Figure 57: “Cocooning” method

Source: Greater Manchester Police 2015

Police officers warn house owners about the incident and recommend safety measures (e.g. what to do in the upcoming days, contacting other neighbours who are not at home at the time of speaking). This strategy also needs to adjust to conditions, such as winter time, when the sun sets earlier. In some cases, it is also necessary to understand the issue of frequent burglaries in a given area from the local perspective and to recommend some preventative changes, such as improving visibility in the surrounding of the house through adjustment of green areas.

Figure 58: Preventative measures around houses

Source: Greater Manchester Police 2015

Case study / application effects

The strategy used in the city of Trafford for analysis and fight against burglaries is applicable also for vehicle thefts. Since offenders attempt to enter parked cars, reduction in burglaries has an impact on this crime, which showed a decline by 29%, as well.

Evaluation of project results was positive. The year 2012 saw a 38% decline in burglaries compared to 2010, when these techniques were implemented. Nationwide, this offence reduced by 8%, i.e. 471 houses protected against burglaries over the past two years, which brough a decline in costs used for damages of £1.85m. Counted per 1,000 inhabitants, the number of burglaries dropped from 13 to eight people. What was a great surprise for the project team, however, was that reduction in burglaries did not cause an increase in another type of crime committed by felons committing this type of offence.

Since the implementation of the “cocoon” method, the police have visited 16,500 addresses. This new approach led to a decrease in the number of repeatedly burglarised houses in Trafford from 110 to only 30 per year, which accounts for 2% of repeated offences, compared to the national average of 15-20%.

Interviews with the victims and potential victims have, besides prevention, a secondary effect. Personal contact and interest of the police to work with the citizens shows the public understanding of the police work and evokes the feeling of safety and trust in police forces. Public trust increased by 7%, amounting to 97%.

A similar project which used identical methods was implemented also in West Yorkshire, where the number of burglaries was reduced from 79 per 1,000 inhabitants to 41 in critical areas over eight months. In total, the number of burglaries was reduced by 65% in critical areas.

Among other projects which applied the method of repeat victimisation was the Kirkholt project. This included the city of Rochdale (close to Manchester), which was selected on the basis of a high intensity of burglaries. The project consisted of two parts with the following goals. In the first stage, the aim was to set cooperation between agencies for sustainable crime prevention and reducing residential burglary. During the second stage, crime-reduction strategies were to be implemented, including initiatives to reduce motivation to offend. The programme comprised the following parts:

1. *Target removal* (e.g. adjustments to electricity/gas prepayment meters)
2. *Natural surveillance* (residents of victimised houses and local residents were watching out for suspicious activity in the neighbourhood)
3. *Target hardening* (victims and residents in the vicinity were offered security upgrades to decrease the chances of a repeat victimisation of their residence)

After the first stage, the number of burglaries fell by 40%. Comparing the year prior to the programme (1986-87) and the last year of measuring the results in terms of the project (1989-90), burglaries dropped by 75%.

Summary

The methods used by the Greater Manchester Police in Trafford and other British cities are highly effecteve in tackling property crime, which is supported by provided statistics. Experts have calculated that patrolling based on repeat victimisation, i.e. targeted patrols in areas facing re-occuring crime, is 9x more effective than random patrolling. Moreover, positive results were achieved without any costs. Factors contributing to this fact are: the allocation of individual resources, and employment of highly effective, straightforward methods of criminological analysis. This example demonstrates the benefit of analysts, whose work can produce positive results, without purchasing costly crime-prediction tools. Another positive impact of the project perceived by the Greater Manchester Police is an enhanced response to crime.

8.2.3. Kent

Kent Police is a case in point of a British police force which has been using the predictive system PredPol. It is therefore a customer which implemented this tool in conditions with a different social setting from the USA cities, which are the usual customers of the company PredPol. Police Kent combines predictive tools and traditional GIS and data analysis.

Information about the city/region

Source: ESRI, basemap ArcGIS Online 2015

Non-metropolitan, ceremonial and traditional county, Kent is a geographically diverse area with urban as well as rural areas. It is located in south-eastern part of England. Its shoreline is 350 miles long. It is an area popular among tourists, which is also partly connected with fluctuations of population. The total size of the area is 3,736 km^2. Kent partially borders the metropolitan area of London, which has a negative impact on crime of in the surrounding areas. The position of Kent between London, a number of significant manors, ports, transportation hubs and a good availability of transportation cause the fluctuation of extimated 16 million people, who go through Kent (Kent Police, 2015). This fact is also a cause of several criminogenic phenomena. The most significant metropole of the county is Maidstone, with a population of more than 160 thousand. Kent population has risen by 2% since 2011, to current 1,510,354 inhabitants (Office for National Statistics, 2015). By 2019, it is expected to rise by other 3%. Different communities live in this city, including a large group of Muslims, Asians and immigrants from Eeastern Europe, which poses a threat from the viewpoint of citizen cohesion and weakened stability of safety.

With its connections with London and Essex, Kent has a strategic position in transportation. An important point in the transport network is Dover, a port used by large numbers of tourists and visitors to Great Britain. In Folkestone, found nearby, is a terminal of the Eurotunnel, which connects Great Britain with continental Europe. Kent is an important tourist centre with various sights. The tourism industry is one of the factors contributing to safety risks (Kent County Council 2015).

Information about the organisation

The force to watch over more than 1.5m residents is Kent Police, which has 5,500 officers, employees and voluntary officers at its disposal. In collaboration with Essex Police, Kent Police is in charge of the IT management and the directorate for serious crimes. From the territorial perspective, Kent Police is divided into a Northern, Eastern and Western division, which are further divided into 13 districts. Headquarters of the county is located in the city of Maidstone, situated in its centre.

Initial situation

Annually, Kent Police deals with approximately 800,000 reports, which eventually mean about 100,000 recorded crimes a year. According to data from June 2014, Kent Police boasts 86.7% clearance-rate, which is the best result of all police forces in the England. The biggest challenge in implementing new strategies for Kent Police was the rise of offences related to sexual motives, cybercrime, child trafficking and to physical threats.

Over the three past years, the management of Kent Police have been struggling with issues related to financial cuts, reducing the £300m budget by £47m. As the major part of the budget is allocated on staff, these reductions resulted in numerous limitations associated with laying off 400 officers and 600 employees. What exacerbates the situation is the fact that another round of cuts in spending is expected in the following years, reaching as much as £60m.

The dramatic drop in available resources and preparedness for the following period brought about radical changes in strategic management of the police. That is why top management decided to implement new methods by applying innovative predictive tools. Following advice of Kent Police chief, the force was inspired by the Los Angeles Police Department.

Projects undertaken

Despite its former scepticism, Kent Police are using the PredPol system, as well as other analytical methods used before the predictive tool. The system has not replaced analytical work, but rather added to the portfolio and improved the system of analysis.

The team of analysts is composed of 30 highly qualified specialists in data and spatial analysis. Fifteen members of this staff specialise in GIS, with two of them being lead analysts responsible for the quality and completion of all analytical activities. This team produce hot-spot maps, statistics, overviews, reports and other materials regularly created for the purposes of strategic planning, patrol coordination, as well as materials for the public. Creation of materials similar to the output of Predpol was tested by the analysts using traditional methods. Due to a large quantity of results in a short time, they could not compete with the system, as the volume of prepared materials reaches 70 thousand reports per year.

A solution yet to be implemented, which could contribute to an effective performance, is modern technologies, such as tablets and smartphones equipped with GPS. This equipment could allow police officers to carry out tasks of an administrative nature, including crime occurrence in the field. Also, their position and movement during shift could be tracked via GPS. These innovations, however, are nothing but a challenge for Kent Police as yet. Current technology tracks officers via signal from their radios.

Case study / application

Preparatory works prior to the implementation of PredPol commenced in December 2012, and the pilot project lasted 12 months, with Northern Kent as the tested location. As mentioned, headquarters of Kent Police found inspiration in and cooperated in the implementation phase with the Los Angeles Police Department. At this juncture, Kent Police is still actively cooperating with the PredPol company, as it is not only an ordinary user to have purchased and applied a software solution but also a client that makes use of the external data processing service. Kent Police analysts regularly send data to the other party, which carries out analyses and predictions, which are sent back for practical usage by Kent Police divisions. This concerns short-term predictions which are used for patrol management.

Prior to sending of the data for processing, it is adjusted by data analysts. Only information regarding the category, place, street and time of a given offence. No additional information is provided. The basic data on crime is sent to the datastore of PredPol three times every day. The resulting map of predictions consists of a grid, each square of which is of the size 150x150m, which indicates the most critical areas for crime. Police officers have two output predictions at their disposal every day. Each district indicates 20 most critical squares for day shift and 20 for night shift. Briefings with missions and indicated critical areas are prepared in conjunction with operational officers and analysts, and distributed prior to each shift in a both analogous and digital version. Hence it takes 1% of the time per shift to acquaint oneself with the task for a police officer.

The system was optimised in autumn 2014, as generating 20 squares per shift failed to suit local conditions. Firstly, the system was tested on using 10, secondly on five squares. Filters were set up for selected offences, namely violent crimes, vandalism, anti-social behaviour and assaults. Currently, the system is still being tested in this form. An expansion to other forces is considered, which would also involve a general change to patrol management.

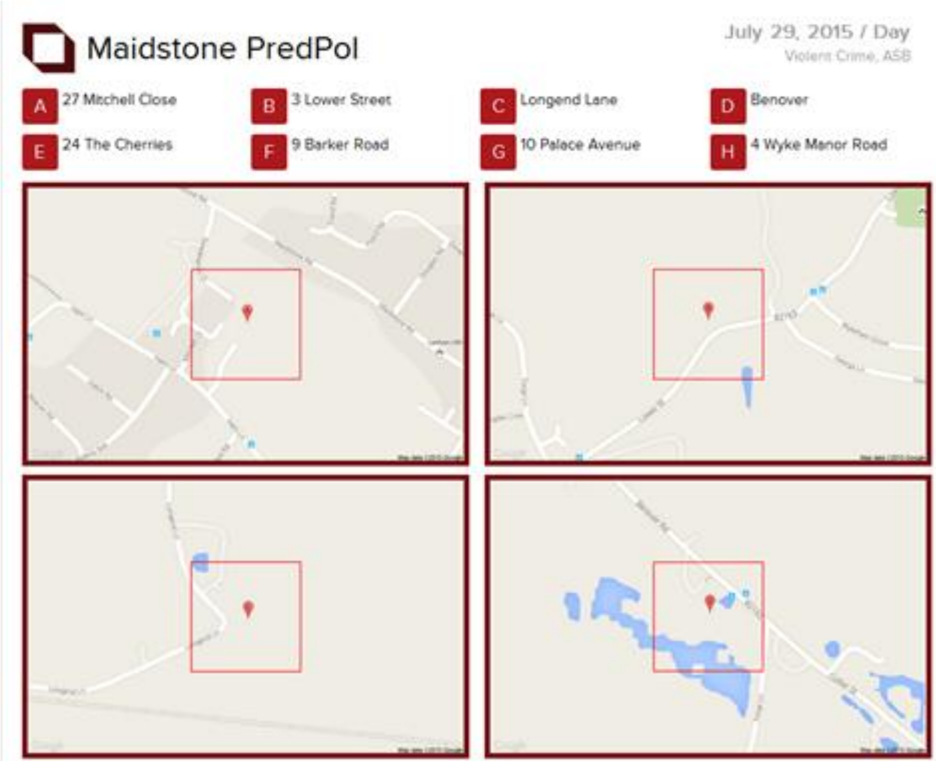


Figure 59: Predicted boxes in PredPol

Source: Kent Police 2015

As mentioned above, predictions involve no additional data which could be used for a more thorough grasp. Teams of local analysts work with this data when they are preparing materials for patrols. Police management thus work and adds their informative value by further analyses. Sources of this data are, for instance, statistical office, banks, mobile-phone providers, data on weather, and location of critical areas.

Practical usage

Originally, PredPol system was to have been used for 12 months, which included acquisition costs of £100,000. Since this solution led to a reduction in crime, consequential and related costs, other financial resources were allocated, which were used as an investment into continuation of the project with a version most suitable in the Kent Police conditions. As the following year also saw positive results, the license is renewed every year. The price **£**100,000 is acceptable for Kent Police, as it is a yearly salary of two constables, and financial savings it brings are far higher. No other associated expenses arise. The police pay for the final product, or more precisely for the generation of predictions. Trainings on using the materials are carried out only for new-coming police officers.

When analysts prepare materials for officers, be it using or not using PredPol, they strive for a user-friendly data which an ordinary officer would be able to understand. Hotspots and squares therefore clearly indicate places where they should be – and otherwise would not be – present. It is recommended to the officers to work with PredPol materials between individual tasks. In some areas, the system is not made use of on a daily basis, which is why these materials are used to a limited extent. This generally concerns thinly populated areas with low crime rates.

As brought up, one of the shortcomings which Kent Police is facing is checking whether officers, following their orders, are found in the critical areas and spend there a sufficient amount of time. It is stressed that officers spend in the given area no less than 15 minutes in the critical daytime.

Application of spatial data is not a mere matter of the police. Kent Police is well aware of cooperation necessary to ensure safety with other actors. Therefore it shares the final maps with their partners, such as local authorities, fire brigade, health-care institutions or anti-drug organisations; this information is not available publically. Nevertheless, should any party make a request for materials of a non-operative nature, the data tends to be provided. Generaly, Kent Police, similarly to the majority of British police forces, fosters cooperation with the public. Citizens are thus acquainted with PredPol and other related activities. Due to this approach, Kent Police can raise citizens' awareness of the police work, which is reflected on 96% of reports which are registered as offences. Images below represent one factor included in regular publically available reports. The first graph shows the timeline of reported offences related to violence against the person, and the second graph of reported offences related to sexual offences in the Kent Police jurisdiction.

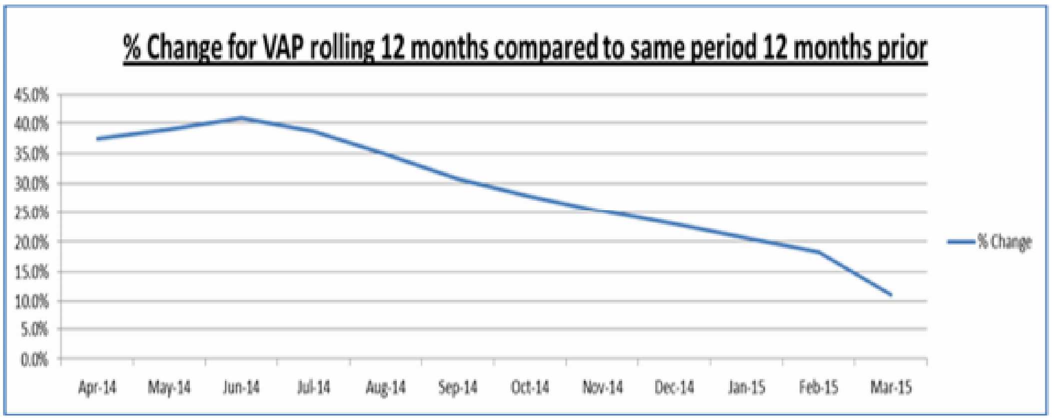


Figure 60: Graph from a police report – decline in violent crimes

Source: Kent Police 2015

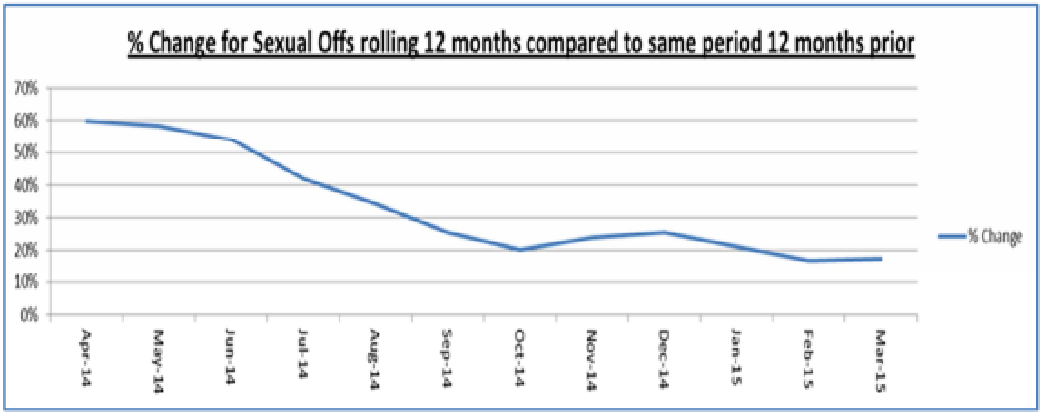


Figure 61: Graph from a police report – decline in sexually motivated offences

Source: Kent Police 2015

Case study / application effects

To validate the accuracy of predictions, a so-called "silent test" took place. The result was that the PredPol system was capable of predicting an identical expected critical area as two analysts in 60% of cases. The system also underwent a long-term testing with the use of data analysis by the police, whose result was that in terms of this solution, behavioural and criminal patterns change within the territory. In particular, scatter of hot-spot areas was observed during a reduction in crime rates.

Staff dismissal, caused by budget cuts, was followed by a rise in crime shortly. Two initial years of full usage of the PredPol system by the Police saw a successful prediction rate in 25-30%, when crime occurred. Measures which stemmed from analyses helped reduce the occurrence of anti-social behaviour by 7-10%. In the case of violent crimes and general crime, a drop was observed by 7% and 4%, respectively.

Summary

Although the former scepticism towards new solutions was eliminated, police officers are not fully devoted and motivated to use these innovative solutions and methods of work. One motivation is a cooperation on a proactive approach, to which was not devoted enough time due to a large number of routine tasks.

The results being self-explanatory, there are no doubts about the PredPol system. In addition, police officers have found other options to enhance their work. Findings of an evaluation carried out by the police show their positive feedback, recommending this approach to other units as well. The question arises, however, whether these positive results would have been achieved with the PredPol system, following traditional methods of data analyses and preparation of materials for decision-making on the part of the both police management and officers.

8.2.4. Cambridgeshire

This subchapter deals with the collaboration between Cambridgeshire Constabulary and Cambridge University. These two institutions carried out a research project aimed at defining critical areas, followed by an effectiveness assessment of controlled patrolling based on data analyses.

Information about the city/region

Source: ESRI, basemap ArcGIS Online 2015

Cambridgeshire is one of the traditional, non-metropolitan counties in Great Britain, located in the region of East Anglia. The largest city and an independent administrative unit of this ceremonial county, is **Peterborough** (343 km^2). The city population was 190,461 in 2014 (Office for National Statistics 2015). The demography of the city is quite diverse. After the Second World War, almost three thousand Italian workers entered the city in search of work, who laid the foundations of the present Italian community. At the end of the 20th century, an influx of Pakistani was observed (according to the census from 2011, 12 thousand Pakistanis live in the city), and after 2004 of eastern Europeans. It is estimated that every tenth Peterborough inhabitant comes from one of the countries from Eastern Europe (Lithuania, Poland, Slovakia, etc.). This leaves a mark on the safety in the city.

Information about the organisation

Peterborough is composed of 24 parts. The agency responsible for the security in the city of Petersborough and its surrounding areas is **Cambridgeshire Constabulary**. This agency, employing approximately 1,600 police officers and supporting staff, covers an area of 3,500 km^2, inhabited by almost 0.7m inhabitants. Strong immigration is a cause of cultural and language differences, which leave a mark on the development of local communities. The local police force tackles this issue by investing into the best practice and by solving problems jointly. An example of this practice is cooperation with the Fenland organisation in terms of human trafficking and exploitation of migrants. The Peterborough police force is divided according to areas into North, South and East team. The East unit, taking care of five boroughs, including the city centre, employs 45 police officers (Cambridgeshire Constabulary 2015).

Initial situation

Petersborough policing and partol targeting was formerly focused mainly on areas which experienced a wave of violence and an increase in crime rates. After a police response, problems with some types of crime were solved and the forces were moved to other areas, which might have caused a mere displacement of crime to other parts of the city. In 2014, the pilot project was launched which was to facilitate identification of areas with increased, enhanced allocation of resources.

Similarly to other cities, the police aimed to become part of the community. The model used is SARA, standing for Scanning, Analysis, Response and Assessment.

Projects undertaken

In the period of April 2013 and April 2014, Cambridgeshire Police ran a project focused on identification of critical areas, followed by coordination of patrols. Pilot city for the project purposes was Petersborough. In collaboration with specialists in spatial data analyses from Cambridge University, which initiated the project, data gathered from emergency calls to all rescue forces over a five-year period was analysed. Using this data, 74 hotspots were identified in the city area. In these areas, the correlation between increased patrol visibility and decrease in crime rates was investigated during the year of testing. When results were evaluated, the areas with new patrol management were compared with areas where no such system had been applied.

Figure 62: Hotspots defined in terms of the project

Source: Cambridge constabulary 2015

Forty-seven auxiliary community officers were involved in the project, who formed the patrols in the areas in question. These officers have an authority and means different from ordinary police officers and their purpose of involvement is their presence and visibility, which is a preventative measure in itself. These officers are instructed in what actions they should perform and when to be present in the critical areas. Another position in the project is supervisor, who is responsible for managing auxiliary officers and distribution of information. Three sergeants from Cambridgeshire Police are in charge of this activity. The lead project manager supervises tactical implementation, resource management and close cooperation with experts from Cambridge University. Project manager was in the command of all uniformed patrols in the city directly in Petersborough. Last part of the project team are analysts who prepared the data, after which Cambridge University experts created hotspot areas.

Case study / application

The project was focused on the preparation of a long-term strategy of resource allocation, when hotspots viewing high-risk areas were identified. These 72 high-risk areas were divided into halves. While one half was surveillanced by special patrols of community officers who were assigned task for a specific time, the other half was managed in the old manner. This approach was adopted during selected main times: Wednesdays to Fridays, from 3-5pm. Ideally, police officers should spend their time at least 3x15 minutes per day. Hotspot areas were not updated while the project was under way.

It was important for the police officers to focus on the given area all the time. Police officers often follow their own targets, focusing on something else. Therefore, localisation of officers was of the essence. To evaluate the movement of the patrols, whether they were present in proper areas at right times according to the plan, signals from radios were tracked. The officers' position was tracked every two minutes. This parameter is, however, adjustable.

In terms of the project, police officers were focusing on the following types of criminal activity: burglaries, burglarised vehicles, stolen vehicles, drug-related issues, assaults, anti-social behaviour and public disturbance.

Practical usage

Owing to the use of own technical and human resources and the cooperation with Cambridge University, there were no arising costs on the project for the police. All activities were carried out in terms of the ordinary police work.

During this project, police officers did not need any special training. They participated in briefings where they were provided with all necessary information. Also, analysts acquainted them with further information about what aspects they should focus on in the given place. The aim was to inform the police officers about how everything worked and to raise their interest in this new style of work. It was important to convice ordinary police officers that it is not allowed to do the patrolling based on one's own decision where one should be present. In the initial phase, police officers were zealous about this approach. In the course of the project, however, their enthusiasm waned slightly. Still, the results showed it was a worthwhile work. It is a shift from reactive to a proactive approach. If police officers are on the right place and nothing happens, it is correct. It has a positive impact of the preventative measures.

The public did not obtain any information about this pilot project, nor is planned to disclose its results. At the beginning of the project, a non-disclosure agreement was concluded between the Cambridgeshire Police and Cambridge university due to the protection of sensitive data. Similar agreements had also been conluded between other actors before, and they always had to abide by the conditions of data usage. As regards sharing common statistics, these are shared with local community organisations at the city level, such as schools or social services.

Case study / application effects

Accurate statistics deal with the project results have still not been evaluated. However, preliminary data illustrate an increase in arrests regarding drug-related issues and stolen vehicles. Analyses carried out by Cambridge University specialists revealed preliminary results which show a 40% drop in calls for service, and a 28% drop in victims from high-risk areas. What Petersborough Police perceive as a major contribution is an apparent increase in public trust in the police. This fact was also supported by public surveys done after the finish of the project.

Owing to an increased police presence in the problematic areas, their responsiveness to potential crime activity also increased. In the course of the project, each police officer responded to four calls for service more every day on average, which increased their response time by 25%. It was found that the visiblity of the patrols in these areas increase by 22 hours per week on aggregate. The opinion was confirmed that the police should work more with their patrols and send them to specific places.

Summary

The police in Cambridgeshire do not have a designated team of experts specialised in spatial data analyses, which were processed by a university in terms of the project. Should the approach in question be implemented into police work, qualified professionals would need to be hired.

The predictive model tested is based on historical data on crime and its spatial aspect, using traditional tools for processing, data analyses and spatial data analyses, which is a suitable solution for the application of mid-term and long-term predictions.

8.2.5. Home Office

The Home Office is the government department of the United Kingdom responsible for the police, visas, immigration and security forces. It also deals with the safety policy of the country related to drug issues, counter-terrorism and security.

This institution provides information about crime to citizens through crime maps and other statistics on their websites *http://www.police.uk* . At the national level, crime is mapped by all British police forces at this juncture.

Initial situation

Public availability of data on crime / crime maps in Great Britain was started when Boris Johnson was running his election for the Mayor of London in 2007, which he won. He aimed for a larger freedom of crime-data publishing so that the public could observe maps of crime, thus making agencies responsible for given areas. He promised that if he won the election, he would make police chiefs publish this data for the sake of transparency. What was of the essence was to maintain the protection of crime victims' privacy.

Case study / application

In 2009, this situation was solved. For the first time, a map with 32 London boroughs and types of crime occurring in these areas was made publically available. Clicking on the map/borough, crime-rates are shown, along with information about the rise/fall in the given offence. However, no specific streets were mentioned. Three levels of data was provided: police beats, boroughs and a series of streets (no less than 5). A textual interface for individual analyses was also available.

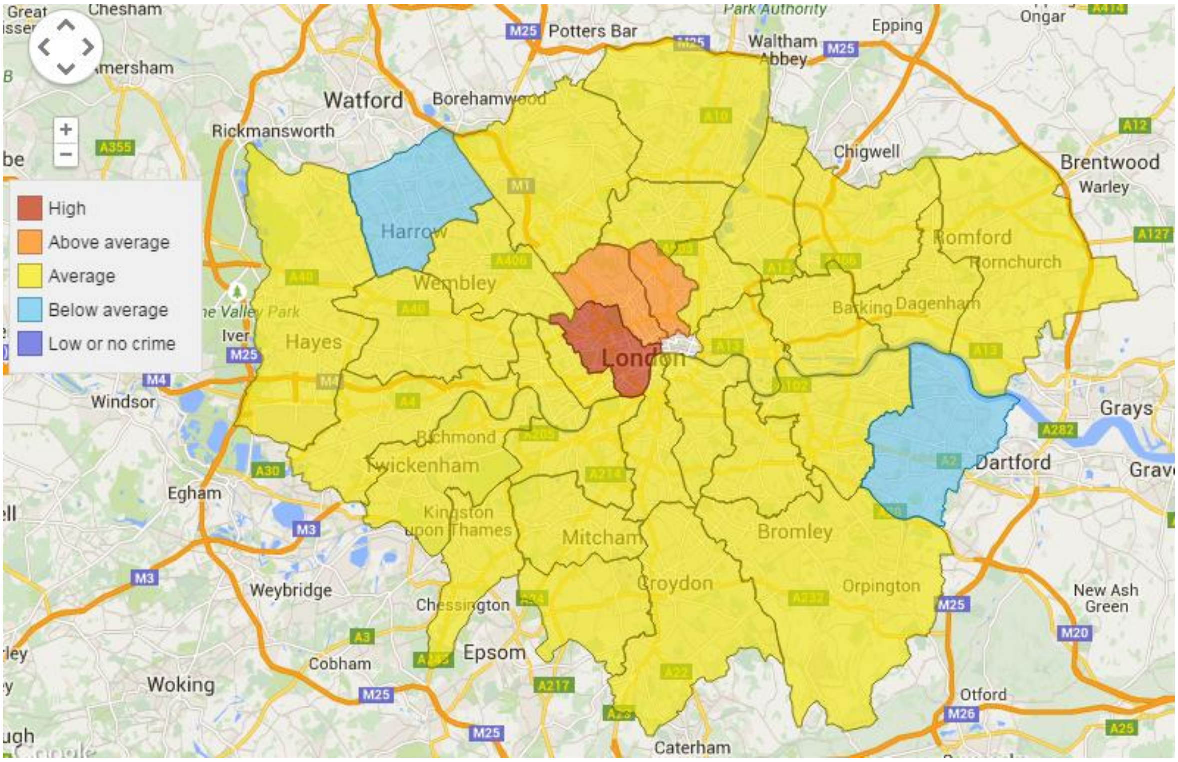


Figure 63: Crime maps, London boroughs

Source: Metropolitan Police 2015

In the following year, the option to public information about crime at the local street level was added. However, this does not concern accurate coordinates of an offence. Instead, a generalised position is visualised. Data is visualised in snap points (Figure 56), which provide general data to protect victims' privacy. The figure in the snap point states the number of reported crimes over a given period.

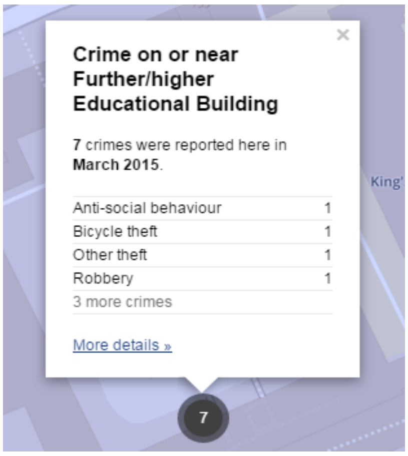


Figure 64: Snappoint

Source: police.uk 2015

Data processing

Generalisation of crime scenes is carried out with Voronoi polygons, which represent a catchment area for statistics visualised in a certain territory. In total, the main list contains more than 750,000 "anonymous" points. In this respect, requirements of the Home office had to adjust to those of the police. Polygons were drawn through the middle of the streets. The polygons the showed the residential address of each street. Were polygons to comprise less than eight addresses, the centre was removed.

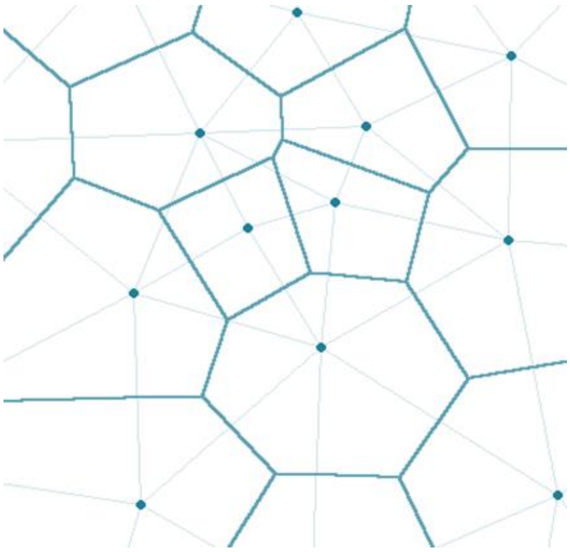


Figure 65: Voronoi polygons

Source: Geodyssey Limited 2004

As a result, by inserting a postal code, any place in Great Britain and local crime rates can be found on the websites. Provided are police statistics and information about which agency is in charge of policing, what is the composition of the team and how they can be contacted. Besides, set priorities of the local agencies are defined – generally different types of crime. Also, there is information about the steps the police have taken in tackling the crime in question, the way investigation was conducted and the conclusions reached. It is possible to visualise tables and graphs, including the duration of solving the issue in question. In this way, the Police and the Home Office brief the public and increase their feeling of security. The citizens can thus have better knowledge of the crime in their area.

Data is also recorded in terms of the program entitled "Stop and Search". Spots where citizens were searched by police officers can be monitored, along with the reason why a person was stopped (what suspicion the police officers had), as this activity can not be performed without any reason. The information is provided by the police officer who performed the action. There is also included what kind of action the officer did. Were he to do a certain action without any result, it would be considered against the law. A problem could arise regarding the abuse of majorities and ethnical groups.

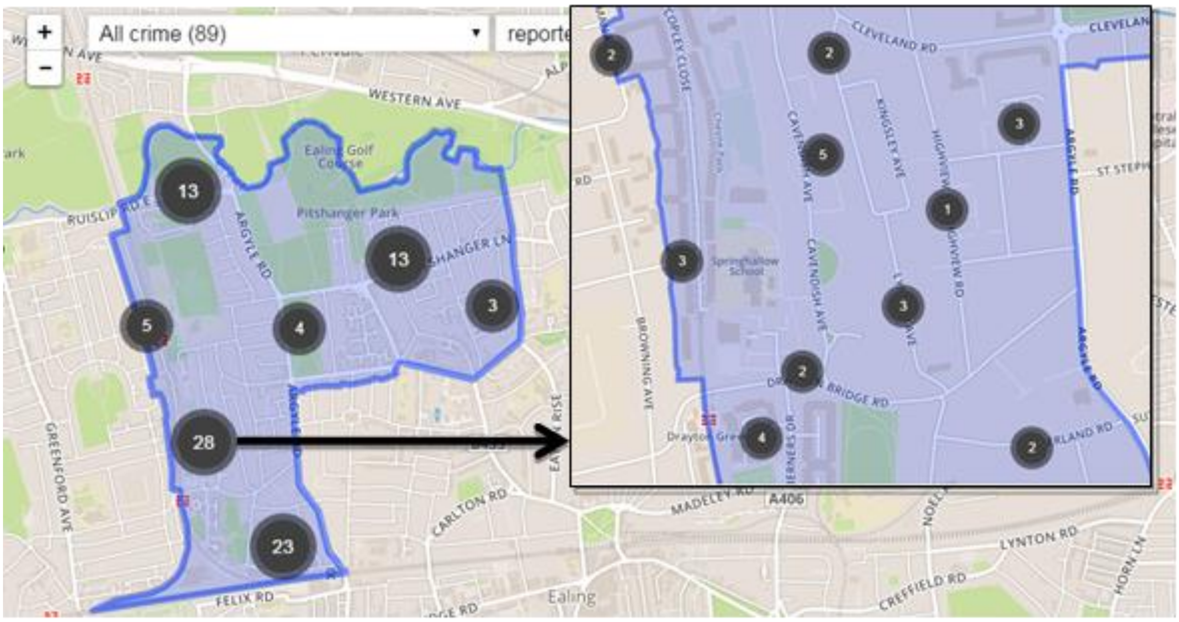


Figure 66: Crime map using snappoint

Source: police.uk 2015

A borough can be visualised based on postal code or name. Users can also draw their own polygon or circular buffer, where the crimes will be shown. The visualisation also enables setting a time period, which will be drawn in the map, including the affiliate police station, geographic information and the result of investigation. Everything stems from information sent on a weekly basis. Data is updated by police forces in a csv format and uploaded on the Home Office, where the administrator secures and validates it. Prior to the publishing, all data is adjusted and coordinates generalised. Also, precise information is deleted, and the offence is adjusted to suit 14 categories (Figure 65) - *anti-social behaviour, bicycle theft, burglary, criminal damage and arson, drugs, other crime, other theft, possession of weapons, public order, robbery, shoplifting, theft from the person, vehicle crime, violence and sexual offences*.

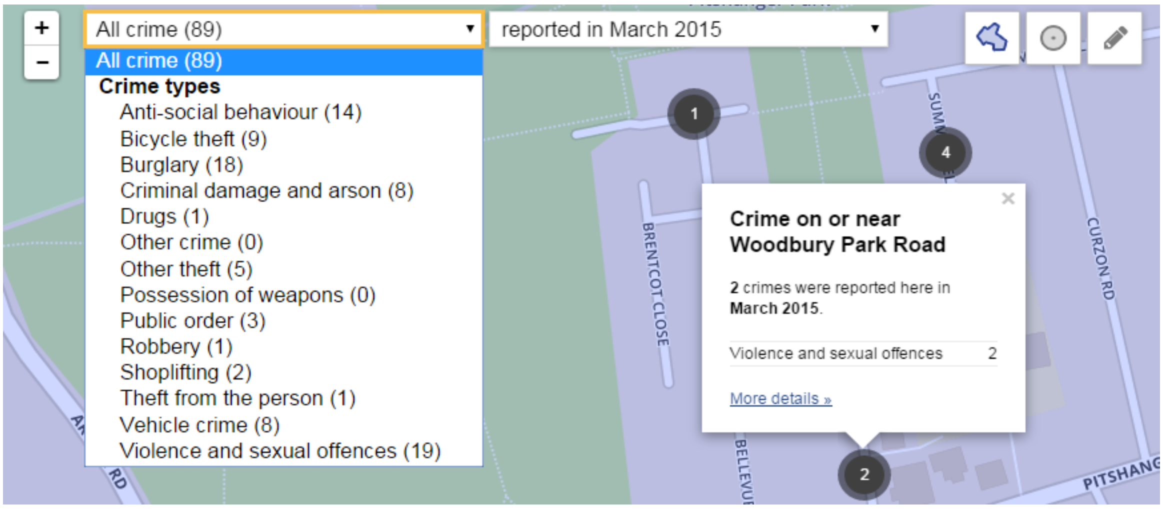


Figure 67: Categories of mapped offences

Source: police.uk 2015

Such adjusted data is uploaded to the general database, hosted on Amazon servers. As regards the data on websites, such as contact information and information about police officers, this is stored in xml format (Extensible Markup Language), provided directly by relevant local agencies.

Data disclosure

Regarding the public response to public availability of data in maps of crime, the problem begins with the method of generalisation. It is immediately evident that situation visualised in the map is close to a certain area, which, however, need not be the exact place where crime occurs. This situation is especially relevant in larger areas, such as amusement parks or department stores, which are highly exposed to crime. Regarding urban areas, basically everything falls into place, since there is a large number of places where crime occurs. These place are also quite dense and their area small, as opposed to rural areas, where the localisation is less accurate and in reality can differ in the matter of kilometres. This problem is solved by increasing the bubbles/icons. Still, it is a persistent problem. For this reason, the websites *https://data.police.uk* provide a description of the methodology of generating these visualised snap points.

Case study / application effects

The biggest challenge and problem in implementation of this system of publishing crime information was the way to tackle two questions: transparency of information on the one hand, and police effectiveness on the other. At the beginning, there was a limited amount of data provided, but it was supplied in a general form so as not to interfere with privacy. Gradually, snap points were added to the maps. No extensive negative responses were observed over the whole period of publishing the data. Currently, more detailed information is supplied, such as the month, day and hour when an offence took place.

This innovative product thus teaches citizens to work with the safety situation from one’s own perspective, as well as to cooperate with the police. It thus makes the police work with the public more effective and serves as part of preventative measures.

The biggest surprise when the project was launched was the public interest, when more than 10 million people visited the websites. Due to this enormous interest, it was necessary to focus on the system hardware, so that it could process all spatial queries without collapsing.

In theory, public availability of data was an issue at the beginning. In fact, however, it was not the case eventually. It were the costs that the police was limited by. Financing, allocated by the Mayor of London (approximately £300,000) for this purpose, enabled building of the system from the beginning. Monthly costs on data acquisition and processing, and maintenance of the websites, extend £28,000.

8.3. UNITED STATES OF AMERICA

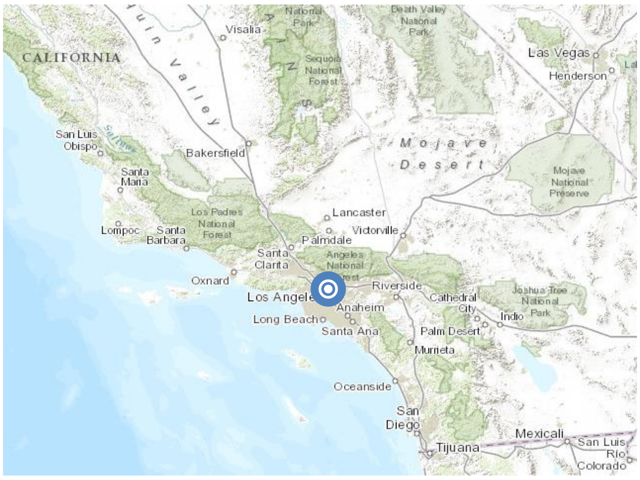
During the visit to the USA, a series of meetings were held. These meetings dealt with the experience with crime mapping, analyses and predictions from the perspective of traditional GIS tools and data processing, as well as innovative predictive tools. One item on the busy schedule which allowed for a variety of experience from different police forces was a visit to the campus of the ESRI company, along with other meetings with developers of specialised commercial software. Information acquired is reflected on in most examples described in chapters dealing with not only the USA, but also other countries.

Main sources of information:	Personal meeting held on: *March 23rd 2015 - Lancaster* *March 24th 2015 - Los Angeles Police Department* *March 25th 2015 - San Diego Police* *- Automated Regional Justice Information System* *March 26th 2015 - San Diego Sheriff, County Public Safety GIS* *- San Diego Harbor Police* *March 27th 2015 - Redlands, ESRI Campus* *March 30th 2015 - Tempe Police, Analysis & Research Center* Internal documents provided by the representatives of the visited organisations
Persons invoved:	Heads of the individual police departments Officers working with the implemented solution IS administrators of the police Analysts and geoinformatic staff Software companies – suppliers of the solutions Academics

8.3.1. Los Angeles

Los Angeles, California, was an attractive city for a meeting due to its size of the police force, the size of the city the force is responsible for, and the amount of data used in tactical and strategic analyses, and the use of the PredPol tool.

Information about the city



Source: ESRI, basemap ArcGIS Online 2015

Los Angeles is the second most populated city in the USA. According to the US Census Buerau, its population was 3,884,307 in 2013, which is approximately one tenth of the population of California. The population of the city is constantly increasing. The population rose by 2.4% between the years 2010-2013. The population of the whole area of Los Angeles County (the most populated in the USA), composed of more than 80 cities, was 10,116,705 inhabitants on an area of 10,509.9 km2 in 2014 (The US Census Bureau). Los Angeles is located in south-western part of California on the coast of the Pacific Ocean. Due to its closeness to Mexico, Los Angeles is a specific area with a large number of Hispanic and Latino inhabitants. According to a survey by the US Census Bureau from 2013, these inhabitants represented 48.3% of the county population. Although the data about the city of Los Angeles comes from 2010, it supports the figures. In this year, Hispanic and Latino inhabitants represented 48.5% of the city population. This composition, as well as the migrants' poverty is one of the causes of higher risk in this area. Potential risks stem from significant differences between inhabitants of different districts of Los Angeles. On the one hand, there are rich parts, such as Hollywood or Venice, on the other poor, immigrant districts.

The city is an important centre for various disciplines, from industry to culture. This leads to changing population, economic benefits, but also safety risks. Los

Angeles is also an important transport hub. node of traffic. The Port of Los Angeles is the most important gateway for Asian trade. Los Angeles International Airport is one of the busiest in the USA, and the city is also criss-crossed by multi-lane roadways.

Information about the organisation

Los Angeles Police Department (LAPD) is one of the three largest police forces in the United States of America, employing 9843 police officers and 2773 civil employees in 2013 (FBI 2013). Its jurisdiction is divided into four areas (bureaux): Central, South, Valley, and West, between which is divided 21 divisions and police stations. Central Bureau is the most densely populated, Valley Bureau is spread on the largest area, and in West Bureau the most famous quarters are found (Hollywood, Hollywood Hills, Veince, etc.). In total, LAPD officers ensure the safety of more than 3.8m permanent residents of the city. Part of the LAPD structure are also specialised units, such as the most known, SWAT (Special Weapons and Tactics), trained in tackling high-risk situations (LAPD 2015).

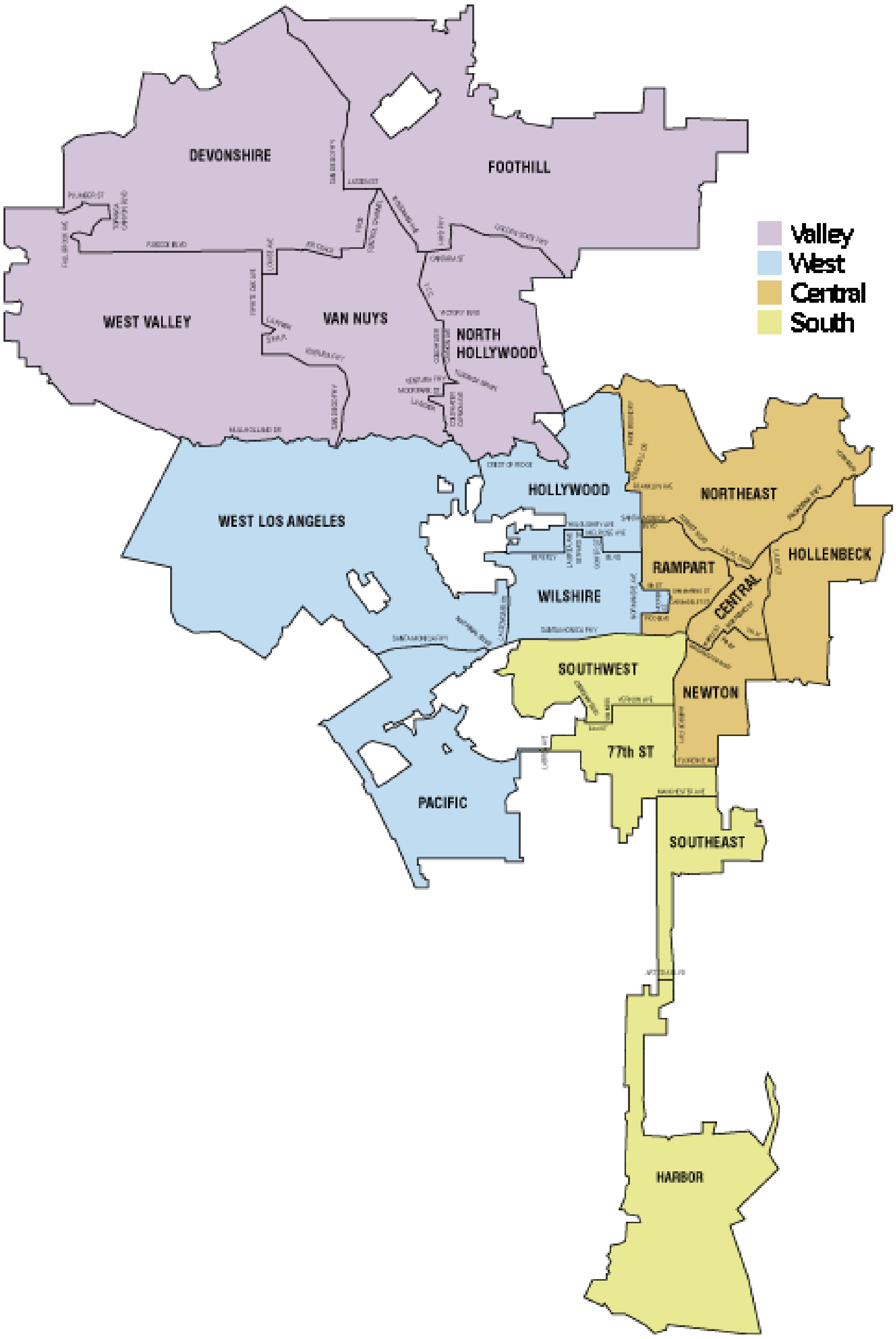


Figure 68: Los Angeles police areas and LAPD divisions

Source: Tripod 2015

Real Time Analysis and Critical Response Division

The meeting was held in the **Real-Time Analysis and Critical Response Division (RACR)**, a centre which deals with the security situation in real time making use of specialised tools and processes.

Each large department in Los Angeles has its own operative centre similar to RACR, which, however, is the only operating round the clock. This centre monitors the situation in the jurisdictions as well supplementary information which can have an impact on the safety in the streets. It is an integrated centre from which fire departments are managed.

Figure 69: Real-time Analysis and Critical Response Division

Source: Cironline 2015

Operations can be divided into two basic types. The first is **tactical analyses**, i.e. continual monitoring of safety, traffic, reported events, patrolling and other relevant information operative officers have to respond to appropriately. The second type is **strategic analyses**, when analytical materials for policing purposes and statistics about crime and police performance are prepared. These materials are submitted to the management of the police.

RACR divisions serve also as a regional centre: they are responsible for not only the city of Los Angeles but also the counties of Los Angeles and Orange. From the viewpoint of tactical preparedness, police officers deal with safety at the national and international level. That is due to the fact that Los Angeles is a vast city which is a major transportation hub, where a variety of goods, often dangerous (guns, medicine, radioactive materials), is transferred.

RACR operates at **three emergency levels**:

1) There are always six officers present, supervised by one superior who is responsible for the shift management and ordinary situations.

2) In case of a more serious situation, a lieutenant, two sergeants and, depending on the seriousness of the situation, senior officers are called in.

3) Should a very critical situation arise, where more analysts are needed, other staff are prepared who fill in the operative capabilities of the unit. The number of staff is thus doubled.

Levels 2 and 3 are reached several times every year. The police also cooperate with the Planning and Research Division, which, in case problems should arise, comes to RACR, the main coordination centre. Its members are officers highly specialised in different subjects who are responsible for tackling critical situations, such as operations after an earthquake, when rescue and safety works are of vital importance.

Initial situation

In connection with RACR it is worth mentioning that prior to the implementation of innovative tools for patrol management and crime prediction, it had not utilised ordinary GIS tools for spatial data analyses. Therefore, benefits of the below-mentioned implementation can be attributed to the implemented state-of-the-art tools.

Projects undertaken

LAPD uses the **PredPol** system for predicting crime. It calculates criminogenic data with information about place, time and the type of offence. The tool predicts a specific time frame and place with a high risk of crime occurrence.

Another application LAPD utilises is **CrimeMapping**. It monitors the state and localisation of specific offences. This software, described in more detail in section 7.2, is used only marginally by the LAPD for supplementary information.

Palantir is a piece of software the LAPD uses to monitor patrols in cars and walking patrols. This enables the operating officer to see the location of events taking place in the city. Each of these events is recorded by the officers in the field, and the current state is updated in the operating centre every two minutes. Its members therefore see the critical events in next-to real time, thus in a necessary case they can react flexibly. This is not an innovative process or use of the tool. However, Palantir has prompted patrol management, which would take much longer to carry out with the spatial arrangement.

The LAPD automatically generates reports with an evaluation of each officer, unit, division and even the LAPD as a whole. This approach is called **Compstat**. The evaluation reports contain information about the number and categories of offences, along with supplementary statistical data. The division is also evaluated according to their response time, which is one of the effectiveness criteria. Among statistics also observed are, for example, the number of police officers who had a car crash, whether force was used, the time spent on sick leave or overtime. These Compstat sheets are available in the LAPD intranet to all officers. They therefore serve, according to the LAPD management, an informative, but also motivational purposes to police somewhat competitive police officers.

Case study / application

The RACR management is of the opinion that the usual outcome of spatial data analyses in crime are hotspot maps. Were a police force to be responsible for a vast area with a limited number of officers, areas of presence would need to be specified more precisely than is possible with these methods. Therefore, PredPol software is emphasised in analytical work. The system generates predictions for squares of 150x150 meters in size, which is a relatively small area, suitable for the planning of patrols. For the area the LAPD is responsible for, a grid with almost 3000 squares is generated, which is impossible to manage. The algorithm therefore processes the 10 most critical areas for each division which uses PredPol. The squares are updated for each shift, i.e. every 12 hours. Some of the generated squares represent areas with continual crime. These squares are thus persistent. Useful predictions are therefore those that are outside these areas.

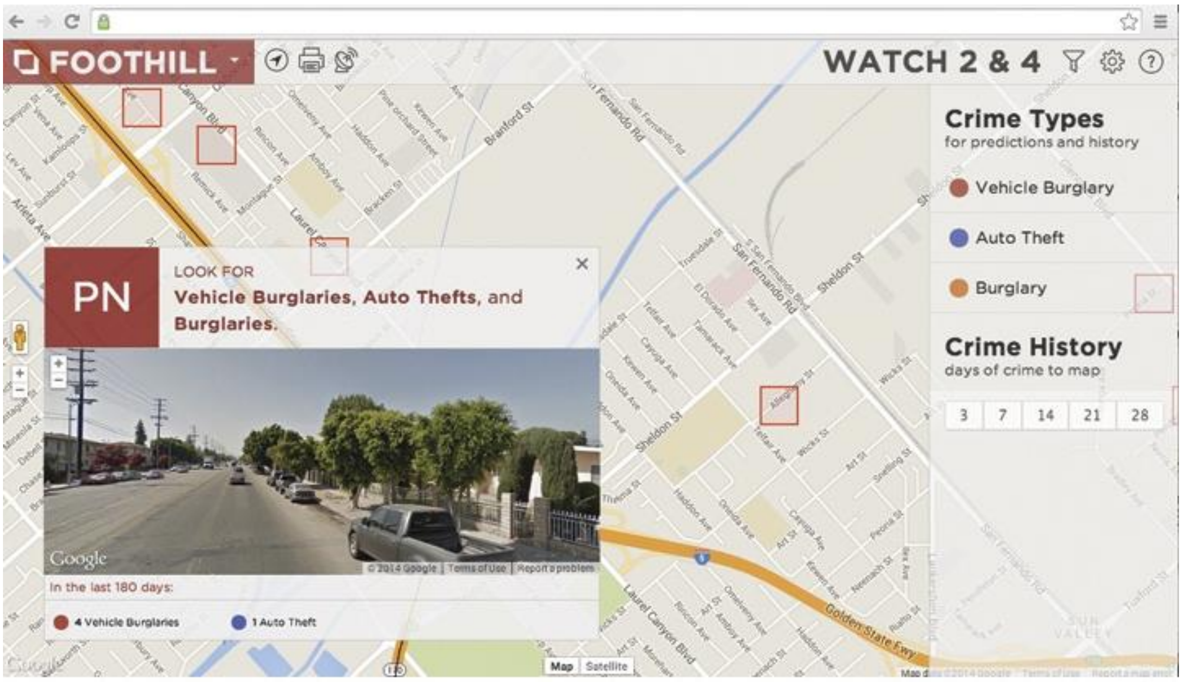


Figure 70: PredPol interface – LAPD Foothill Division

Source: Policemag 2015

LAPD acquired the PredPol system free of charge due to an exchange of data from police databases, which are in the case of the LAPD quite vast. The system is developed on the basis of the data of the LAPD jurisdiction. At the time of the first implementation of PredPol, the LAPD used predictions in some offences, namely gun violence, robberies and vandalism. Gradually, attempts were made to include traffic accidents as well. This, however, is more related to traffic safety and the arrangement of crossroads, which impedes the use of any algorithm. Predictions of these events have therefore not been included. A similar problems occurs in murders, which take place randomly and their total number generated by algorithm is very low.

According to the RACR captain, use of sufficient amount of quality data is necessary for the system. A unified data-management system is therefore necessary. The first step is a database with a unified structure for all users. The USA use a federal standard which unifies the data structure so as to be available to all police forces. The weakness of this approach is that not all states of the USA use identical classification. During unification, data is aggregated and consequently the accuracy of categories of some states is lost.

Regarding data storage, the LAPD has several servers located at police stations. It also makes us of servers at the Los Angeles city hall. Data saved on the servers are accessible online via an internal information system, not only from stations, but also from police vehicles, which are equiped to carry out administrative tasks in the field.

The LAPD may retrieve information from thousands of cameras dispersed around the city. Some of these can recognise number plates, which is also connected to the necessity of the protection of this data. It is a large amount of data, whose storage abides by strict regulations in some city in the USA. The issue is the personal data protection. Therefore, the amount of data stored has been limited. The data publically availabe has to be spatially aggregated for the sake of privacy. This data is publised, for instance, by using CrimeMapping, which also informs the public about current safety situation and the occurrence of particular offenses.

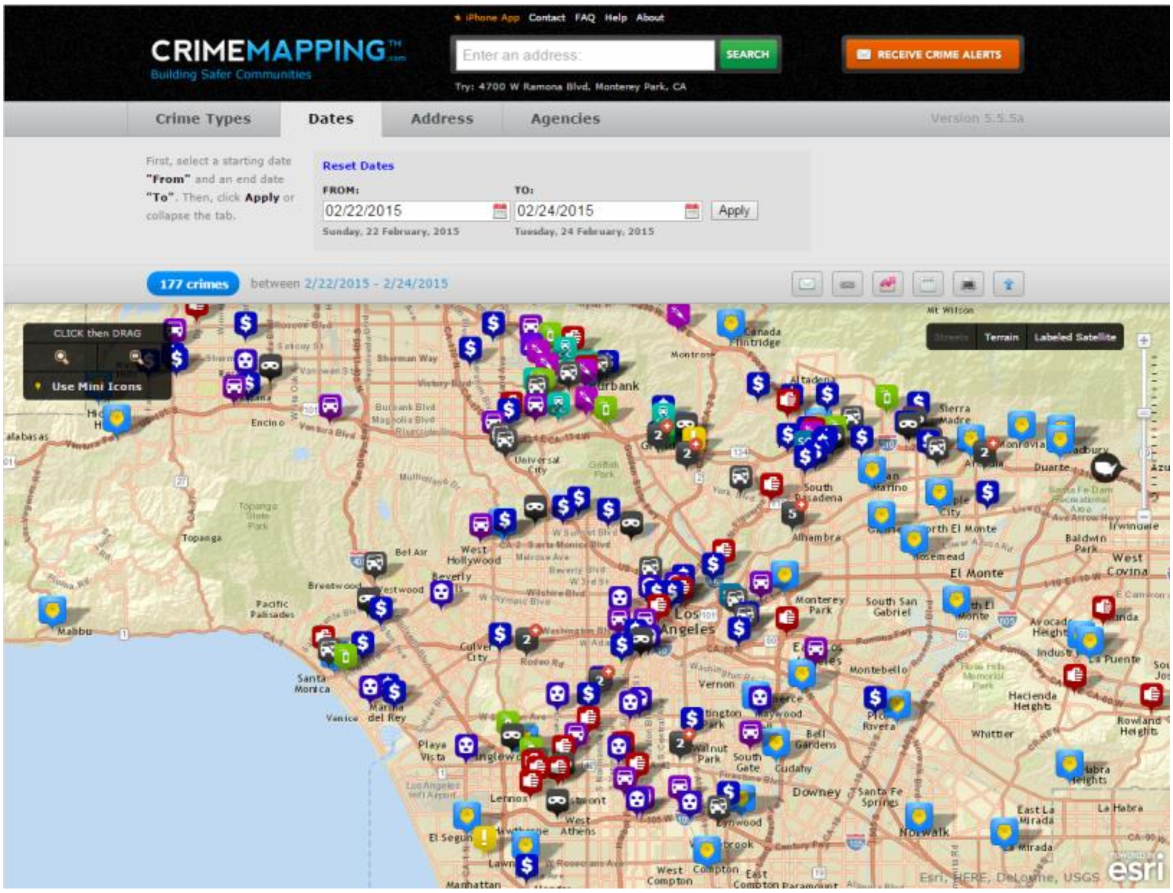


Figure 71: Crime visualised in CrimeMapping

Source: CrimeMapping Omega Group 2015

Data disclosure is voluntary in California, and there is no legally binding document dealing with this issue. It therefore depends on the decision of police force chiefs whether criminogenic data will or will not be disclosed. For instance, the Los Angeles fire brigade ceased to disclose this data, as 70% of these cases pertained to medical details, which are considered classified. This led to a public distrust and suspicion that the fire brigade is deliberately concealing information. As a result, it was ordered under a political influence that information be disclosed in an adjusted, discrete way. Were this situation to occur in police forces, the steps taken, according to the RACR captain, would be similar.

Implementation

Captains of the individual LAPD divisions are not coerced to use the predictive system in patrol planning. However, they have to advocate such decisions. Every week, inspections are carried out at the departments, focused on specific offences which took place in a given area. Captains have to submit reasons how and why a situation was dealt with, and what steps have been taken to prevent the situation from happening. The general approach is, according to the RACR captain, predictive systems are not applicable in all situations. Consequently, PredPol is used as a complementary tool which by no means should not and can not replace insight of an experienced police officer or operating officer in charge of patrolling.

PredPol is considered to have contributed to reduce crime after its implementation. There is also a positive perception of the fact that evaluation of police officers has changed. Formerly, they were evaluated by performance, for instance the number of arrested people or clearance rate. These days, the approach towards officers' evaluation has changed in the LAPD. They are appreciated for fulfilling their schedule regarding the amount of time they should spend in an area as a preventative measure. Evaluated is not only an officer's performance and solving of a case, but also the fact that no incidents took place. Still, this is a process difficult to measure, so division captains and commanders have to support the work of their staff.

The LAPD organises continuous trainings on operating software equipment. Five in-house trainers carry out trainings on a daily basis, and up to the present time, 2200 officers have attended the classes. Each officer undergoes the training in a specially equiped room, on which **$**30,000 was expended. There are also marked hidden costs, connected with the replacement of an officer who is being trained.

Despite lowering police-force budgets, necessary financial resources are saved also in connection with innovative methods and tools. It is therefore planned to increase the number of officers to 12,500 by 2017. Other visions include the purchase of communication devices which could localise the position of officers more accurately, call them for service in extraordinary circumstances and send them orders during patrolling in real time.

Case study / application effects

The expected contribution of the PredPol system is crime reduction. LAPD Foothill Division figures show a 20%-reduction in offences between 2013 and 2014, which marks the period of implementation. In the four-month period following the implementation, the division saw a 13% reduction in crime rate, while the average value observed by other divisions with did not implement the system in this period is 0.4%.

One advantage of the implementation of PredPol and other tools is the user-friendliness. According to the RACR captain, what is beneficial is the fact that analysts can attend to other tasks then preparation of materials for patrols, which can be handled by a less qualified officer these days. Work with data is a work of the future without which success can not be reached.

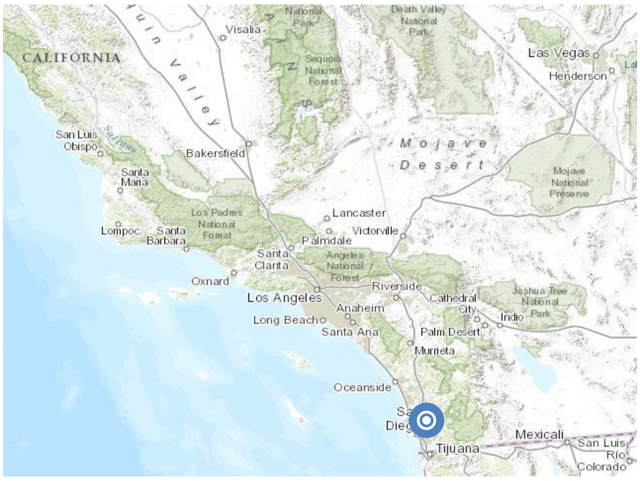
Summary

For the RACR captain, the algorithm behind PredPol is unimportant and he trusts its outcomes. At the same time, he states that such tools have a drawback that the police officers tend to rely on the automated processes. There is an imminent risk that the more police officers will use a product that will do their work, the less aware they will become as they will not develop their natural skills. An ideal balance needs to therefore found between these to sides. What deserves special attention from this viewpoint is the work of new-coming officers, who have limited abilities and therefore the tools they are using must be selected accordingly.

8.3.2. San Diego

San Diego is an example which demonstrates an outstanding cooperation of different police forces ensuring public safety in San Diego city and county with respect to data sharing and a unified approach.

Information about the city/region



Source: ESRI, basemap ArcGIS Online, 2015

San Diego is the capital of San Diego County, located in souther California. In 2014, 3,263,431 inhabitants comprised the population of the county of 10,895.1 km^2 in size (The U. S. Census Bureau). It is situated not far from the border with Mexico, and directly bordering the Mexican city Tijuana. This fact has an influence on the composition of the population. In 2013, the population of San Diego, with an area of 842.2 km^2, was 1,355,896 (The U. S. Census Bureau). People of Asian, Hispanic or Latino origin form a large part of the San Diego population. According to 2010 census, Asians represented 15.9% of the total population, which is more than the average of California; Hispanic population represents approximately 30% of the population. Despite the short distance from the border, San Diego is considered one of the safest cities in the USA (Forbes 2011, Business Insider 2013). This is owing to the elaborate police system but also the fact that San Diego is an important international port. Also, the US Navy is based in this city (San Diego 2015).

Information about the organisation

The authority in charge of policing in San Diego is the **San Diego Police Department (SDPD)**, which divides the city into nine divisions and 19 service areas. According to the SDPD official website, there is 1.5 police officer per 1,000 residents. Safety of the coastal areas is ensured by the **San Diego Harbor Police (SDHPD).** The jurisdiction of this agency is the whole San Diego bay, where the cities of San Diego, Chula Vista, Coronado, Imperial Beach and National City are situated (San Diego Police Department 2015).

San Diego Sheriff's Department (SDSD) is a law-enforcement agency in charge of security in the whole San Diego county, and is superior to all local police forces. SDSD provides judicial support for the county.

Initial situation

Prior to the implementation of modern tools, a unified IT system was in San Diego police forces. Owing to its obsoleteness, it had to be replaced by a new solution which could operate with tables, maps and analytical tools. In the initial stages, data store, hardware infrastructure were built and software tools implemented. The first tool for spatial analysis was ArcGIS Desktop, which was used to generate analyses and specialised maps which were included in reports handed to police management. Gradually, other systems, described in the present subsection, were implemented.

Projects undertaken

Currently, San Diego Sherrif's Department has 31 analysts, and the five-year goal is to employ more than 40. They specialise in generating tables, graphs, maps, working with mapping systems and specialised software, which are products used in the preparation of reports. These analysts cover an area with approximately three million inhabitants. The SDSD management see a great potential in analytical work and modern methods, hence their receive adequate support and undergo development. For instance, the San Diego court employs one analyst only, although the number of those focused on judicial area and penitentiaries is necessary to increase. They follow the approached when each analyst focuses on a particular area. Each analyst specialises in either a specific type of crime or a certain set of issues, which enables an in-depth analysis and prevents generalisation which leads to an uneffective tackling of issues. It is recommended that at least one member of any group focused on a particular issue should be an expert in that given field. This is the priority approach applied at SDSD.

SDSD, as well as SDPD, SDHPD and the integrated system of emergency calls, operates with the **ArcGIS** platform from ESRI across the organisation. This widely used tool is used to generate specialised maps, spatial data analyses and to carry out analytical work. Police forces also use the application **CrimeView Dashboard**, which offers a myriad of functions to use by operating officers as well as other officers. SDSD also uses the **Argus** system for monitoring police patrols, and **Insider** for an overview of plans and images of building interiors. In ensuring public safety, the agency cooperates closely with the fire brigade.

Case study / application

San Diego police forces use **CrimeView Dashboard** for various analyses, administration and information processing. This system enables access to information about individual offences or calls for service. Also, communication and cooperation with other law-enforcement agencies is recorded with respect to offenders and their investigation. Data available concerns profiles of felons, with their criminal record, address and other personal data. Using a spatial module, relations can be found between the data in criminal records, including the crime scene, the offender's whereabouts and move. The correlation between the types of areas where they commit crime and the distance from their home. Frequently places where offenders commit crimes belong to different areas of a district, which is in the jurisdiction of another department. Therefore, relations between individuals living in rural areas can be observed. Such relations are not risky, but members of gangs often live in these areas and are offending in other places. The area of offending basically verges Mexican border. These analyses are important for both understanding behaviour of individuals and profiling communities in San Diego. Offenders are on the move and can therefore commit crime in areas where they are virtually uknown by the police. Such a tool is therefore an important aid to understand their behaviour and acquire some information about them. However, cooperation and data sharing among individual forces responsible for safety is essential. SDSD, SDPD and other forces made a big step forward when starting their cooperation and work with the same sources of data and gradually some software as well. SDSD analysts think that analytical work involves more than analysing areas and their crime-rates; it also entails finding correlations and causalities, which can be facilitated by GIS methods and tools.

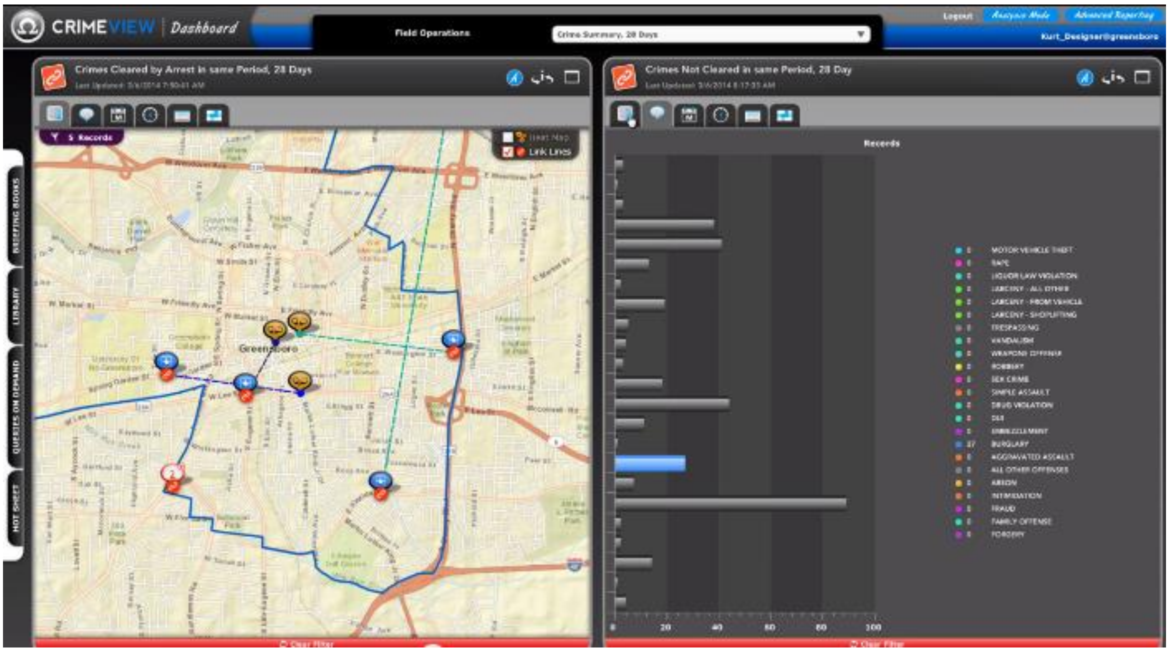


Figure 72: Analysis of spatial relations of behavioural patterns

Source: Omega Group 2015

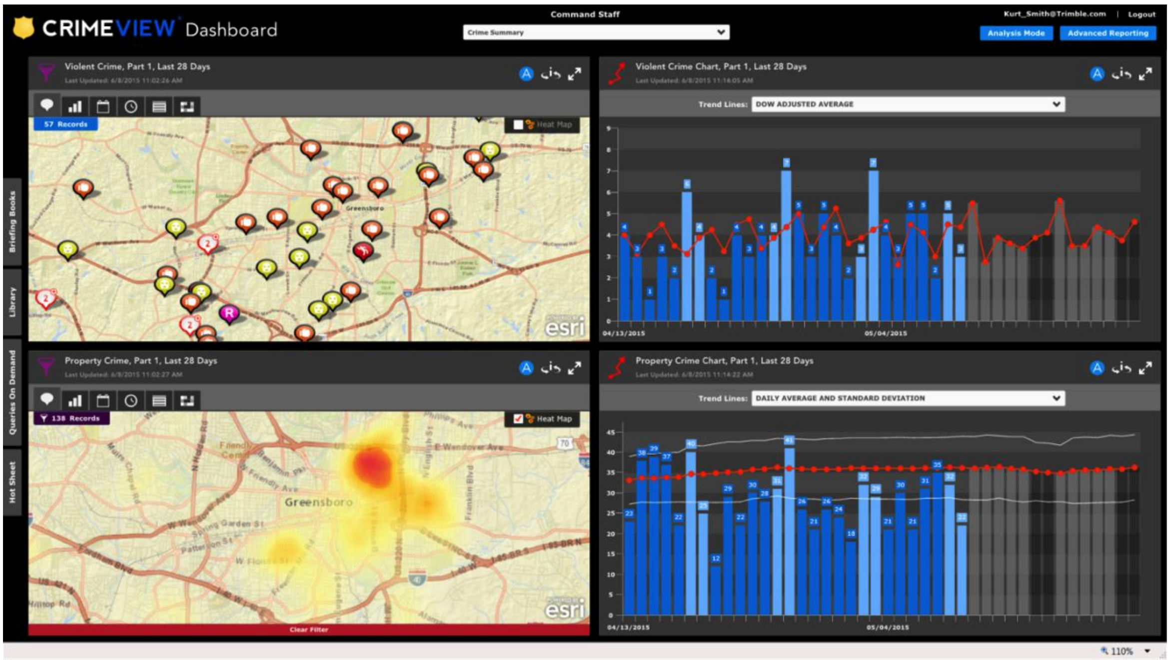


Figure 73: CrimeView Dashboard interface

Source: Omega Group 2015

Another innovative tool used by SDSD operating officers and analysts is **Angus**. This system operates in the monitoring mode, which enables real-time monitoring of police vehicles. In this mode, number of unit and case currently dealt with is stated. Also, figures pertaining to the speed of police cars can be observed. Other data can be viewed, such as current traffic, traffic CCTV and the distribution of houses and land lots in an area. This system forms part of cooperation at the operating level of several groups involved in the operating management of the police. Analyses also work in the opposite fashion. It is possible to focus on a specific offence and, in relation to it, acquire information about police units participating in the operation. It is possible to make use of different conditions and filters which define the focus of the specific analysis. This system is adjustable by the user and is not exclusively targeted at police forces, as it can be altered for commercial purposes. Still, in spite of a variety of implementations, the system serves one single purpose, which is higher effectiveness of management and financial savings.

Another item in SDSD portfolio is **Insider**, a system for operating useage of detailed information about buidlings in San Diego county. Insider contains 5-6 thousand house blueprints, floor plans, situational plans, photographs of interiors, 3D models of rooms and their arrangement, in some cases also including the arrangement of furniture. It is a helpful instrument in special-force operations involving kidnappings, or in operations of the fire brigade. Using Insider, the units can easily find orientation and distribute their resources depending on the situation. This software can be configured and connected with other tools, for example *Google StreetView*, as is the case in SDSD.

All San Diego police forces operate in a unified platform in their analytical work, which is **ArcGIS Desktop** and its extension **CrimeAnalyst**, both ESRI products. In this software, they create thematic maps. An important activity is the preparation of missions, focused on a specific crime-related issue. Missions are planned using hotspots focused not only on public crime but also its specific types. This enables police officers to concentrate on particular targets, specifically on offenders. It is underscored that GIS tools bring a supplementary source of information which add to traditional methods of investigation. The tools used facilitate elementary analyses which show the place and time where and when crime occurs. In addition, some of these system utilise innovative approaches which can provide an in-depth analysis, focus on offenders not only at a group but also at an individual level.

Practical usage

The immense benefit of CrimeView Dashboard is perceived in the simplification of actions not only in the general context of patrol management, but also in the analysts' work. Using automated functions, the basic processes can be prompted since they are an indivisible, though simple, part of conventional analytical methods. Eliminated is for instance the necessity to prepare and process data prior to the use in special software, as well as convoluted setting of executed analyses. Nevertheless, these modern automated tools are not suitable for all users and purposes. As regards data processing by statistical software tools, San Diego police forces do not concentrate on this area. From time to time, correlation analyses of relationships between phenomena are carried out, still on an occasional basis. Emphasis is put on simplicity of analyses and clear, accurate results, which serve as pieces of information for officers and as materials for orders to officers, knowledgeable about their territory and its conditions.

Each headquarters in San Diego county is divided into smaller subunits, each of which having a local station, managing its area in accordance with specific requirements. Consequently, a variety of maps are used. Some areas in the SDSD jurisdiction are characterised by high crime-rate. However, there are a number of areas in the mountains or deserts, which are not densely populated and therefore not high in crime. These are typically inland areas, as opposed to densely populated areas, which are found on the coast. Analysts frequently scrutinise multiple areas. Therefore a whole range of types of housing is found there, commencing with the populated ones, presenting a security risk, ending with rural areas, where crime is but a marginal issue.

Across police forces, a system for data-sharing through a centralised database was built. This was achieved after the establishment of the **Automated Regional Justice Information System (ARJIS)**, an agency in charge of the communication and operation of a platform generating the data-exchange process between 110 law-enforcement agencies. These include, for instance, city authorities, local police forces, federal police, Sheriff's department or fire brigades. In terms of these organisations, a total of 48 interfaces are used. It is ARJIS that enables the interconnection of this information used by the parties in question. The user-friendly system allows for numerous settings of areas where selected statistics are shown on the basis of one's own consideration. Locations and information about traffic accidents, offences, fines, or identifications of searched number plates can be displayed. Also a warning can set off should a wanted person be identified. The system therefore markedly contributes to effective monitoring of the situation and to a reactive approach at the both local and regional level. The organisation administering ARJIS is also responsible for the analyses and preparations of legislative measures, which need to be carried out for the sake of legal authorisation of data sharing and disclosure.

At each department where members of the analytical unit are positioned, strategic meeting are held every week. Analysed are individual interventions and the current state of different types of offences. At the moment, analytical units are not in the state where they would be actively using predicted missions, which offer CrimeView Dashboard as a functionality. So far, such tasks are obtained directly from the chiefs, which is a common practice. As regards the particular use of predictive missions, these can be observed mainly in the San Diego Harbor Police Department. The chief considers these predictions when planning police patrols, consulting the areas with the officers on regular sessions. It is therefore not a planning based solely on an analysis.

Materials created by analysts using modern tools for data analysis are, due to intranet and mobile connection with patrols in the field, used for the purposes of all officers based on their role. Applications such as CrimeView are launched on local servers controlled in the SDPD building, and users thus use them remotely after logging in through data- and application-capacities during their work. The content of the services differs according to the role of the user. This approach was established as a standard of SDSD, SDPD and other cooperating police forces.

Case study / application effects

The effectiveness of the implemented system was not measured with respect to crime rates. However, it can be identified in connection with time savings in terms of analytical operations, which was demonstrated by a concrete example. A routine investigation of property relations required going through a number of sources of information, which lasted about four hours. Now, a system is available which enables a comprehensive gain of the information. In addition, the officer obtains supplementary information from a variety of sources, which results in a process requiring mere eight minutes. It has been calculated that the investments, associated with the implementation, are returned in 18 months in time savings should the employees work under ordinary circumstances. The benefit is not only the saving of time, however. It also saves the mental capacity required during ordinary activities. The employees thus have room for other tasks.

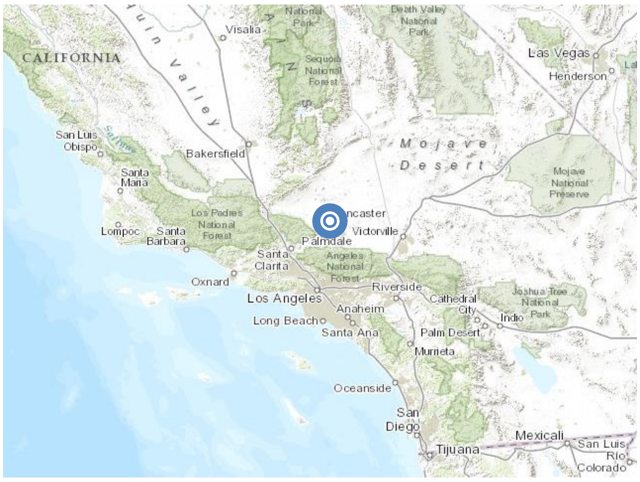
Summary

San Diego is an example showing the elaborate system of cooperation between different actors ensuring public safety. The ARJIS agency played a key role in achieving this state. It provided the solution of crucial areas of interest in integrating modern tools for analysing and sharing data among individual users. According to the San Diego police forces, the advent of analytical work brough about widespread changes to the organisation of work, which begin with the change in the mindset regarding the tactics and methods of policing. Major changes can not dispense with adjustments to information infrastructure and a new operational structure. Such changes are long-lasting and are associated with extensive investments. In the long run, however, it is assumed that the costs will be returned in financial resources that would be connected with new offences, which are effectively prevented.

8.3.3. Lancaster

The city of Lancaster is an example of using common tools for analysing and visualising data which can help reduce crime, without the need for costly predictive tools. An exemplary model is also the cooperation with academic workers, one of whom is the head of the group of analysts, whose opinions, stances and practical experience are mentioned below.

Basic information abou the city/region



Source: ESRI, basemap ArcGIS Online 2015

Lancaster is a city situated in Los Angeles county, California, with a population of 159,523 (The U. S. Census Bureau 2013). Its size is 244.2 km^2 and its area is located approximately 100 km north of Los Angeles. The city is characterised by its considerable numbers of Hispanic and Latino population (38% in 2010, The U. S. Census Bureau) and also more than 20% of African Americans, more than double the size of the California average (6.2% in 2010). Lancaster population is one of the fastest developing in the USA. Its population rose by 40 thousand between the years 2000 and 2013 (Lancaster 2015). It is the composition of the fast growing population that can be one factor having an impact on the safety in the city.

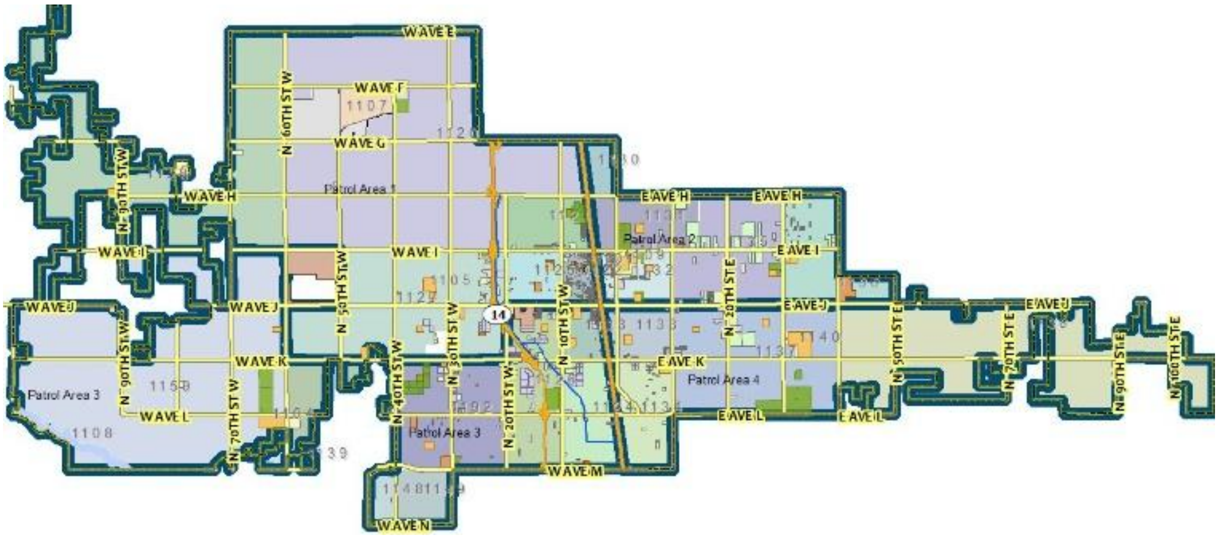


Figure 74: Police divisions of Lancaster, California

Source: Lancaster 2015

Information about the organisation

The **city of Lancaster** is characterised by its absence of any police department. Policing is authorised by a contract with **Los Angeles County Sheriff's Department**, which is the fourth largest police force in the USA, and which provides the services of 98 police officers to the city. In particular, the city is located in the jurisdiction of the northern division of the force, along with Malibu/Lost Hills, Palmdale, Santa Clarita Valley and West Hollywood.

Initial situation

As most cities, Lancaster also had to face budget cuts, which also had an impact on financing of city security – the services provided by Los Angeles Sheriff's Department. Complicated decisions about what steps should be taken to achieve the maximum effect with limited resources led to cooperation with experts from the field of crime analysis. Consequently, a team of analysts was hired, whose task was to make use of modern methods and create materials for better comprehension of crime patterns and strategic decision-making.

A milestone in the process was the implementation of data exchange system, which took place in the 1990s. Before building databases connecting individual cities, Lancaster had no access to the information of Los Angeles Sherriff's Department. This change in approach enabled cities to use high-quality data.

Large-scale processing of data began, which would have been impossible before. The network was launched due to connected FBI databases of large cities, continuously expanded.

Projects undertaken

The team of analysts hired by the city of Lancaster is responsible for preparing outcomes and materials used for decision-making in strategic planning of the city. These materials are also used by police forces for their planning. The team regularly generate reports including detailed statistics on crime in the city, graphs, tables and mainly map output. They prepare maps of high-risk areas with various forms of visualisation, from heat maps, through localisation of high-risk areas using grids, to traditional visualisation by means of cartograms.

The following images illustrate outcomes created by Lancaster analysts. Figure 75 presents crime occurrence (absolute values) analysed and visualised in the grid of the city of Lancaster. Basically, it is the method of grid thematic mapping, i.e. the use of a grid with a certain amount of localised points. Rectangular network of streets is practical for an accurate divison of patrol actions in the given areas.

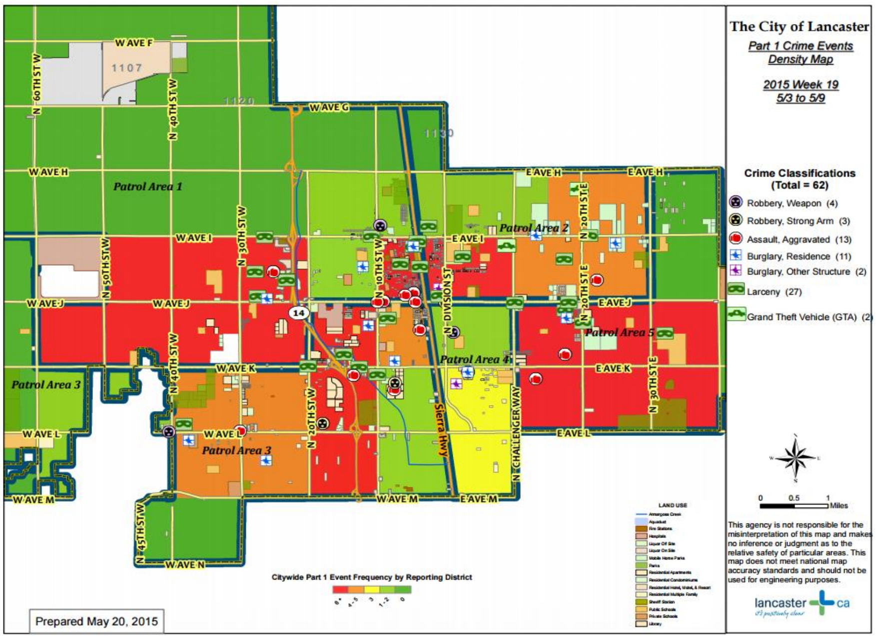


Figure 75: Crime occurrence in the grid of Lancaster

Source: Lancaster 2015

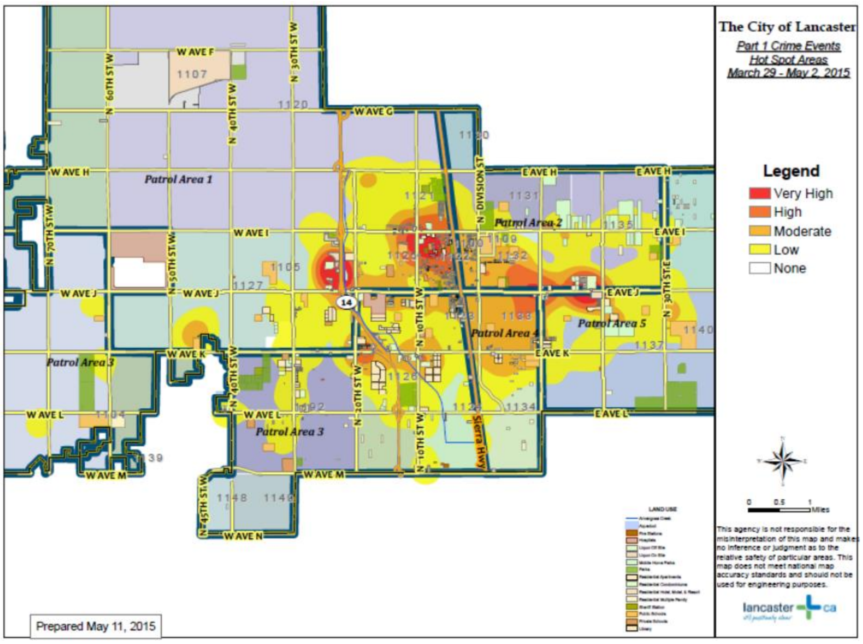


Figure 76: Crime hotspots in Lancaster

Source: Lancaster 2015

Another example is a map formed by squares which symbolise areas with the highest density of crime. The analysis is also based on a grid, similarly to the previous example. In this case, however, a continous field of cells were used, of which those with the highest frequency of incidents were selected.

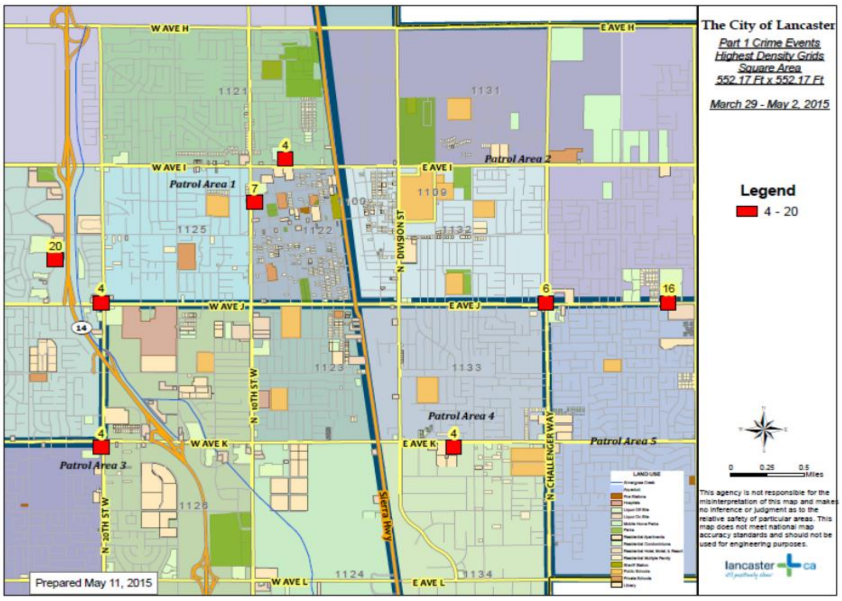


Figure 77: Crime intensity in Lancaster using a continual field of cells

Source: Lancaster 2015

The following maps illustrates a crime prediction based on analysis of historical criminogenic data. It also makes use of a rectangular street network. A detailed description of the preparation process of this map is unknown.

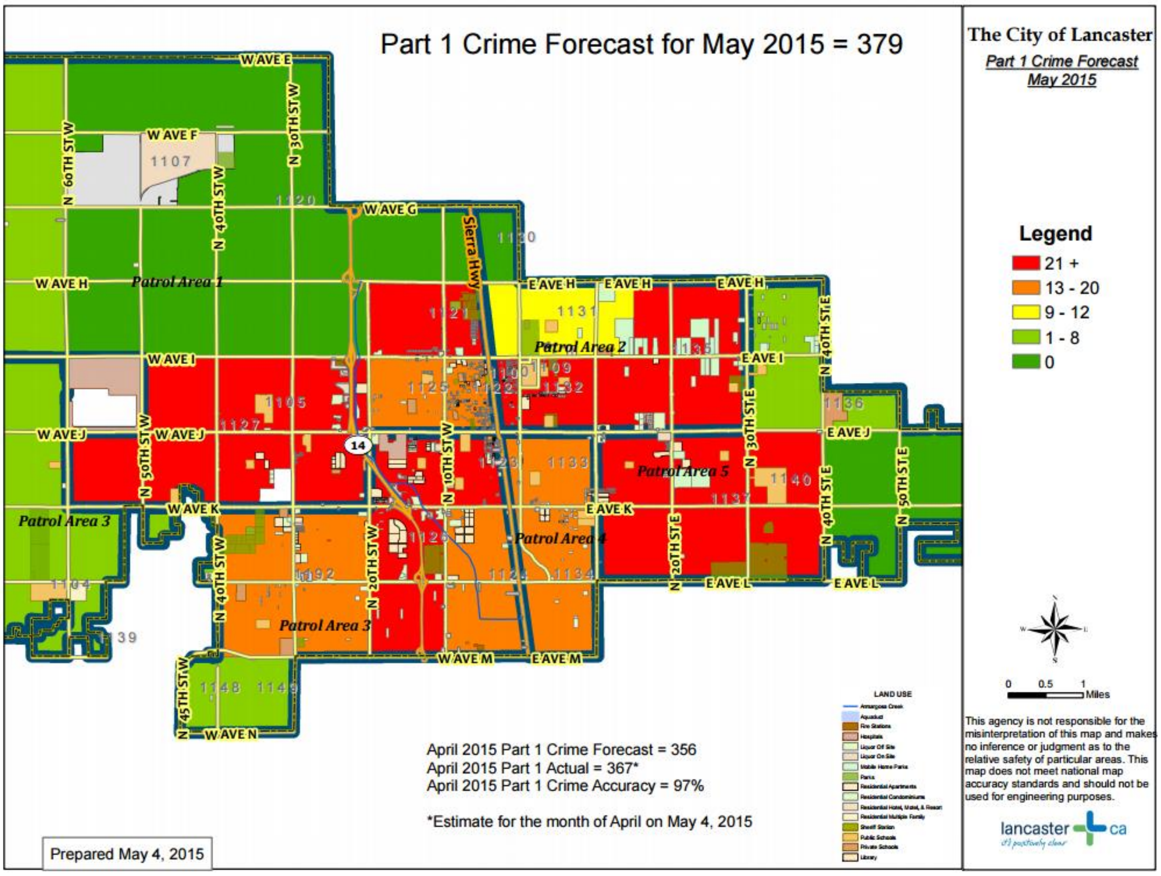


Figure 78: Crime prediction in Lancaster

Source: Lancaster 2015

Another output of the analysts (Figure 79) indicates the change in distribution of crime in January-February 2013. It is a heat map which visualises areas with a relative increase in crime in red, and decrease in crime in green. The rest of the area remains relatively stable.

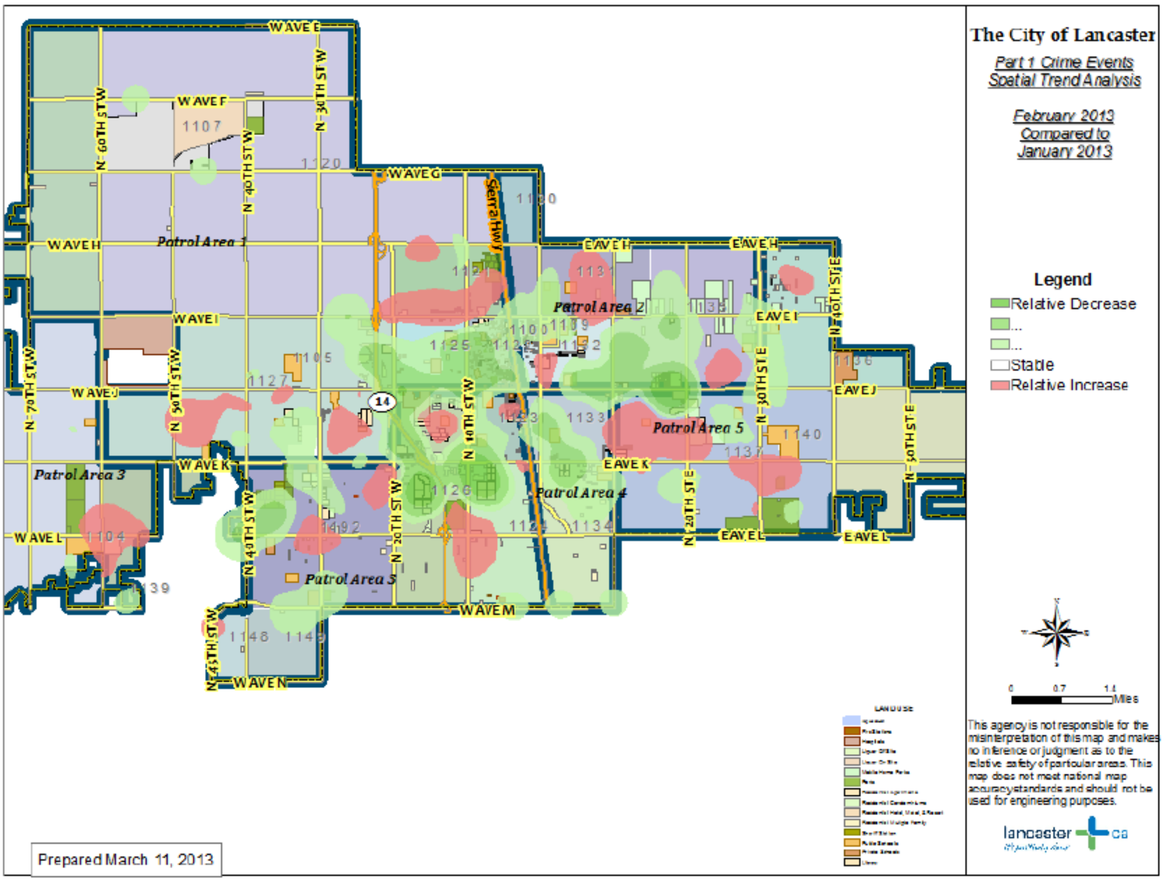


Figure 79: Heat map of crime development

Source: Lancaster 2015

Lancaster analysts focus mainly on Risk Terrain Modelling, which allows for an in-depth analysis. The head of the section appreciates the fact that buildings and this in general remain in stable positions, and the only objects moving are people around them. As mentioned, the most frequent offense in Lancaster are thefts. High-risk spots were identified, such as bars, petrol stations, malls, restaurants or carparks. The location and risk factor of these places can be used as a variable. The city focused on the most critical places and started negotiating with the owners of facilities where primary preventative measures were to be applied. Their cooperation with the police and city is thus necessary. So far, it has been successful.

Lancaster analysts have been carrying out analyses of the demographic situation in the city. Basic knowledge and understanding of demographic and distribution of inhabitants is crucial for generating crime analyses. It is also a key factor for understanding and proper interpretation of outcomes of analyses and connections. Hence also demographic data is used in analytical work, and the source of this information is usually the census. Another complementary source of data used by Lancaster analysts was data about water consumption, provided by water management, which helped track demographic changes through regression analyses. Other data is obtained from different sources, such as witness testimonies, statistical offices, weather forecasts or public events. Analysts also use a number of specialised basemaps, such as urban maps, maps of built-up areas, street network or thematic demographic maps.

A suburban area, Lancaster suffers from substantially different volume of crime than larger surrounding cities. Originally, an algorithm was to be used in analytical models, which had already been used in other cities. It was found, however, that due to the specificity of Lancaster, a new model would need to be developed. The implemented tools needed validation, and other experts in modelling tools for security purposes were invited to cooperate. For the sake of complex understanding of the situation, a huge volume of records were digitalised, going as far back as 2000. Models used for analysing crime were developed using these historical data.

In the process of generating analyses, data from Los Angeles Sheriff's Department is used. Databases utilised are updates on a regular basis. However, Los Angeles Sheriff's Department is not in possession of technology which would allow it to carry out these tasks in the field. Data is therefore fed in manually, after a police officers has arrived at the police station. The updates are thus applied with a one-day delay.

Application

Analysts in Lancaster use traditional methods and tools for processing, analysing and visualising data. The utilised tools are **ArcGIS Desktop** from ESRI, **IBM SPSS Modeller** and **CrimeView Dashboard** from OMEGA.

The IBM SPSS licence is used for generating analyses of available data and tracking patterns in this data. The following types of offences are observed: murders, rapes, assaults, domestic violence, arson, burglaries, thefts, car thefts and pickpocketing. Each of these categories has its own criteria to reduce the occurrence. Combining more variables, analysts can use statistical methods to identify correlations between phenomena and thus arrive at conclusions resulting from these relations. ArcGIS processes data by various categories and visualises it in specialised thematic maps.

CrimeView Dashboard is a modern complex system used mainly due to its promptness of analyses, which can be generated with automated or pre-set functions. Generation of outcomes is therefore quite efficient, and their design can be set according to one's requirements. This system performs spatial queries with data from police database, maps of crime density in an interactive map field, which enables zooming a situation in different sizes. Another function used are data filters according to various criteria and time, generation of analyses and statistical output with this data. Thereby regular overviews are generated, without the need to engage a user. The system generates this material automatically on the basis of former user settings. Also analyses can be launched automatically, as well as the system of automatic warning should it detect unusual situations. Compared to ArcGIS, however, the variability of analyses and detailed setting of individual steps is far from optimal, which is why these tools are irreplaceable in some operations, and CrimeView Dashboard is a complement of verified processes.

The software as well as associated services are hosted on external servers, which were already in place, that is why the implementation did not bring any significant requirements as regards hardware. Only additional investments include training for analysts who learn new approaches and are therefore trained to properly understand new situations. They are trained in statistics but also in using software equipment. Also, external experts are invited to cooperate, providing consultations and professional advice to analysts.

Practical usage

Prior to the advent of analytical work, the year 2008, the police had been dealing with crime related to gangs. When analysts focused on data, they saw no significant connections with gangs. It was found that the major problem in Lancaster are thefts. Data thus allowed for identification of the real situation. Interestingly, a decreasing tendency in crime was seen since 2006, which, however, was identified by analyses of data back in time. Real causes of crime were thus defined and measures leading to a larger decline in crime established.

Lancaster in conjunction with Los Angeles Sheriff's Department tried randomly locating patrols to 15 beats and they investigated the effectiveness of tracking their movement. It was found that their presence made no difference to crime occurrence. Having applied a reverse strategy, directive management of resources, this approach proved highly appropriate. This is the advantage of predictive systems. It is possible to say, however, that software tools merely validate results of research and analyses, which are considerably cheaper and which have often already taken place. This is why traditional analytical methods are emphasised. According to the head of the team, it is vital to use the method of Risk Terrain Modelling, when each input of new data and each small change means that the model of risk terrain develops while running.

The head of the team highlights that it is important to realise that maps are a perfect means of visualisation, but they can merely show when and where a given phenomenon occurs. It fails to provide an answer to the question why it occurs. This is the problem of some tools and predictive and ordinary analyses. Police officers need to know why a certain type of crime is happenning. Knowing this, they can respond to a situation properly, implementing preventative measures. Therefore a comprehensive view of the situation is necessary, which can be acquired either by analysing of complementary information, or by own experience and knowledge of the context. This opinion emphasises that fulfillment of the sense in using spatial analyses goes hand in hand with the human factor.

Analyses can be used not only by police forces, but also by city representatives, who can use the materials for strategic planning of the city. It was the city representatives of Lancaster who gave the primary impuls to implement a new approach based on analytical work. Apart from creating strategies, city representatves also use these materials in the political context. By contrast, the police are interested in the high-risk areas, rather then the general situation.

Sharing detailed crime data and information is not supported by Lancaster. The publically available data is just general figures which can be downloaded in weekly reports along with the maps from the city websites (*cityoflancasterca.org*). These reports are published regularly with a time delay. As regards the information value, compared to materials provided in other cities, they can be considered above standard.

Case study / application effects

Owing to a team of experts in data and spatial analyses, the city of Lancaster developed a functional system of predictions analysing data using a set of several software tools. A personalised model was developed, and the results of policing, measures after its implementation, illustrate a decline in crime by 35% in 2010, compared to 2007, which was the first year when a decrease in crime was observed. In 2011, the drop in crime reached 42%. In absolute numbers, 449 offences per 10,000 inhabitants were recorded in 2007, in 2012, it dropped to 208 offences per 10,000 inhabitants.

What the city representatives consider crucial in this decline is not only the implementation of analytical tools, but also the creation of demographic analyses, which precede crime analyses. Mutual connections between the demographic and security situation are substantial, and to understand one part, it is important have a knowledge about another. Effective prevention is thus targeted more easily. Financial benefits were not calculated precisely. However, it is estimated that savings related to crime reduction amount to $ 1.5 million per year.

Summary

The team of analysts can use criminogenic data from the past 15 years (2000-2015). It is very good quality data whose use in combination with appropriate software tools and knowledge of suitable processing methods and data analyses brings positive results, even without the need to expend large sums of money. Implementation of an expensive solution does not guarantee the desired result.

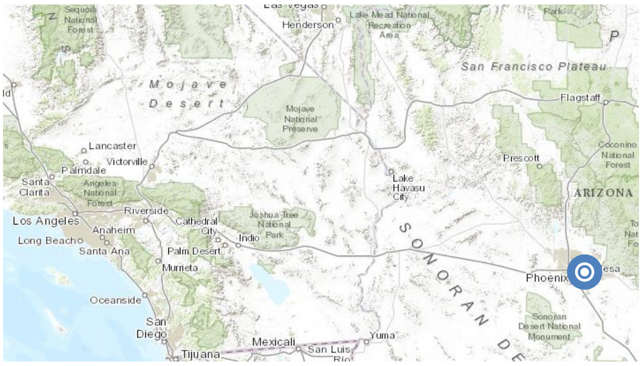
The approach selected in Lancaster is primarily based on analysts' expertise. With properly qualified staff, it is possible to carry out research and apply scientific knowledge. It is therefore necessary to cooperate with academics who are capable of detailed understanding of methods, tools and algorithms, as well as to have specialists with experience from the police in the team who can place the analyses into a criminological context. Many departments have workers who are incapable of carrying out these tasks, which is why they are performed in a bad way or not at all.

The city of Lancaster is an example of a cooperation of multiple actors, who are either responsible for the situation in the city, or influence it. Owing to the analyses carried out by the city, the highest threats are identified. Also, cooperation of these actors who join forces in setting preventative measures is established. It is a collaboration of police forces, city representatives, social services, entrepreneurs, landlords, businesspeople and others. Representatives of the city realise that security is everyone's, not just police's responsibility. The cooperation thus makes a positive impact on the safety in the city.

8.3.4. Tempe

The visit to the department of crime analysis at the Tempe Police Department was inspiring regarding the general view on the role of spatial analyses in crime prevention, but also from the viewpoint of a combination of several tools for creation strategic and tactical analyses of the police.

Information about the city/region



Source: ESRI, basemap ArcGIS Online 2015

Tempe is a city in the Maricopa County, Arisona. Its size is 103.4 km^2 and population 168,228 (in 2013, The U. S. Census Bureau). The population of the whole agglomeration, which also includes Phoenix, is more the four million. In the city is situated one of the largest campuses of the Arisona State University, where a large number of minors study (according to Tempe data more than 60 thousand students). Their concentration can be a factor influencing the security in the city.

Information about the organisation

The body in charge of policing in Tempe is the **Tempe Police Department**, which according to official websites (Tempe 2015) employs 491 police officers and civilians. Its budget exceeds $ 60 million (2014). For policing purposes, the city is divided into six zones (see below). Tempe also carries out a volunteer program, which extends and consolidates the services of the local police force. Currently, more than 125 volunteers living in the city – students, pensioners, but also full-time employees – participate in this program.

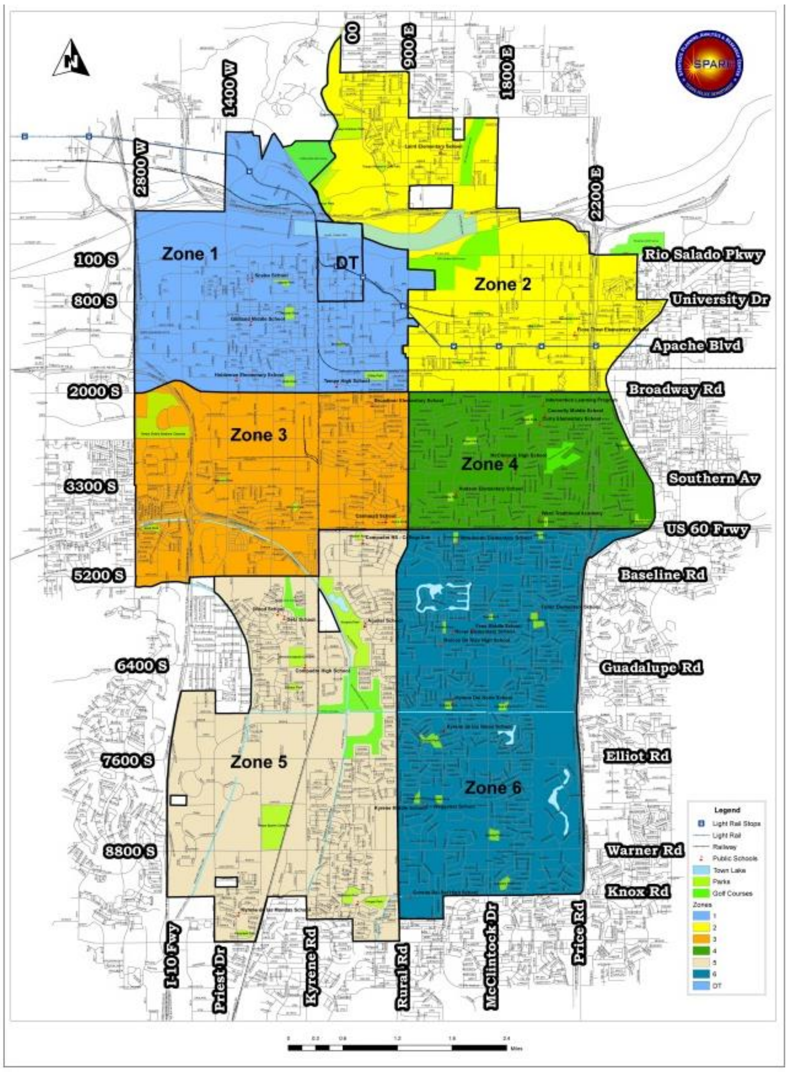


Figure 80: Police zones in Tempe

Source: Tempe 2015

Initial situation

Police Tempe employs 260 police officers. Although the city is considered relatively safe, there are areas where crime is an issue. One of the six areas suffers from 40% of reported crime. Analytical methods can visualise this spatial distribution. Measures can be taken as a result, leading to an effective tackling of the situation. Every year, a new strategy is devised. It should determine to which areas a certain number of officers should be allocated and what they should focus on. Should any changes occur, this tactics can be adjusted on the basis of further evaluations of the situation, processed by the department of crime analysis.

Projects undertaken

Tempe police has a **department for crime analyses**, which is composed of two centres concentrated to different types of crime analyses. **Strategic Planning and Research Center (SPARC)** focuses on long-term crime analyses, including analyses quantifying the administrative part of police work. Other activities performed by SPARC include generation of spatial analyses of emergency calls, generation of reports, evaluation of police programmes, department of strategic planning, analyses of patrol location, administration of GIS equipment and map layers, criminological research and creation of statistical studies. The second centre is **Crime and Intelligence Center (CIC)**, which deals with short-term crime analyses, real-time analyses, tactical analyses, processing of trends and crime patterns, providing information to investigators, creation of predictive analyses, securing the flow of information among the individual operating groups and other activities. All specialists working at the deparment of crime analyses are highly qualified in different areas (criminology, geoinformatics, statistics, data analytics, etc.). From the viewpoint of crime mapping, analyses and predictions, GIS form the main unit of the staff who specifically focus on applied statistics, spatial data analyses and programming.

Case study / application

Analysts use for processing and storing data programs **IBM SPSS,** the set **Microsoft Office** (Access), **SAS** and **ODBC Connection Manager** for databases.

After analyses and data processing, maps and other output is created with the set of **ArcGIS** tools, developed by ESRI. ArcMAP generates maps of crime intensity applying the kernel density method. The result are hotspot maps. Crime intensity is also visualised in cartograms. Such output of spatial analyses is produced and evaluated on the basis of four-year experience.

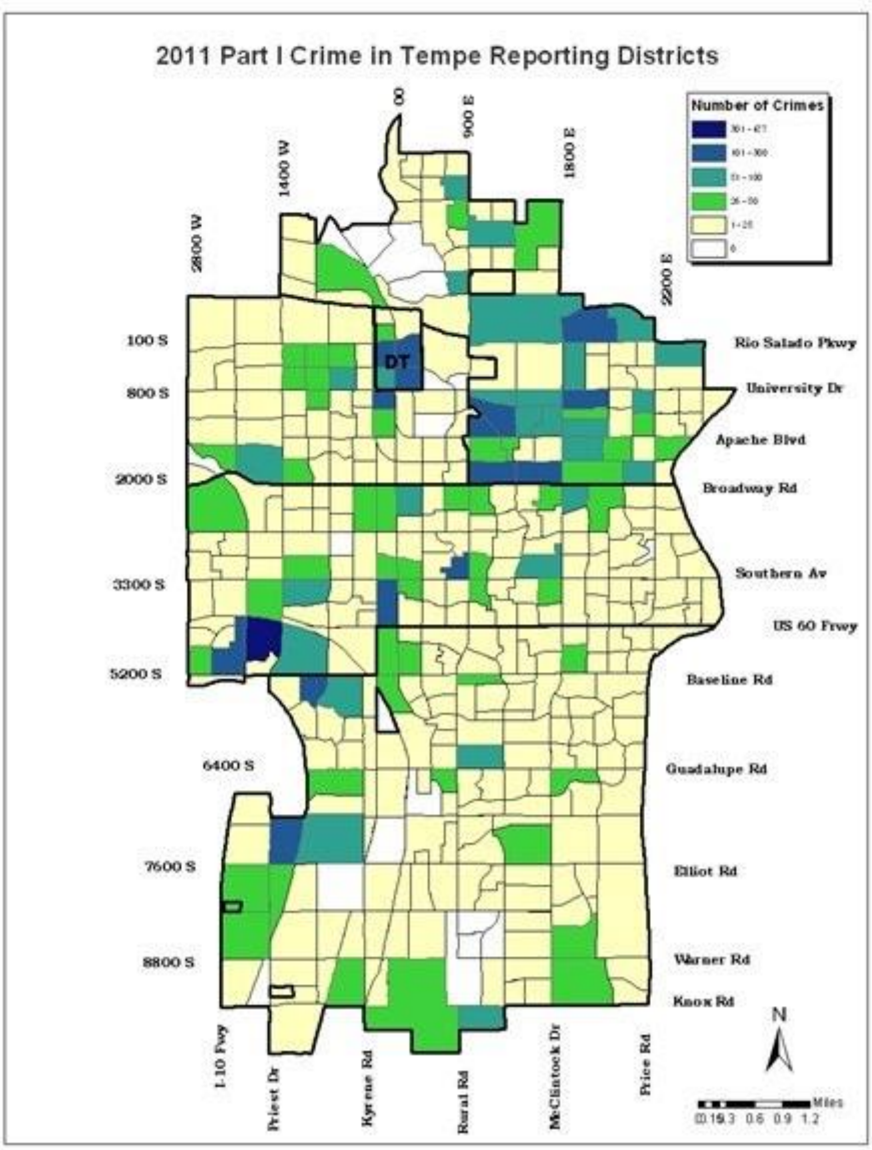


Figure 81: Crime-rates in parts of Tempe

Source: Tempe 2015

Similarly to other US cities, the police in Tempe use **CrimeView Dashboard**, which analysts consider contributive due to its functions, such as overview statistics, thematic, spatial and temporal selections and visualisations of crime, and other common functions. The police in Tempe also use planning of *Located Based Missions*, which enable establishing and focusing on user-defined goals and current issues.

Another system utilised is the application **ATAC** (Automated Tactical Analysis of Crime), aimed at predictive analyses, crime mapping and generation of reports. This application is helpful in terms of identifying causes and relations contributing to the occurrence of crime. It also included data mining tools and a communication platform for sharing and publishing results of analyses. Tempe police use this application to create information cards, which reflect on the current situation of crime in the city. These cards are generated using data from the central database of offences. It is, however, a complementary tool used for internal purposes. The information it includes can not be shared publically.

Compstat is a tool used to track statistics of police forces. It includes comparative statistics which contain spatial information, temporal information and historical context in relation to crime occurring in the area of the Tempe Police. These statistics are generated on a weekly basis, and every month a comprehensive report is created for the management of the police. The report contains overviews of a situation by individual types of crime, coordination, division of the city into individual zones and the situation presented in tables, graphs and statistics. On the basis of a COMPSTAT output, also police officers are evaluated. No evaluation by person is used, however. The units are assessed as a whole.

Mapping and gathering data on crime is done in the field by officers who use tablets and smartphones which, besides aministrative work related to investigation, are used to communicate with an operating officer. Police officers in the field can thus obtain information either by themselves or by receiving it.

Practical usage

The deparment of crime analysis processes reports (bulletins) which are then submitted to officers and serve as materials for decision-making. These reports provide current statistics, development of situation and maps in different scales, which provide a spatial view of the situation. Generating these materials is the main day-to-day work of the analysts. It allows for seeing not only the development of crime but also crime series, when analysts concentrate of a specific type of crime. Analysts utilises, among others, the methods of risk terrain modelling and geographic profiling. It is therefore possible to blend knowledge and information. Owing to an empirical experience, a list of potential targets of crime can be created, on the basis of which potential victims can be contacted by the police. In this way, the police apply preventative measures.

Besides criminogenic data, the analysts also work with data on emergency-call reports. It is a secondary source of information which is indicative of how to work with the public and how to inform the public about the police work. In turn, this could raise public trust in the police and thus feeling safe. Every week, the Tempe police registers approximately 1,700 reports, although only in 15-20% of cases it is a crime. Actions leading to the rise of public awareness is considered crucial in order to raise the effectiveness of policing as well as save costs expended on often unnecessary actions.

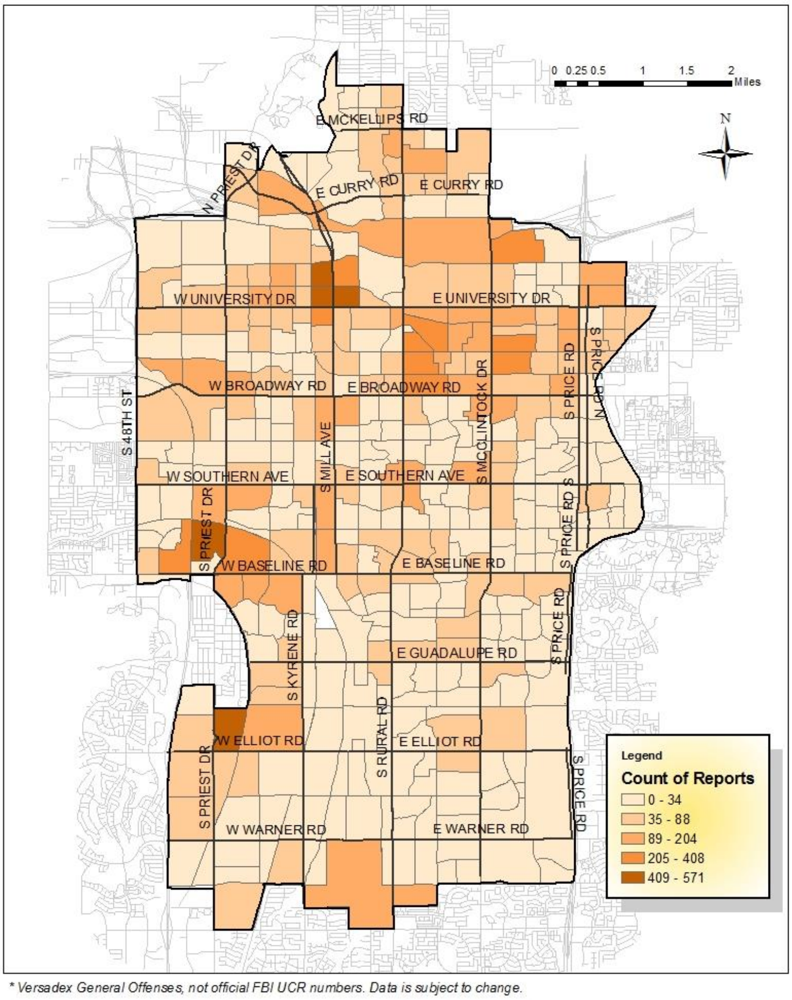


Figure 82: Reported crimes in Tempe in 2014

Source: Tempe 2015

Every year, an annual survey is done to obtain public feedback on the activities of law enforcement. It is, however, not focused only on the work of the police, but also other agencies, such as fire brigade or emergency services.

Sharing of crime maps and statistics is performed via a *Tempe Loud Party Report*, posted in the city website (*tempe.gov*). Another form of sharing crime data is a publically available mapping portal **Raids Online** (*raidsonline.com*), which provides the user with various filters, such as time period, types of crime or basemap layers. The users can customise the setting and view a dotted location of crimes. In the selected scale, the density of occurrence of specific crimes can also be calculated. The result is a hotspot map (see Figure 83). In the hotspot map in question, all types of offences over a one-month period were calculated. This approach to publishing information is not limited to Tempe and the agglomeration of Phoenix, but it is also used in a number of cities in the United States of America.

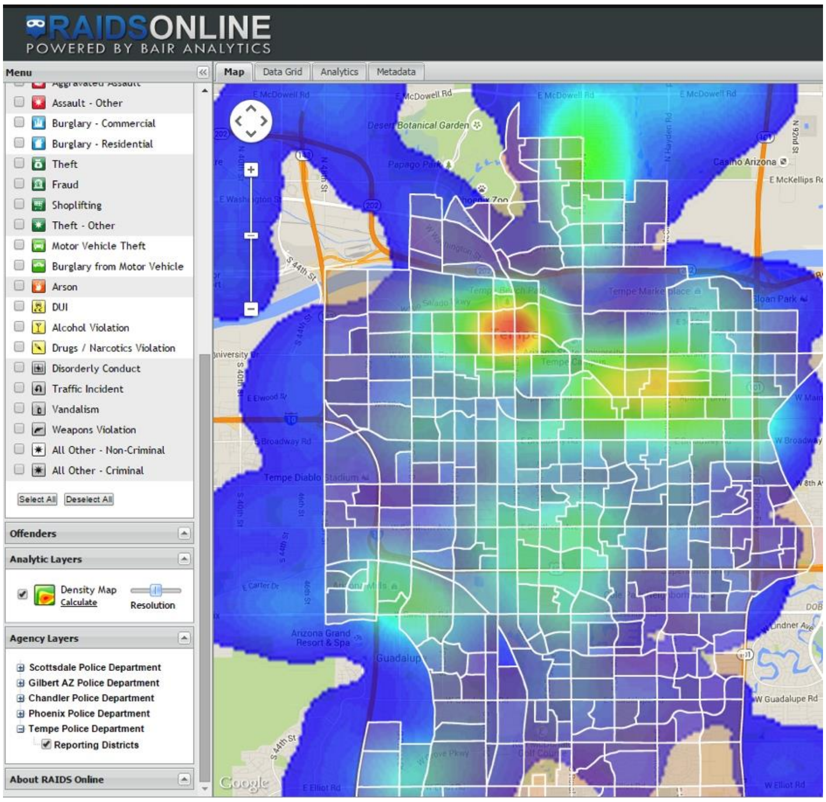


Figure 83: Hotspot map of crimes in and around Tempe

Source: Raids Online 2015

Case study / application effects

Prior to the implementation of modern analytical methods, the primary goal was to reduce the occurrence of crime in the area of Tempe by 5% every year. Originally, crime intensity in selected areas was in focus, as Figure 84 illustrates. Later, kernel density began to be used. In terms of this method, hotspots were identified and strategies and targets defined to reduce crime in the most problematic areas. In 3-6 months from the implementation of these strategies, the rate of burglaries in high-risk areas decreased by as much as 12%.

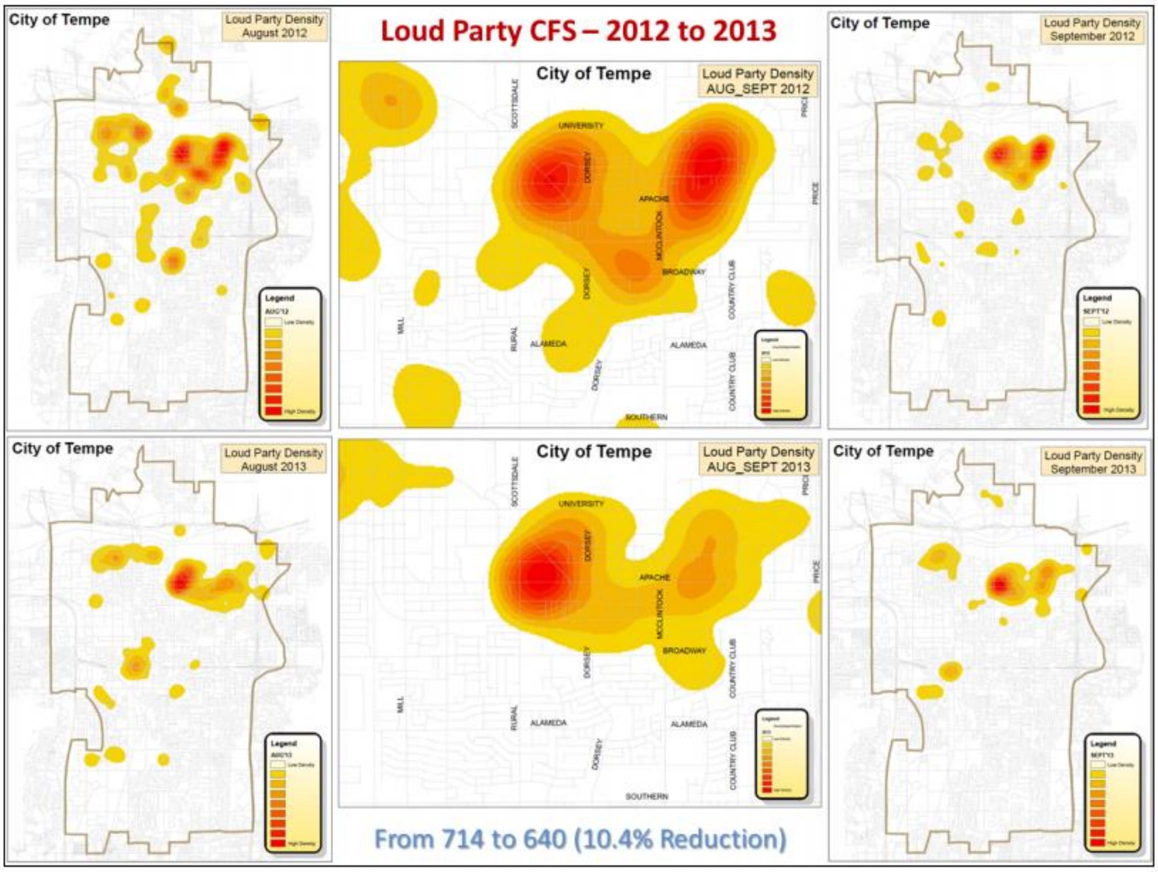


Figure 84: Hotspot – loud party report

Source: Tempe 2015

Summary

According to the head of the analytical department, what is crucial for the police is the organisation of command. It depends on the police management how they will approach it and what methods they want to lean on. In general, police officers know very wll where in their beats crime occurs. What they do not have sufficient knowledge of, however, are the connections. This is where analytical methods could help. Spatial perception of crime is important for a complex understanding of its essence, origin and behaviour. Using analyses, different measure can be taken leading to either repression or prevention of crime. At the same time, he says that to make full use of analytical work, it is vital not to underestimate the human factor, hunch and expertise. These are the fundamental aspects of a successful analytical work which no automated systems can replace.

8.4. AUSTRIA

Visit to Austria brought new knowledge about the nationwide system of analytical police work at the level of each federal state, represented by the state of Styria. Also, approaches applied in the capital of Vienna are described. In addition, a description is provided of the Criminal Predictive Analysis project (CriPA), which was developed through a cooperation of multiple Austrian institutions and whose outcome will be an independent crime-prediction system.

Main sources of information:	Personal meeting held on: *March 18th, 2015 - Joanneum Research, Graz* *- Landespolizeidirektion Steiermark* *March 20th, 2015 - Landespolizeidirektion Wien* Proceedings of the first workshop held on December 10th, 11th, 2014 Proceedings of the second workshop held on June 10th, 11th, 2015 Internal documents provided by the reprentatives of the visited organisations
Persons involved:	Chiefs of police departments Officers working with the implemented solution Analysts and GIS personnel Universities and organisations involved in the CriPA project (Criminal Predictive Analysis)

Austria is a federal republic situated in Central Europe, occupied with its size of 83,879 km^2 by 8,507,786 inhabitants in 2014 (Eurostat). The country is administratively divided into nine federal states, fully identical with nine police regions. The average population in each region is 920,000 (Krulík & Lupač 2012). Namely, the states are: Vienna (the capital of Vienna), Lower Austria (St. Pölten), Upper Austria (Linz), Salzburg (Salzburg), Styria (Graz), Burgenland (Eisenstadt), Carinthia (Klagenfurt), Tyrol (Innsbruck) and Vorarlberg (Bregenz). [6]

[6] http://bezpecnostni-sbory.wbs.cz/clanky/1-2012/bezpecnostni-sbory_horisontal_eu_1-uvod.pdf

While Lower Austria is the largest, Vienna is the most populated state. The division of Austria into federal states is illustrated in the following map. Federal states are further divided into counties and statutory cities (Krulík 2012).

Source: ESRI, basemap ArcGIS Online, 2015

In 2005, the police force in Austria underwent a considerable reform, when three then existent forces - the Police, Gendarmerie and Border control - were merged a single National Police Force, *Polizei*, which abides by the national administrative division. As a result, there are nine state police directorates (in the case of Vienna a city directorate), nine state criminal offices and nine state traffic departments. The Austrian police force is also divided into 110 districts and 14 cities with state police directorates. Vorarlberg is the only state without such a directory. According to the international comparative study on police forces (2012), 27,613 police officers and 5,249 civilian employees worked for the Austrian police force in 2011. Also, the budget of the Austrian police force was the fourth largest (EUR2,353.7m), after France, Great Britain and the Netherlands. (Krulík 2012)

8.4.1. Styria

Information about the city/region

Source: ESRI, basemap ArcGIS Online 2015

The size of Styria, 16,401 km^2, makes it the second largest state, after Lower Austria. In 2015, its population was 1,221,014 (Statistics Austria). It is situated in the approximate centre of Austria, in the south-eastern part. In the west, it borders Carinthia and Salzburg, in the Norht Lower and Upper Austria, in the east Burgenland and in the south Slovenia. Historically, also Lower Styria belonged to this territory, which belongs to Slovenia these days. The capital of Styria is Graz. With a population exceeding 250 thousand, it is by far the largest city of the state. Population of other cities, such as Leoben or Kapfenberg, reaches 20 thousand inhabitants. (Das Land Steiermark 2015)

The natural centre of Styria is Graz. The city is the economic centre of the state, which has been focused on automotive industry over the past years. This industry replaced the former dominant coal mining and heavy industry, which also resulted in a high unemployment rate, migration of young people and general structural damage to Styria in the 1980s. The city of Graz is also a distinguised university city in the region. (Das Land Steiermark 2015)

Until 2013, the federal state comprised 16 counties. However, some were merged, resulting in 12 counties and one statutory city of Graz. (Das Land Steiermark 2015)

Projects undertaken

The department of criminal analysis with the Styria Federal Police Force employs two analysts and hires two external programmers used when necessary. In other states the situation is identical. The system of utilising software tools in all states is identical, using ArcGIS by ESRI for processing spatial data analyses and generating data analyses and maps. Some analyses of geocoded data and spatio-temporal analyses use the Geotime software. The most used software for generating maps is ArcMap and its extension Spatial analyst, which enables generating hotspots, a typical outcome of crime analyses.

Police officers with different expertise discuss analysts' demands in terms of mapping and crime analysis, as well as the need of proper materials. Having defined their demands, the team of analysts are using current methods or are creating customised applications generating required materials for police work. Some departments focus more on analyses of crime patterns and the development of crime, rather than materials for operating actions. Analysts and other involved police officers engage in crime mapping, hotspots, GPS mapping, distance analyses for a particular area, geographic profiling and other analytical methods. Generally, it can be stated that the basic portfolio of activities and output analyses is unified across Austrian states. The development of new analytical methods and approaches on the national level is done by the Central Information Service, whose team consists of three specialists dealing with geographic profiling and other analyses. This service also oversees operational and strategic analyses, develops new technologies, legal mechanisms and creates support as regards analytical work for all crime-analysis units in the individual states of Austria.

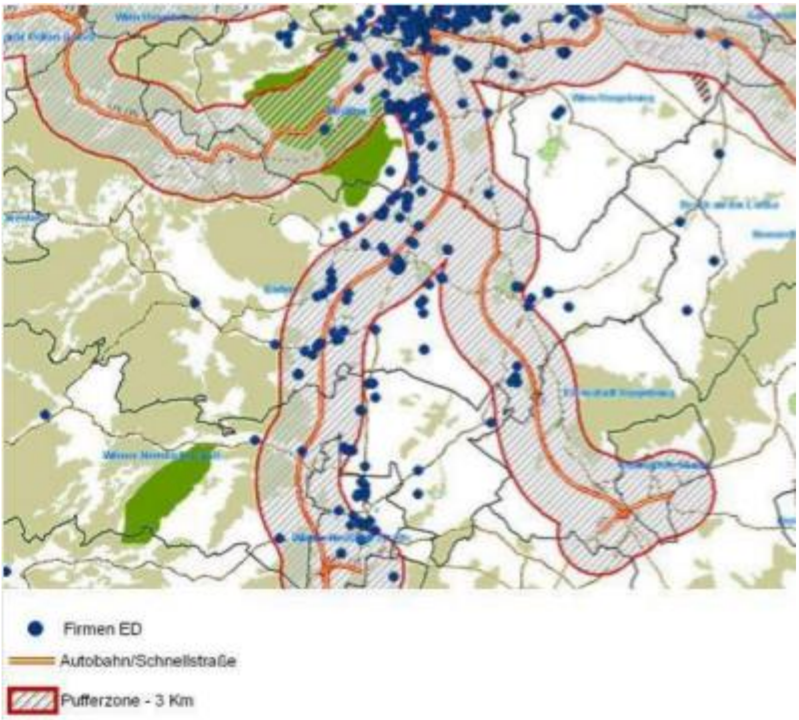


Figure 85: Crime occurrence along selected infrastructure

Source: Styria Police 2015

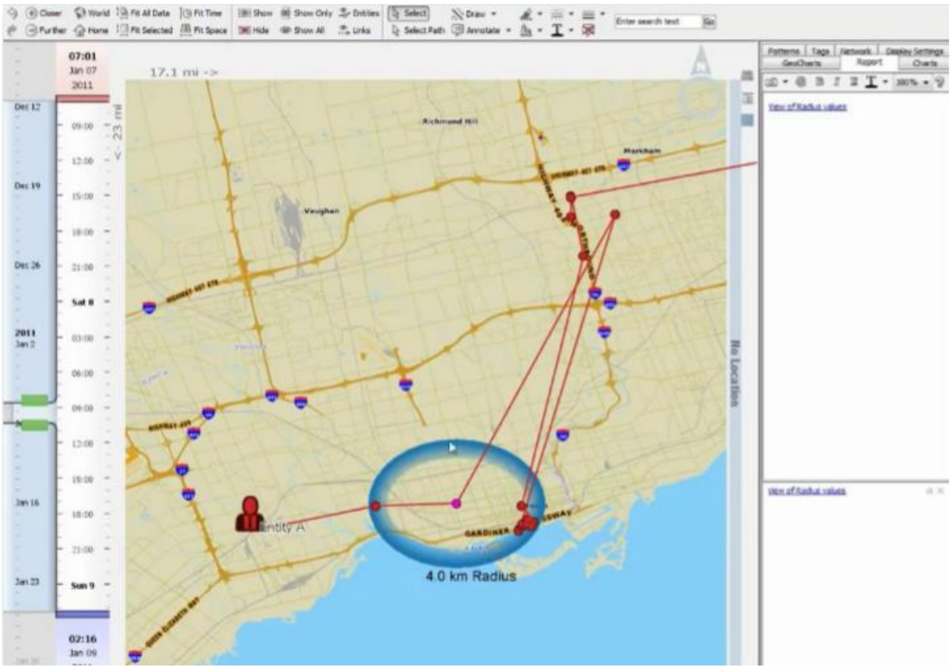


Figure 86: Perpetrator's behavioural pattern in GeoTime

Source: Styria Police 2015

Police analysts work with criminogenic data available in the official centralised database of felonies. Through an internal system, this database is available to all authorised police officers. Police officers in Austria make a record of a situation in the field, and feed this information into the system at the police station. According to internal regulations, it is their duty to return back to the police station after an accident, note everything down in the information system and then go back to the field. What is apparent is the absence of modern IT technologies, which would enable them to carry out these mapping and administrative tasks right in the field. Another data for analysts is provided by statistical office and self-government agencies. Sensitive information, such as addresses and other personal data, are available in a database from the Ministry of the Interior, to which the police is also accessed and can make use of it.

Practical usage

Information generated by analysts are used by the individual police units which defined their needs and appearance of the output materials. Usually, these are maps of crime intensity in a specific area with the possibility of focus on a specific type of offence. In practical terms, analyses describing trends of hotspot displacement are used, as well as analyses focused on particular crimes bound to a specific perpetrator or a type of a group of perpetrators. Observing patternsof development in time and space with sufficient knowledge of the issue and environment, it is possible to predict the future situation and respond timely.

As regards the expertise of analysts, the managemenf of the crime analysis unit in Styria holds the opinion that new staff need not be hired to cover analytical work; if, however, possible, a person selected from the current staff should be trained if having capacities to carry out such work. In terms of the Austrian police, analysts are trained by the Central Information Service, which organises courses led by professional trainers. Every two months, the managing staff take part in lectures abroad, thus acquiring new knowledge for their work.

As regards data sharing with the public, the opinion of the Austrian police is relatively conservative. Crime data is provided to the public only under exceptional circumstances. The reason is, similarly to other European countries, data protection. Even the Austrians say that this is a moot topic, and a key legal problem which hampers data exchange and sharing. This situation is similar to the Czech Republic as regards data exchange between the National Police Force and local police forces. Special police forces in Austria, such as anti-terrorist squad or anti-corruption squad, can require data from local police forces; the situation is complicated should the direction change, however. Generally, it can be said that the situation is improving, and in the case both parties are willing to cooperate and legal mechanisms enable it, the data is shared.

Case study / application effects

Management of the Styria police is aware that analytical and predictive work has an impact on the reduction of crime. It was confirmed in 2013, when the frequency of burglaries was analysed in areas with an increased risk, where patrolling was intensified. A crime reduction of 20% was observed. There are, however, no figures demonstrating the contribution of analytical tools to police officers' work. Generally, implementation of modern analytical methods can be regarded positive, which is supported by a reduction in crime after their engagement.

Summary

The Crime analysis unit in Stria has a team of highly qualified analysts working with the GIS. Their work is not routine since they have to respond to new demands, which causes the concept of analytical work in the Austrian police to develop. The level of cooperation between the individual analytical units of federal directorates of the states is outstanding. Analysts, as creators of tailored tools, exchange information and thus contribute to a more efficient work of their colleagues considerably. The entity behind the development and use of criminogenic analyses the Central Information Service, whose role in maintaining the functionality of the system is indispensable.

8.4.2. Vienna

Information about the city/region

Source: ESRI, basemap ArcGIS Online 2015

The capital of Austria is Vienna, with a population of 1,766,746 inhabitants in 2014, living on an area of 414.9 km^2 (Statistics Austria). Vienna is also a federal state,with the largest population, accounting for more than 20% of the Austrian population. The city is surrounded by the federal state of Lower Austria. The city is highly attractive for its residents. In life-quality surveys, it regularly tops the rankings; moreover, since 2010 it has been always announced as the city with the highest quality of life (Mercer quality of living ranking 2010, 2012, 2014, 2015).

Vienna is an important economic, cultural and political centre, where numerous international organisations have their seat, such as the Organisation for Security and Co-operation in Europe (OSCE). Vast numbers of tourists, who visit Vienna every year, present a challenge for the local law enforcement agencies. Vienna is also a multicultural centre as well as a centre of migration. Out of all inhabitants born outside Austria, more than 40% of them live in Vienna (Krulík 2012).

Information about the organisation

The capital has a specific position in the Austrian police system. The jurisdiction of the Vienna Police Force is divided into 14 beats (Brigittenau, Döbling, Dounaustadt, Favoriten, Floridsdorf, Fünfhaus, Innere Stadt, Josefstadt, Landstrasse, Liesing, Margareten, Meidling, Ottakring a Simmering). These beats do not conform to the administrative division of the city as some beats include multiple districts. (Krulík 2012)

Initial situation

According to statistics, there is higher occurrence of crime in Vienna than in the rest of Austria combined. This makes the idea of policing in general and from the analytical perspective rather specific, differening in some respects from the concept typical of each state of Austria. The most critical long-term issue of Vienna from the viewpoint of crime is a high number of burglarised cellars and robberies. The Vienna Police Force therefore primarily focuses on these types of offending. Other types of frequent crime the police are tackling are, for example, burglarised apartments, broken-in vehicles or pickpocketing. General crime is the largest problem in core, crowded areas. To locate areas with the highest risk and to map the current development, the Vienna Police Force makes use of spatial data analysis. At the same time, the police are also interested in the CriPa project, which they perceive as a contribution to their work so far.

Projects undertaken

Analysts of the Vienna Police Force have been working with GIS tools since 2003. The system of utilising software tools in all states is identical, using ArcGIS by ESRI for processing spatial data analyses and generating data analyses and maps. Some analyses of geocoded data and spatio-temporal analyses use the Geotime software. The most used software for generating maps is ArcMap and its extension Spatial analyst, which enables generating hotspots, a typical outcome of crime analyses.

At this juncture, there is no designated team focused on analytical work. The police specialists work in separate police units. Along with other national forces, the Vienna Police Force strives to focus on challenges for specialised units which define the need for specific outcomes. Creation of some outcomes is a regular activity, others may be specific, unique demands depending on their purpose. Analysts' work consists in generating tables and maps which reflect on the current situation, but also specific felonies. Data analyses are used to verify connections and information, followed by an assessment report on what the acquired information is usable for, how the situation in problematic areas can be solved and who will be reponsible for the actions. These reports are submitted to the police director, his/her deputies, the director of the Criminal Office and other members of the police management. The materials are re-distributed to other units which use them in planning strategies but also occasional operations.

Data is gathered by writing it at the police station, as mentioned above in the description of the general situation in the police forces in the individual states. Previously, criminogenic data of the Vienna Police Force was saved in the Protocol Data System, replaced by a centralised system Safety Monitor (SIMO) in 2004, which in comparison to the previous approach is not as elaborate in terms of the work with personal data as the previous system. It is connected to a spatial database which carries out localisations of felonies and which imports data into GIS tools. Another source of data are specialised complementary databases which concentrate on specific issues. An example is the database of the railway police force, containing data on thefts and incidents on trains. Specialised databases are not connected to the central database. In addition, just authorised users and analysts are allowed to use them. Should the databases be not used for a long time, they are turned off to prevent wasting resources on their maintenance.

The Vienna Police Force is also engages in disclosing unreported crime. To stay informed about the situation, the police gain information in collaboration with specialised organisations which provide help to, for example, abused women, maltreated children or drug-addicts. Surely, not always is the police informed about the situation. In the case of felonies, however, organisations are legally bound to pass on information about the crime.

As has been mentioned, the police do not share data with the public. To do this, a direct minister's or court's order is necessary. There is a case when data was provided to a private person. It was a comprehensive statistics of crime in Vienna, which had to be anonymised before the provision. Using GIS tools, grids were generated which covered the field of localised crimes, and each square of the grid provided a number of crimes which had taken place in it. Provision of such data is not usual and generally is driven by a political order.

Practical usage

Implementation of GIS tools was associated by trainings and costs on purchasing software licences and hardware at departments whose infrastructure was inappropriate. Concrete costs were unable to calculate due to the incontinuity of the implementation. A large benefit after the implementation of GIS were IT skills of some participants who quickly learned to use the tools. Still, they performed some activities incorrectly, which is why trainings led be external GIS experts were necessary. The Vienna Police Force emphasises the improvement of police officers' - in this case analysts' - skills and knowledge.

Most departments of the Vienna Police Force have a high share of employees older than 50 years. This entails unwillingness to work with new things. First reaction to new tools was negative, including even misunderstanding of its meaning, mainly in senior police officers, as expected. However, a certain level of scepticism is considered positive in the Vienna Police Force, as it may help to reveal some shortcomings. Utter sceptics were convinced about the impact of new analytical tools by a considerable simplification of work. Management of the Vienna Police Force regard the role of senior police officers as significant from the viewpoint of preparation of analytical materials. Due to their long experience, they know what officers in the streets need, which makes the preparation of the documents for their work easier. They also try to get officers' feedback in order to know whether the present form of materials suits them, or whether some changes should be adopted.

Case study / application effects

After the implementation of GIS tools in the Vienna Police Force, no steps were taken to measure the increase or decrease in work efficiency or costs. According to police management, it is not even needed as the benefit of this approach is evident during the work and its simplification. Whether the new concept of analysts' work reduced crime is also difficult to asses, due to the absence of any mechanism to determine whether a reduction in crime was achieved by implementing GIS tools.

Summary

After years of using GIS tools, these activities are considered an indelible part of police work in Vienna. There is no doubt about its benefits, therefore higher professional level of analyses is kept on being emphasised. Also, high demands are placed on innovative and creative processes, which results in the analysts' ability to adjust their work to colleagues, who make practical use of the materials prepared. However, apparent are also increasing demands on analysts, who fail to fulfill their tasks in time do to inadequate number of staff. Therefore, there is the need to increase the number of analysts working in the Vienna Police Force.

8.4.3. CriPA – Criminal Predictive Analysis

The following text deals with the CriPA project and was provided by a member of the team in charge.

This research project is a collaboration of a multi-disciplinary consortium of several law enforcement agencies (federal, state, and local), Joanneum Research research and technology institute, the private sector (SynerGIS), the Department of Geoinformatics – Z_GIS at the University of Salzburg, and the Institute for the Sociology of Law and Criminology (IRKS). It is funded by the Austrian Research Promotion Agency as part of its Austrian Security Research Program KIRAS. The project aims to develop suitable methods and software components, and their integration in the default system so as to tackle to crucial issues.

The first involves long-term, large-scale predictions to estimate future trends of crime for the decision support of strategic measures to crime prevention. As social changes in demographics and the employment structure considerably influence crime, effects of these changes on crime are analyzed. These results and further factors of influence are used for prediction of medium- and long-term trends of crime.

For short-time, small-scale predictions and risk models, prevention is most important. Small-scale predictions of the occurrence of crime and an appropriate integration into a geographic information system (GIS) support the resource planning and strategic crime prevention of the law enforcement management. Spatial models for risk analysis are developed, implemented and validated. In doing so the early identification of spatial and temporal patterns as well as the consideration of relevant factors of influence on crime and the integration of these methods into a GIS is very important. Evaluations and experiences of police experts are systematically recorded, prepared and integrated into the models to improve the precision of the predictions. All models are implemented in a real-time capable, web-based, GIS-based reference system. The validation of the system is based on real data.

The integration of the developed Predictive Analytics methods into the dashboard of the Austrian law enforcement management is intended.

Predictive Statistical Modeling

One major objective of CriPA is to develop statistical models for predicting medium- and long-term trends of crime for deriving appropriate strategic crime prevention measures. On the other hand operational preventive measures, as resource planning and police patrols, require short-time, small-scale predictions and risk models.

To comply with these two aspects statistical time series analyses and spatial models as well as space-time models are developed, implemented and validated within CriPA. In doing so the early identification of spatial and temporal patterns as well as the consideration of relevant factors of influence on crime and the integration of these methods into a GIS is very important.

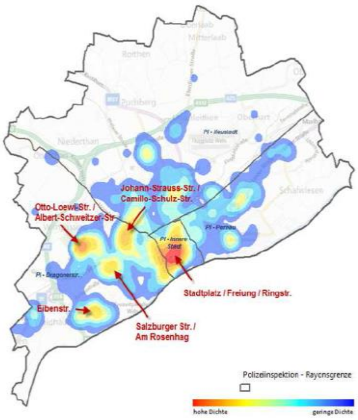


Figure 87: Density map

Source: CriPA 2014

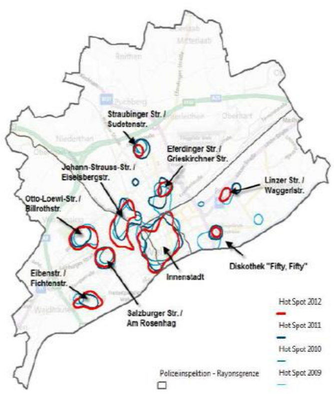


Figure 88: Overlay of contours

Source: CriPA 2014

Spatio-temporal modeling approach for small scale-crime prediction

The first example is a spatio-temporal model for small scale-crime prediction. This approach uses spatio-temporal generalized additive models to discover underlying factors related to crimes and predict location and time of future criminal activity. Based on a regular grid of size 250 x 250 meters, we model the probability of a burglary happening at a certain location and time given some relevant features such as geographic features (e.g. distances to geographic landmarks) and demographic features (population and building information). We also include spatial and temporal effects to account for spatial dependence and capture seasonal fluctuations.

The model is applied to burglaries that happened in Vienna between 2009 and 2013. The approach predicts probabilities of a potential future burglary on a spatial grid that can be visualized using a heat map in a geographic information system (see below).

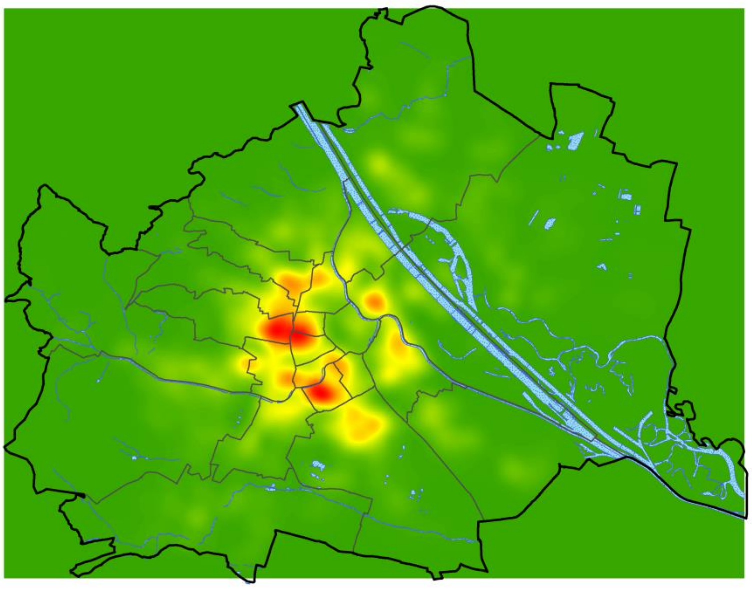


Figure 89: Prediction of burglaries in Vienna for July 2013 by spatio-temporal generalized additive models

Source: CriPA 2014

Geoadditive model for large-scale crime prediction

We develop a spatio-temporal model approach for large-scale prediction of criminal activity in order to identify and act on future trends of crime. This approach is based on a geoadditive model where the number of burglaries at district level per week is modeled as a function of temporal components, spatial components as well as district-specific characteristics (e.g. population structure in a district, infrastructure and building information, average income).

To account for temporal effects, we use an overall trend component, a seasonal component to capture seasonal fluctuations (e.g. burglaries at dusk) as well as calendar effects (e.g. turn of the year, Easter etc.). As we assume that neighboring districts are more alike than two arbitrary sites (spatial dependence), we additionally include a spatial effect.

The following image illustrates the estimated function of burglaries (blue line) and a prediction of burglaries in terms of four months for a certain district in Vienna.

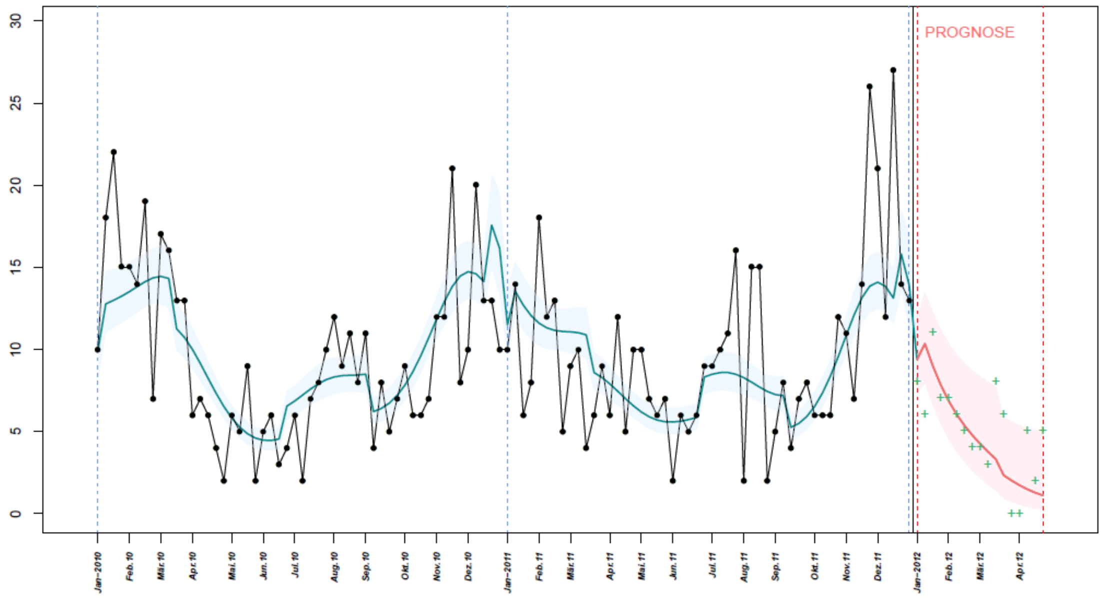


Figure 90: Prediction of burglaries for a district in Vienna with a 95% prediction interval (green: true burglaries)

Source: CriPA 2014

Long-term predictive model for crime monitoring

The last example deals with the development of a long-term predictive model for crime monitoring in Vienna. Using the method of functional time series analysis, we forecast the weekly burglary counts for each district in Vienna for the year 2013 based on the burglary counts of past years and/or similar districts (the 95% prediction interval is calculated). To implement a monitoring system for detecting unusual crime behavior and trends, we have to define several decision rules:

- If an original point in a certain district falls outside the prediction interval, it is an eye-catching point.
- If it is at least the third consecutive week outside the interval boundaries, it's an outlier.

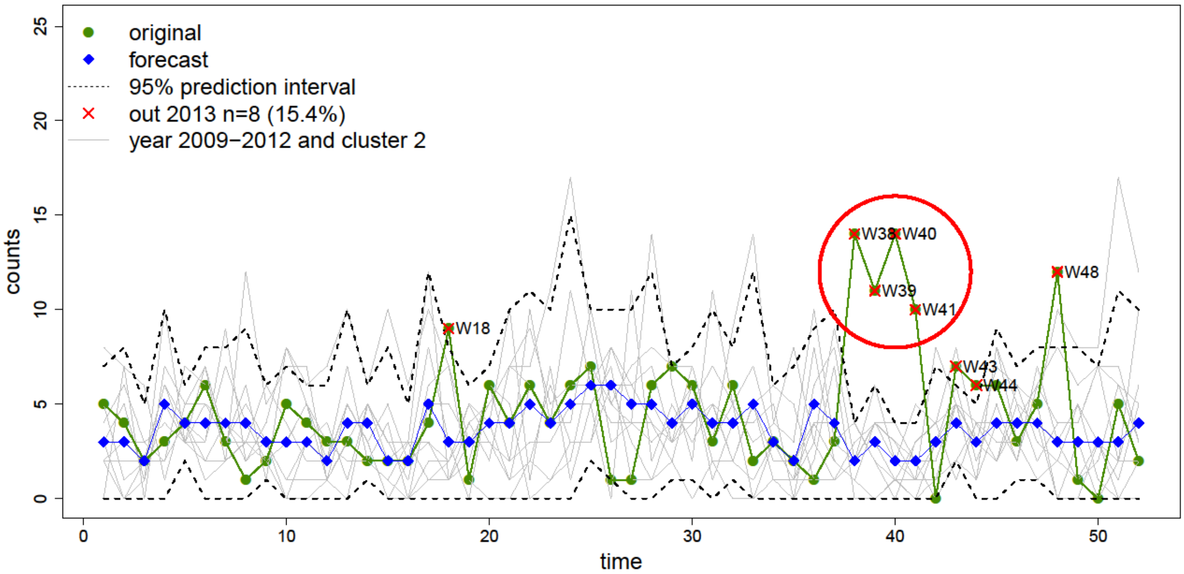


Figure 91: Original counts and forecast of burglaries for 2013 in district 6 in Vienna

Source: CriPA 2014

Forecasting Crime Using Exploratory, Retrospective and Prospective Methods

This research primarily applies geospatial methods and technologies to analyze the probability of future crime occurrences. This study is also the first to investigate whether predictive concepts and methods developed in the US and the UK over the past decade can be successfully applied to Austria and, by extension, to other countries of mainland Europe that share a similar history, culture, economy, etc. This may also be the most comprehensive research to date on this topic. The results of this research are both immediately shared with the police, where they are implemented when deemed relevant and practicable, and also serve as the main input into the building of a prototype software tool for law enforcement agencies to predicting crime.

The study areas include the three largest cities in Austria and two medium-sized cities. The crime data are collected from the Security Monitor (SIMO) administered by the Austrian Federal Police that stores all reported crimes in Austria since 2004. The main attributes for each reported crime include the exact location of the crime occurrence (the x- and y-coordinates of the address, if known by the victim), the time of the occurrence (to the minute, if known by the victim), and the crime type. Non-crime data sources are numerous and constitute, for example, data from the federal government, such as Statistics Austria and Geographic Information System (GIS) databases from individual states that include the selected cities. In addition, the results from a recent and already completed KIRAS project led by Joanneum Research that identified the most significant criminogenic factors of crime in Austria have also been incorporated.

The analysis thus far has been both exploratory and confirmatory applied to both retrospective and prospective analysis. The exploratory analysis has, for instance, found no statistically significant relationship between apartment burglaries and full moon days and a significant peak in apartment and home burglaries in specific neighborhoods in Graz during the fourth week of January from 2009-2013. This information led the police to concentrate resources in these neighborhoods during the fourth week in January 2014, resulting in an above average clearance rate of these crimes. The retrospective analysis has focused on the application and evaluation of spatial (Getis-Ord Gi*, local Moran's I, kernel density estimation, spatial and temporal analysis of crime, and nearest neighbor hierarchical clustering-NNHC statistics) and spatial-temporal hot spot methods (near repeat calculator-NRC, space-time Gi*, and SatScan statistics). Of the purely spatial hot spot methods, the NNHC statistic has shown the most promising results thus far. However, no conclusive evidence has been found in the evaluation of the three spatial-temporal statistics selected. Already completed research has confirmed both the near-repeat phenomenon for robberies and burglaries in Vienna and the correct spatial-temporal prediction of between 25-50% of future robberies, auto-thefts, and burglaries with the risk terrain modeling approach (a prospective analysis method) for the city of Salzburg, Austria.

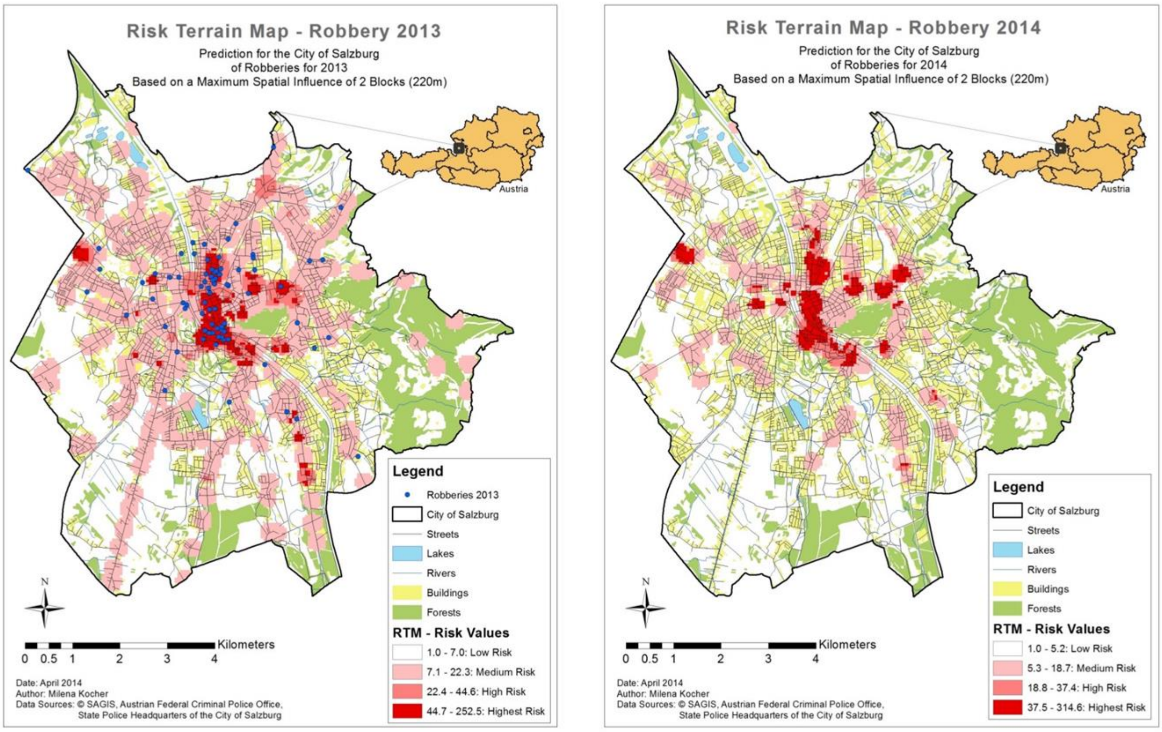


Figure 92: Predictions, RTM

Source: CriPA 2014

Including unstructured knowledge

CriPA attempts to improve the prediction of future crime by integrating and taking into account the implicit knowledge of the police officers on side. This is done by including the free text fields which were filled in by the policemen during the recording of the crime. Together with the domain specific knowledge these free text fields are analyzed by text mining algorithms to extract additional features regarding emerging trends, stolen goods and modus operandi. An attempt to perform a clustering based on this data together with time and location based information to identify possible series of burglaries will also be investigated.

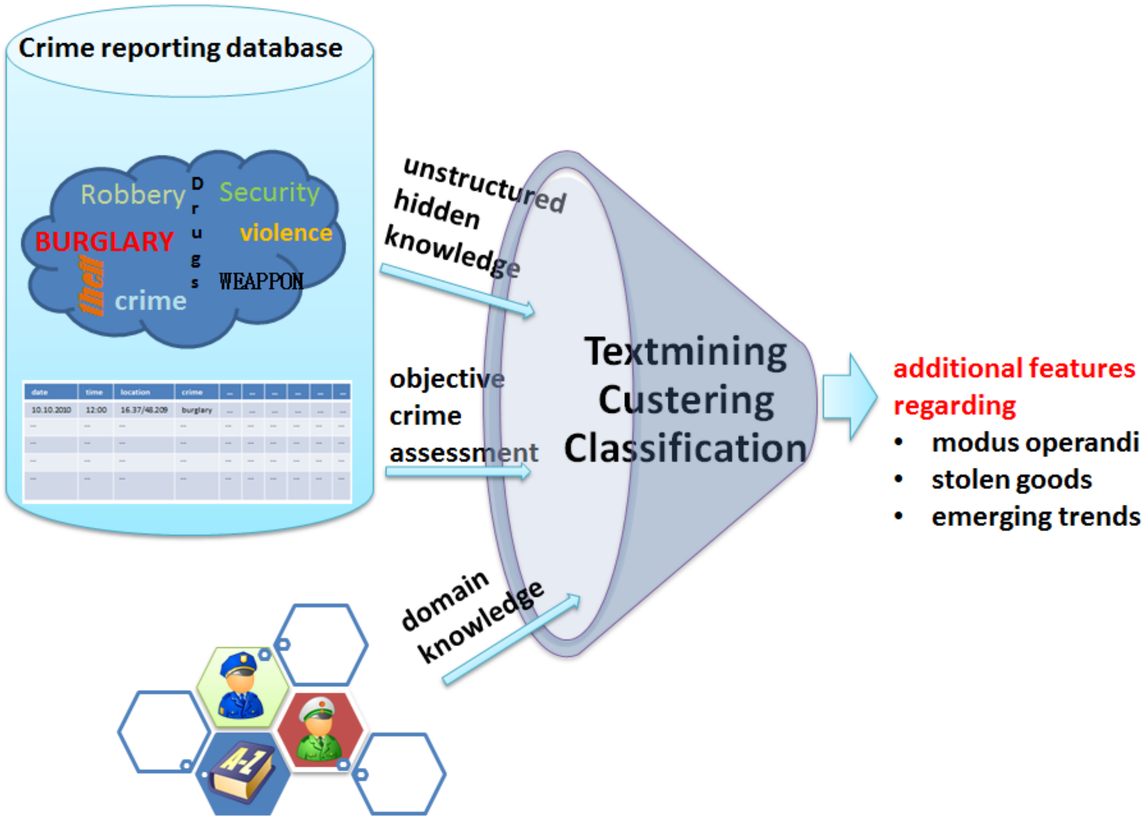


Figure 93: Inclusion of unstructured knowledge

Source: CriPA 2014

Interviews with project external experts

The overall function of IRKS within the CriPA-consortium was it to ensure the provision of societal aspects at the different stages of the project, since it is an obligatory part of the KIRAS programme to integrate humanities, social sciences and cultural studies into all of the funded collaborative projects. A central point is in this connection the consideration of acceptance and acceptability by stakeholders and – even more so – end-users of (IT-) security solutions that are developed within the projects.

The main assignment of IRKS focusses hereby on work package about "qualitative analysis and societal aspects", namely the circumstances of crime development in connection with societal transformation with a special focus on the inclusion of project-external experts.

IRKS conducted elaborate interviews with selected Austrian law enforcement officials. The interviews were held as qualitative face-to-face consultations on the basis of a code of practise.

Topics included but were not limited to:

- the specific expertise regarding crime trends and the connection to societal aspects
- statistical models and IT-tools
- questions of acceptance regarding these (prognostic) tools
- a review of end-user opinions about the pros and cons of such prognostic tools
- and detailed recommendations.

The results were summarized and presented in a "work report on experts' assessments regarding long-term crime development and practitioner's expectations relating to prognostic tools". The report is also going to be integrated into the final project report.

Development of a demonstrator to forecast future crime

SynerGIS Informationssysteme GmbH is the Austrian distributor of Esri products and additionally offers a variety of software products based on Esri technology. These self-developed products involve GeoOffice as a Desktop GIS, WebOffice as a Web GIS, and ProOffice as a tool for maintenance management.

In the project CriPA, SynerGIS is responsible for the development of a demonstrator to be tested and evaluated by a test group within the Austrian police. This demonstrator should serve Austrian law enforcement agencies to identify places with a greater risk of repeat victimization. Based on this information, police resources can be effectively deployed to combat future crime events.

The tools that are used to develop the demonstrator are based on cutting-edge technology from ESRI. The CriPA demonstrator will therefore be set up using ESRI's WebApp Builder to create a framework to visualize historic burglary events, hot spots maps from techniques provided by Z_GIS and Joanneum Research, and especially the forecasts for future burglary events. This basic WebApp will be customized to provide all the necessary functions and tools for data queries and the prediction of crime. The customized functions will include spatial statistical tools and data mining tools in R. When a new burglary event is occurring, the database is being updated with this additional event. Based on this update, the server will process the data for new future crime locations. This is another benefit of server-based processing and Web GIS, as the analysis does not need to be run on each client manually.

After internal tests using retrospective burglary events, SynerGIS will share the demonstrator with the test group of the Austrian police to monitor the forecasts in real-time. In this phase, SynerGIS assists for further adjustments on the routines and application itself to satisfy the needs and to include common practices of the police.

In the first half of 2015, a simulation analysis was carried out in the period October 2012-September 2014. The analysed data was divided into four periods: winter 2012/13, summer 2013, winter 2013/14 and summer 2014. Observed were various temporal and spatial parameters. The area of interest was not only the city of

Vienna, but also a county with a high and a county with a low occurrence of burglaries.

The results indicate marked differences between seasons and areas. A retrospective analysis shows that 30% of burglaries in hotspots, and approximately 5% of burglaries in the county with a low occurrence of burglaries could have been prevented. As a result, agencies should focus on high-crime areas, where it is really possible to prevent a high number of crimes, rather than on work with human resources, whose localisation has, in fact, a limited impact on crime reduction. Throughout Vienna, it was possible to attain the reduction of approximately 10%. This figure, however, increases with every season, which, as the experts say, is due to the incremental accuracy of acquired data. If the data is more accurate and stored in real time, more precise predictions will be generated.

8.5. SWITZERLAND

The example described in this subsection deals with the usage of traditional analytical methods - GIS tools and spatial data analyses - as well as predictive software **PRECOBS** (standing for *pre-crime observation system*), developed by IfmPt and used by the **City Police Force Zurich**.

Main sources of information:	Personal communication
Persons involved:	Analyst of the situational centre, City Police Force Zurich

Information about the city/region

Source: ESRI, basemap ArcGIS Online, 2015

Zurich is situated in the norhtern part of the Swiss confederation. Its population (380,777 in 2013, Eurostat) makes it the largest city in Switzerland. At the same time, it is the capital of the Zurich canton, whose population was 1,425,538 inhabitants in 2014 (Eurostat 2014). As in the rest of Switzerland, a lot of foreigners live in Zurich. According to Eurostat (2013), more than 150 thousand of Zurich population was born outside Switzerland, and 40 thousand outside the EU.

Official websites of the city (2015) state that the city provides employment for more than 330 thousand inhabitants. Zurich is, quite justifiably, considered a significant transportation hub. The city is a distinguished financial, education, cultural and sports centre with a Europewide significance.

Information about the organisation

Police forces in the Zurich canton have various structure. More than 40 police forces are in charge of ensuring security. **Cantonal police Zurich ensures criminal, traffic and security situation throughout the canton. The City Police Force** (Stadtpolizei Zürich), the largest communal police force, fulfil their duties in the sole city of Zurich. Policing in the city is divided into five regional stations with continuous surveillance (City, Wiedikon, Aussersihl, Industrie, Oerlikon). Also, there are eight stations in the borough of Enge, Unterstrass, Hottingen, Riesbach, Altstetten, Höngg, Affoltern and Schwamendingen. Located at the shore of the Zurich lake, one part of the City Police Force is the river police (Wasserschutzpolizei). (Stadtpolizei Zürich, 2015)

Specialised analytical unit of the Zurich police is divided into two parts. The first is the **department for analysis development**, where the team is composed of head criminologist, who leads the unit and is responsible for the generated output,

, and civilian analyst, educated in forensic sciences and providing the expert quality from the criminilogical standpoint. The second department is **situational centre**, which has its own head and four analysts who are educated and experienced in working with analytical and GIS tools. These analysts generate the above mentioned output and work with the PRECOBS system as well as focus on its development.

Initial situation

Crime mapping using GIS was implemented in 2006 in Zurich. Before this, crime and all connected statistics had been mapped in an aggregated way in terms of the 12 city boroughs. Police officers thus currently are in possesion of accurately localised data on crime.

Projects undertaken

These days, crime mapping, analysis and prediction are an established, developed part of policing in Zurich. Since 2008, weekly and monthly reports are created for internal police purposes, used also for regular checks of accuracy of internal processes. Created are hotspot analyses using **ArcGIS** by ESRI, where the specialised extension CrimeAnalyst, for the analysis of criminogenic data, is used. With the use of this system, a variety of specialised basemaps is generated besides reports for the purposes of police management and chiefs of patrols.

A significant milestone was the year 2014, when the Zurich police began working with **PRECOBS**, a Near-Repeat Victimization-based system. This system is currently focused on predicting area with high probability of repeat burglaries, detected on the basis of analyses of already detected burglaries and the calculation of the probability of occurrence in a certain distance from the place of the original event within a particular time frame. The system pilot run took place in 2013 and 2014. Since 2014, it has been used continuously. It was developed with respect to the requirements of the Zurich police and is specialised in prognosing burglaries of commercial premises, such as offices, malls or restaurants, for instance.

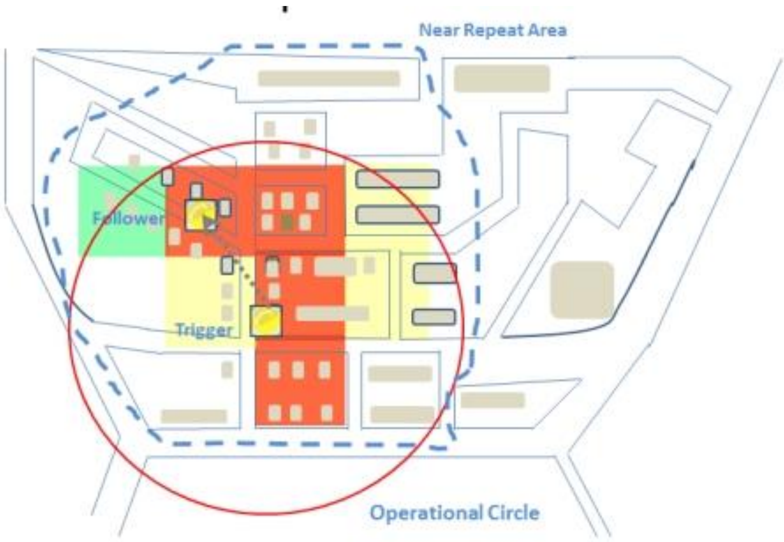


Figure 94: Repeat victimisation principle

Source: Institut für musterbasierte Prognosetechnik, 2015

Application

The PRECOBS system operates in an application interface that visualises areas in a grid with a probability of burglaries. Time period can be set in the analyses as well as a selection of criteria entering the calculations. The figures below illustrate the results of an analysis for the period of May 29th to June 4th 2015, graphically visualised in the map. A place is highlighted where a burglary was committed not long before, a circular buffer, which defines a surrounding area of a specific distance from this place, delineation of the high-risk area using the street network, and resulting squares 250x250m in size, which are the product of the calculations and which indicate the areas to focus preventative measures on, leading to the prevention from further burglaries.

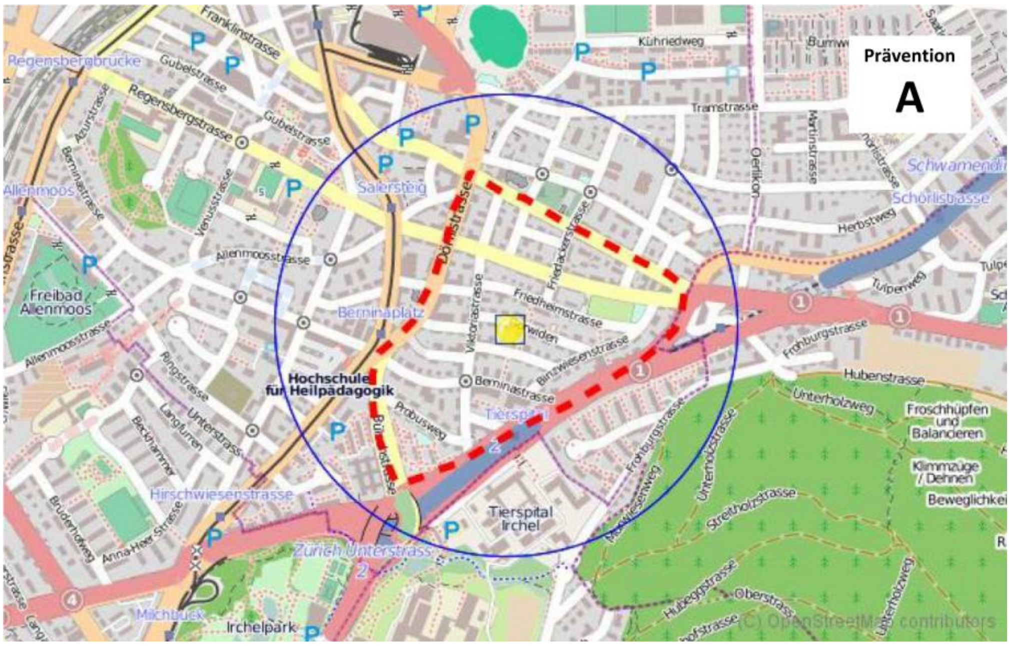


Figure 95: PRECOBS map field

Source: Policie Curych, 2015

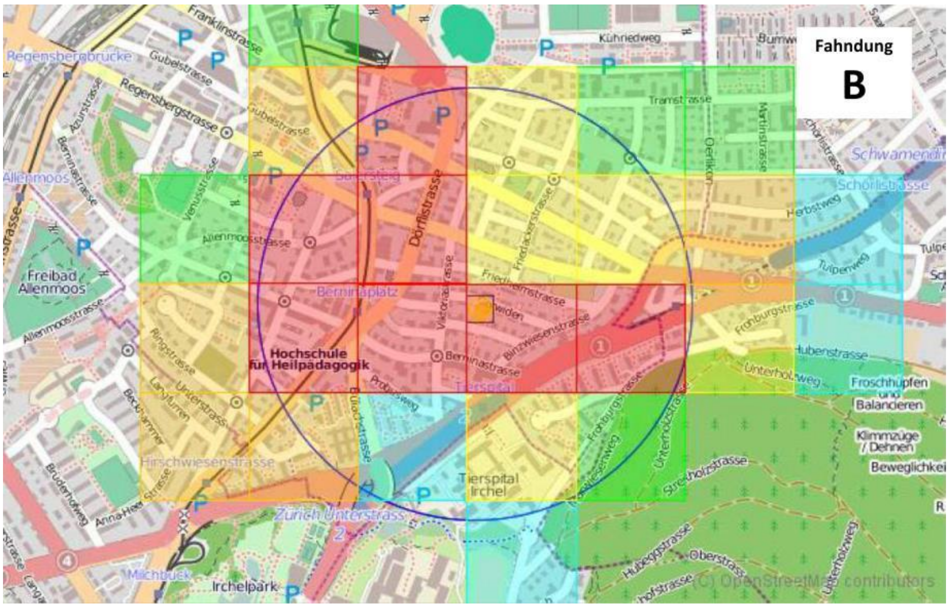


Figure 96: Squares indicating high-risk areas

Source: Policie Curych, 2015

In figure 90 indicates detected areas with repeated offending, or rather a high-probability of burglaries in a specific time period. The function *Near-Repeat Area Statut* thus provides a view of the situation in a larger area, in this case an assumed situation which needs to be faced in Zurich area. In this particular case, the analysis relates to July 1st 2014.

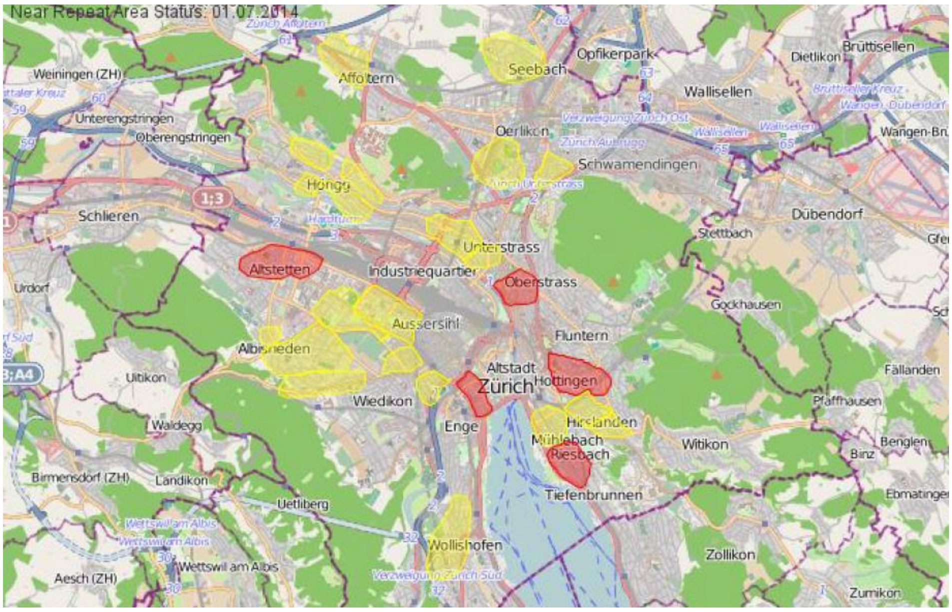


Figure 97: Near-Repeat Area Statut

Source: Policie Curych, 2015

Practical usage

Both internal police data and secondary data are used in generating analytical materials, such as the data of the statistical office (socio-economic data). Mapping is carried out in the streets using tablets or notebooks which the patrols have in their vehicles. The public obtain information in a bulletin, in which they can provide their input and inform anonymously about unexpected situations. Zurich police aim to raise awareness leading to a reduction in unreported crime.

Police data is not shared with the public usually. The only exception is the provision of data for research purposes or another form of collaboration with the police. So far, crime data was disclosed mainly at annual press conferences, where statistical data on crime was presented, and maps on a variety of topics published, such as prostitution, violence or burglaries. Exact figures were were always generalised in terms of the twelve city boroughs. It is planned to disclose this information regularly, approaching this as a service for the citizens, who are rightful to be informed to a larger extent than so far, according to the City Police Force Zurich representatives.

The team of analysts is regularly trained be experts in spatial data analysis products by ESRI, mainly using the CrimeAnalyst extension. The analysts are also required to develop processes and methods, thus the specific form of education is connected to practical experience as well.

PRECOBS was purchased for approximately € 100,000. About 10 % of the purchase price is paid for the maintenace annualy. Expenses associated with traditional GIS systems include regular licence fees and the extension of CrimeAnalyst for the ArcMap software, approximately € 4,000 per year. There were almost no costs regarding hardware, as the licences for the specialised software had to be installed only. PRECOBS operates independently, without any need to be integrated into the city information system.

Case study / application effects

Results of analytical work in the Zurich police are apparent. The year 2014 saw a 6.8% decline in burglaries, compared to 2013. The observed areas, where PRECOBS was used, show a 15% decrease in reported burglaries, in comparison to the previous years. However, it can not be claimed that these results were achieved by the implementation of the predictive said. On the other hand, it is no coincidence that these results were found in the areas suffering from the highest crime rate over the past five years, which shows the benefits of the new system.

As regards the effectiveness of policing, or improved targeted prevention, it can be said that many targets have been identified which had not been addressed sufficiently before. The results were also used for cooperation with other actors engaged in the security of Zurich, such as the emergency service, federal service of investigation, with a custom system where updated PRECOBS data is continuously available, but also house owners who have applied preventative measures preventing from burglaries.

Summary

Modern approaches of data analysis and their use in police units gradually spread all over the world. Approach to policing, implementation of spatial data analyses and beginnings of using the predictive system PRECOBS clearly show that the City Police Force Zurich is not an exception and does not lag behind in this area. The contributive nature of these methods is highlighted. The implementation of PRECOBS was also an inspiration for Bavarian police forces, dealt with in the subsection Germany.

8.6. GERMANY

The following example concentrates on the **PRECOBS** software tool (standing for *pre-crime observation system*) of the IfmPt company. The software was tested by the **Munich Police** and **the Criminal office of Bavaria.** Testing of the system took place in Munich and Middle Franconia, Bavaria. This subsection also provides a description of the general situation of law enforcement in Germany, from the viewpoint of using GIS.

Main sources of information:	Specialised literature Personal contact
Persons involved:	Chief criminal investigator with the Bavarian police

Information about the city/region

Source: ESRI, basemap ArcGIS Online, 2015

Middle Franconia (Mittelfranken) is one of the total of seven administrative regions of the Free State of Bavaria. Its size is 7,244.9 km^2 and as of June 30th, 2014, its population was 1,710,482 (Bavarian office for statistics and data processing). The capital of this administrative region is Ansbach, where 39,925 inhabitants lived as of the afore-mentioned date. However, the largest city in the area, is Nurenberg with almost 500,000 inhabitants.

The Bavarian police is represented by the Mittelfranken police presidium, seated in Nurenberg and responsible for the whole administrative region. According to official websites of this police force, the area of 7,243.4 km^2 and a total of 1.7 million population is surveillanced by approximately 5,000 employees (namely 4,200 police officers and 800 civil employees). The following departments are controlled by the police presidium: Nuremberg, the city and county of Fürth, the city of Erlangen, the county of Erlangen-Höchstadt, the city of Ansbach, the county of Ansbach, Weißenburg-Gunzenhausen and Neustadt/Aisch-Bad Windsheim, the city of Schwabach, and the counties of Nuremberg Land and Roth. (Polizei Bayern 2015)

The Bavarian city of **Munich** is the third largest city in Germany. In 2014, the city population was 1,407,836 (as of January 1st 2014, Bavarian office for statistics and data processing), and according to Eurostat, almost 400 thousand of them were born outside Germany. Due to a relatively small area, approximately 310 km^2, is this city one of the most densely populated in Germany. Approximately 30km from the city is found the Munich airport, which belongs to Germany's busiest airports by passenger traffic. Also railway plays a vital role in the city. (München 2015)

Information about the organisation

Since Germany is a federal republic, policing is divided among the Federal Police Force (Bundespolizei) and local police forces, created by the federal states. The Federal Police Force is divided into nine regional directorates, one of which has its seat in Munich. **Bavarian Police** (Polizei Bayern), employing approximately 41,400 staff, is in charge of policing in the Free State of Bavaria. The whole catchment area, consisting of seven regions, is divided into 10 presidiums, of which 1-3 are located in each region. The average number of inhabitants in a police regions is almost 1.25m. One such region has 30 police stations with a crew of 35-120 police officers (Krulík & Lupač 2012).

In the capital of Bavaria, all its districts and the adjacent county, the **Munich Police Force is in charge** (Münchner Polizei), which employes approximately six thousand police officers and thousands of civil employees, which makes it the largest police force in Bavaria (Polizei Bayern 2015). Its jurisdiction extends the area of one thousand km^2 and 1.5m inhabitants.

Initial situation

Germany in general uses multiple terms for the activity of crime mapping, analyses and predictions, such as *predictive policing*, *smart policing*, *crime forecasting* or *predictive crime mapping*. None of these, however, is officialy defined, nor is its content. In general, it covers mathematical and statistical methods, where criminogenic data is used, as well as the probability theory of future crime in a specified area and time period. Examples of the use of GIS in German police forces described in this subsection make use of these methods, and their implementation began as a result of the inspiration by other countries where crime-rates have been decreasing and public safety has been increasing over a long time.

Tools

The following portfolio of GIS tools has been used in German police forces. Also, approximate costs related to the purchase of the products is provided.

The criminal institute uses the *Regiograph Analyse* software, of the GfK GeoMarketing company, as a one-time licence for visualisation of crime data in research projects of criminological nature. **The department of police service** (Polizeilicher Staatsschutz) **BKA** also operates the software *ArcGIS Desktop*, developed by ESRI ,*and PAD Mobifilter* for the administration, analysis and visualisation of geographic data. Visualisation is also generated by mapping server with mapping data of the **Office of Cartography and Geodetics**.

The Department of Serious and Organised Crime uses *RegioGraph Planung*, developed by GfK GeoMarketing.

The company Syborg developed a GIS functionality called *SyGIS* for the **Department of Telecommunication Surveillance**. OpenStreetMap was used as the topographical surveys. Another system is *B-case*, developed by Rola Security, which uses the mapping server *Oracle Spatial/Map Viewer* with the BKG topographical surveys. Police statistics were visualised with Oracle technology (Spatial/Map Viewer/BIEE). **The customs service** uses GIS software *GIS GeodateninfrastrukturZoll* (GDI-Zoll).

The amount of costs expended on GIS equipment amount to €515.000, of which €277.000 was allocated on licences (see above), the remaining expenses relate to human resources connected with analytical work and GIS implementation. Specifically, the following finances were allocated:

- Regiograph Analyse, €998
- ArcGIS, three licences, €3,034 each, i.e. €9,132
- PAD Mobilfilter, three licences, €3,000 each, i.e. €9,000
- Mapping server, open source, i.e. €0
- RegioGraph Planung, three licences, €4,800 each, i.e. €15,400
- Typographical surveys, €22,000
- SyGIS, €35,000
- Typographical surveys OpenStreetMap, €0
- Mapping server Oracle Spatial/Map Viewer, included in the rent licence
- Map conversion OpenStreetMap, €1,750
- Components of visualisation, €41,850 (low service costs not included)
- Visualisation of police statistics with Oracle Spatial/Map Viewer/BIEE, provided free of charge by BKG
- GDI-Zoll, €29,000

Application

The Bavarian criminal office and the Munich Police Force were inspired by Zurich, which was the first city to have implemented the **predictive system PRECOBS** and which is also described as an example in this paper.

PRECOBS was tested in the period October 2014-March 2015 in terms of a feasibility study **of the Bavarian criminal office.** Based on geographical characteristics, **Munich** and **Middle Franconia** were selected for testing purposes. The former as an urban and the latter as a rural area The sample area comprised 93 districts, and the system generated 208 projections over the tested period. The sample involved parts of municipalities or long streets. The project was thus not carried out in specific streets or spots. So as to avoid reduction of effectiveness, the police did not disclose the list of monitored areas.

Practical usage

The predictive system **PRECOBS** is based on the near-repeat theory, and in Bavaria is used for measures against burglaries. The program operates with data of cases that have already happened, specifically with data on place, time and manner a crime was committed, property stolen and with freely available geographic data. The system works with data no older than one week. The system thus generates short-term predictions (for the following days) for areas with a high probability of crime occurrence. The outcome (forecast) of this system is assessed by specially trained staff who process the data according to their consideration and particular requirements. The materials are commonly used for scheduling of patrols of uniformed officers. Also, situations are assessed as to when non-uniformed officers have to tackle a situation. The outcome also provides hints on what activities should be carried out, whether the patrols should focus on capturing an offender or on preventative measures.

Figure 98: PRECOBS environment

Source: Sueddeutsche Zeitung 2014

Benefits

Testing of PRECOBS resulted in a decline in burglaries and an increase in captured offenders. In particular, Munich saw a drop by 29%, in areas strongly beset with this issue by as much as 42%. In Middle Franconia, the observed decline in burglaries was 17.5%. In relation to this activity, almost 7700 individuals were interviewed, and 26 captured when searching for potential targets. Another accompanying factor was strengthening of some police groups.

Summary

Applying the preventative measures in question, the Ministry of the Interior of Bavaria intends to reach its target that "more than 40 per cent of burglaries would be nipped in the bud". To render policing more efficient, the Bavarian Ministry of the Interior also plans to deepen the cooperation on the national as well as international level as regards data exchange with an ensuing investigation of offenders.

Implementation of these steps will require adjustments to legislative measures about the volume of saved data for the sake of finding contact information about offenders, accomplices and other relevant persons.

8.7. ITALY

The below-mentioned implementation is an example of a system carried out nationwide. The meeting was held in the seat of the Iconsulting company, one of the main parties of the project.

Main sources of information:	Personal meeting held on: March 13th, 2015 - *Iconsulting, S.p.A, Bologna* Internal documents provided by the reprentatives of the visited organisations
Persons involved:	Analysts and GIS personnel Representatives of software developers and suppliers of the system

Information about the city/region

Source: ESRI, basemap ArcGIS Online, 2015

In the south of Europe, along the Appenine peninsula, is located the parliamentary republic of Italy. Also, the islands of Sicily, Sardinia and more than 60 more than other sixty belong to this country. The northern border is basically delineated by the mountain range of the Alps, where Italy borders Slovenia, France, Austria and Switzerland. Two independent countries are located in the area of Italy - the republic of San Marino, and the Vatican in Rome. In 2014, the population of Italy was 60,782,668 inhabitants (Eurostat 2014). The population, accounting for 12% of the EU, lives on an area of 302,073 km^2.

The most significant areas of Italian economy were wholesale and retail businesses, transportation, restaurant services (20.1%), industry (18.5%) and public administration, defense, education, healthcare and social care (17.2%). Italy is going through a critical period regarding unemployment. While in 2010, the unemployment rate accounted for 8.4%, placing Italy in the group of EU countries with low unemployment, current unemployment rate is 12.7% (Eurostat 2014), the seventh highest in Europe.

Administratively, Italy is divided into 20 regions. The capital of Italy is Roma, located in the Lazio region. In 2013, Rome had more than 2,6 million residents (Eurostat). Also the city of Milan has more than one million inhabitants. One possible threat is a large number of immigrants. According to Eurostat (2014), more than 4.9 million people born outside Italy lived in the country.

Information about the organisation

The Italian police/security force is considered to be one of the most elaborate systems in Europe. The individual forces share some areas of focus, such as anti-drug policy, secured by the National Police Force, gendarmerie as well as financial and customs police. The structure of the Italian security system is as follows:

- **National Police Force** (Polizi di Stato)

This force is further divided into provintial *areas* and catchment areas, which account for as many as 900 (Krulík 2014). It oversees express highways, railway, briges, waterways, and its division is also the border police and postal police.

- **Gendarmerie** (Arma dei Carabinieri)

It is the only armed military force and its superior is the Ministry of Defence.

- **Financial and customs police** (Guardia di Finanza)

This force deals with financial crimes, illegal immigration and customs checks. Some of these tasks are also carried out the navy fleet and airforce.

- **Penitentiary police** (Polizia Penitenziaria)
- **Forest policie** (Corpo Forestale dello Stato)

As regards law enforcement, Italy is divided into 20 regions, which are further divided into 110 provinces. Each province has a police station, called *"questura"*, which carries out the activities of the National Police Force in a given province (Krulík 2012). A crucial unit of the National Police Force are public security offices (Commissariati di Pubblica Sicurezza), found in provintial administrative centres and subordinate to the provintial police stations. By contrast, seven interregional directorates have a supra-provintial position and these are responsible to the chief of the National Police Force. These directorates are located in Rome, Torino, Napoli, Milan, Padua, Firenze and Catonia. Also gendarmerie has its own structure. There are five supra-regional (Milan, Padua, Rome, Napoli and Messina) and 19 regional directorates. Gendarmerie has also its provincial level, territorial headquarters in areas with special requirements, crews in middle-sized cities (around 540) and more than 4,600 basic stations in small cities (Krulík 2012).

Initial situation

Development of IT brings about higher demands on system functionality and the amount of processed data, which were not as high before. This trends has also permeated Italy and Italian police, which started perceiving the current equipment and structure of police forces as inadequate. It was a necessity to centralise systems and databases used locally back then. It gave rise to a complete update of IT of the Italian Ministry of the Interior and the police force.

Projects undertaken

The department of public safety with the Italian Ministry of the Interior carried out the SIGR project (Integrated System for Georeferencing of Crimes) on the basis of the insufficient condition of the police IT system. The conjunction of Iconsulting and Oracle enabled building up a nationwide database, which is the source of spatial information a complete documentation on crimes committed in Italy used for in-depth analyses of crime and its aspects. With a tool developed to use data from the national database, the police throughout Italy can use sophisticated analyses with added tables, graphs and geospatial analyses. Therefore, the current system of crime data gathering served as the basis of an integrated system for the preservation of data, generation of spatial analyses and statistical data processing, which can be operated in an intuitive environment in all territorial dimensions by the police in Italy. This implementation aimed to implement new methods which will enable the generation predictive and proactive analyses, which will help render policing more effective.

Case study / application

In 2009, a unified database was created and accessed by all police units across the Italian territory and the above-mentioned police forces. The database contains data that can serve to generate statistics and visualise the rate of crime across all regions. The data is uploaded by police officers, who note down all information on a paper form and, having returned to the police station, they upload it to the central database. Available is complementary data, such as demographic information or sizes of areas. Different indicators are calculated through these figures, crime intensity, for instance. The figures as such are insufficient, however. This is the reason why a new IT system was introduced gradually. Currently, the system enables visualising characteristics for a given area also by means of graphs, mapping application and maps.

Project SIGR can be divided into three crucial stages of implementation, which commenced in 2012. In the first stage, the objective of the Department of Public Safety was to create a system that would unify work processes related to crime analysis, making them more effective. The system was to generate analyses reflecting on specific crime patterns via data. As a result, materials for the purposes of the investigation of offences and preventative measure would be generated on the basis of optional criteria.

In the second stage, combined queries were implemented into the system. It thus gave rise to the work with statistical and spatial information, with the use of one geodatabase, i.e. there are no separated databases with different information. One query is required to obtain the wanted piece of infromation. Up to this stage, information navigation had been done by means of a Business Intelligence model. After the structure of the databased was transferred to unified tables across functions, a unified language began to be used. The system was equipped with a geographic concept, and the model was referred to as Location Intelligence. In other words, a shift from Business Intelligence to a GIS solution took place.

In the third stage, a new approach towrds so-called "spatial data-mining" was adopted. It applied grid thematic mapping, i.e. the creation of a grid over an area, which visualises the intensity of threat on the basis of crime occurrence in spots within its squares. It is not an algorithm to be referred to as a predictive method, but rather a method of analysis and visualisation of a phenomenon. Also, other functions were added to the system. These functions, using GIS information, enable spatial data analyses, generation of cartograms, hotspot maps, for example.

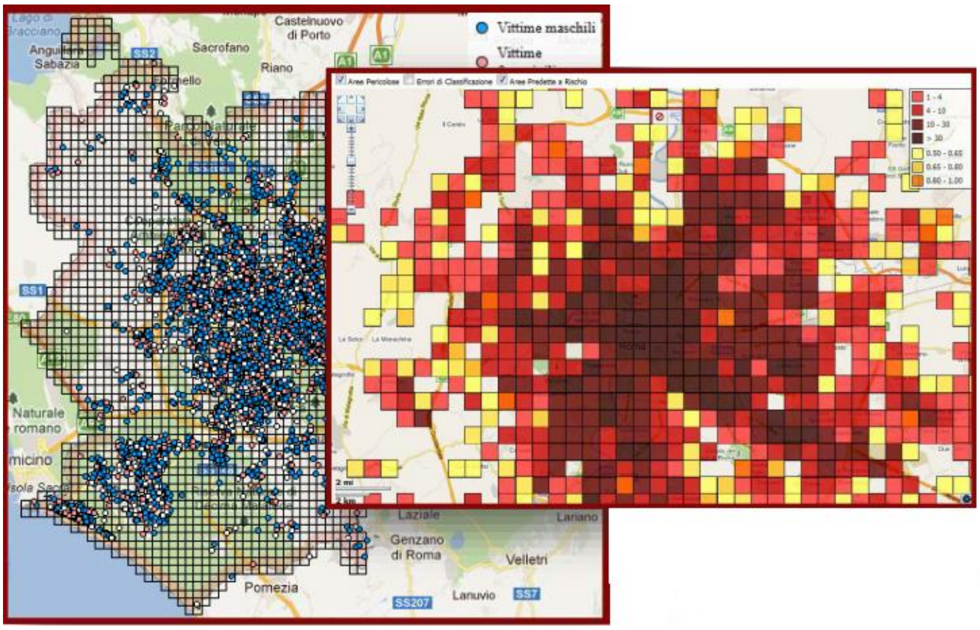


Figure 99: An example of a grid in SIGR

Source: ICONSULTING 2015

The system is user-friendly and intuitive, and its functionality quite broad. In the mapping application, the users can switch between different types of maps, such as topographic maps, general geographic maps and ortophotomaps Google (with added StreetView), Open street map, and various external mapping services.

Figure 100: Topography surveys in SIGR

Source: ICONSULTING 2015

Clicking on a given area in different territorial levels, statistics calculated from the open database can be viewed, including the form of output graph. Individual offences are viewed in dots when zoomed in to lower territorial levels. Each type of offence and each single point views the number of offence, which serves as a reference and link to the central database, where police officers can find further details about the act. The system enables officers to work with dynamic parameters, such as visualisation of offences within a defined distance or buffer of a defined radius from the given police station. The functionality of the system also allows for forming personalised polygons and generation of analyses in this environment.

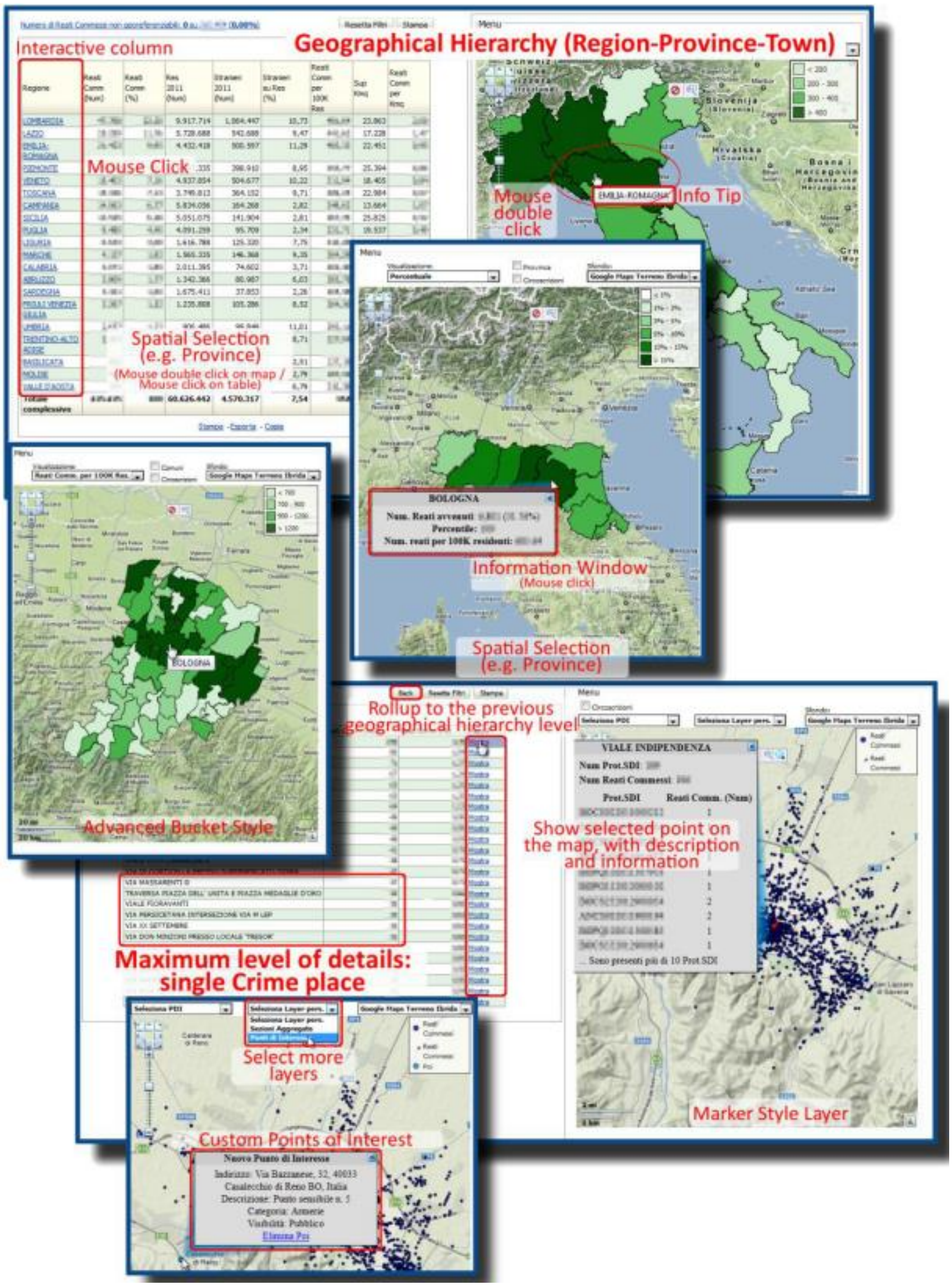


Figure 101: SIGR interface

Source: ICONSULTING 2015

The system is based on Oracle technology and JavaScript library, developed by Iconsulting. The development of the former, gradually added and still used version of the system started three years ago (2012). Due to the extent of changes, it was decided to launch the development of a new version, introduced in its unfinished version. After its execution, its functionality was quite identical with the old version.

The innovative features are a more intuitive work environment and extended possibilities in the generation of statistics and spatial data analyses.

Use

So as to ensure the operability, it was necessary to carry out trainings at the management-level in each stage of the project. Ordinary police officers were regularly presented with the system by the help of other police departments. Besides, user manuals were created and updated in the course of the development of the system. IT specialists from the ministry required no training, their work being the administration of relation database in SIGR.

No problems arose in the implementation phase. That is due to the fact the the implementation has been taking place in the infrastusture of the Italian Ministry of the Interior, with a strictly limited access of the participating developers. As regards the data of the system, strict safety precautions are followed. The system works within an intranet network, interconnecting 70 thousand police offices. No data transfer takes place.

From the development stage till the implementation stage of SIGR, €100,000-1,000,000 were expended on the system. This price has not been specified. It depends on several aspects. This projects can be said to be "incremental" when referring to the requirements, added feature and the necessity of process flexibility. These factors resulted in a price commensurate with the demands of the Italian ministry.

From the viewpoint of sharing data with the public, the Italian police holds a conservative stance, asserting that data on crime should be used by law-enforcement agencies only. However, data pertaining to a specific territorial level needs to be disclosed, as well as statistical data, according to the law.

Case study / application effects

Iconsulting has been provided with no feedback on the economic benefits of the implementation from the department of public safety of the Italian Ministry of Justice, although the cooperation was begun in 2011. Since the very beginning of the project, the Italian government has been considerably interested in the effect of the implementation. Still, the Italian Ministry of the Interior is unwilling to reveal this information. However, the aim of the project and the changes it has brought about clearly indicate a positive impact.

The most expected contribution of the impelementation is financial savings connected with administrative tasks, partially eliminated due to a simplified access to data. Also analytical work is considered a benefit owing to the spatial perception of crime occurrence, which is crucial for policing. The new system has enabled police officers to identify most critical locations and to focus on preventative measures. Using historical data, they can profile areas and prepare strategies for tackling issues. Also, visualisation of historical data enable identifying repetitive events and observe behavioural patterns, resulting in tactical preparedness of the police to face security threats.

Summary

Experts participating in the implementation of the Italian solution are aware that predictive tools need to be observed dispassionately. First and foremost, it is vital to define what predictions actually are. Should no appropriate data be in place, predictions systems are worthless, although promising outstanding results. When applying spatial analyses in policing, it is necessary to know where patrols should be dispatched. Emphasised should be the knowledge of the situation within a territory. In turn, the knowledge combined with modern analytical approaches is a powerfull tool in combating crime.

8.8. POLAND

This example deals with crime mapping and analysis in an information system of the Polish police force. This implementation is another nationwide approach in this study.

Main sources of information:	Personal meeting held on: May 14th, 2015 - *Warsaw* Internal documents provided by the reprentatives of the visited organisations
Persons involved:	Officers working with the implemented solution Analysts and GIS personnel Representatives of software developers and suppliers of the system

Information about the city/region

Source: ESRI, basemap ArcGIS Online, 2015

Poland is a parliamentary republic situated in Central Europe. According to Eurostat, the population of Poland is 38,005,614 inhabitants and its size is 312,679 km^2, making it the eigth largest European country. Polish population represents nearly 8% of the population of the EU. Compared to previous years, however, Polish population has a declining tendency. In 2004, the number of inhabitants was higher by as much as 185 thousand. The north of the country is formed by an extended strip of the Baltic coast, in the West Poland borders Germany, in the south the Czech Republic and Slovakia, in the east with Ukraine and Belarus and in the North with Lithuania and Russian enclave in the area of Kaliningrad.

The main economic area in 2014 (Eurostat) was retail and wholesale business, transportation and restaurant services (27.1%); industry employed 25.1% economically active people. GDP in 2013 was €389,695 billion in 2013 (Eurostat). The unemployment rate are reaching the lowest levels in years. In May 2015, it was 10.8% (Central Statistical Office of Poland 2015).

Administratively, Poland is divided into 16 voivodeships, of which the both largest and most populated is the Masovian voivodeship, where the capital city of Warsaw is found (1,735.4 inhabitants as of January 1st, 2015, Central Statistical Office of Poland). Another city among the most significant and touristically attractive is Cracow, the second most populated Polish city and historical capital of Poland (till 1956).

Information about the organisation

An independent police force in Poland, working next to the National Police Force, is border control. Besides this force, crucial police entities can be regarded the **National Police Force** (**Policja**), the Government Security Office, city police forces, the intelligence service, represented by the interior security agency, customs administration, and central anti-corruption office. The Polish police force is fully controlled by the Polish ministry of the interior, via the main police directorate. The head of this headquarters, and the whole Polish National Police Force, is police president. The International Comparative Study on Police Forces (2012) states that 97,366 police officers and 24,895 civilians were employed by the Police of Poland in 2011. In Europe, only police forces in Germany, France and the UK employ more police officers. Still, their number has been decreasing slightly. The total budget of the police in Poland was €1,888.6m. Between years 2006 and 2012, it was increased by 21.5%, which confirmed the European trend (International Comparative Study on Police Forces 2012).

In connection to the administrative division of Poland, there are 15 territorial directorates of police force, and an equal police headquarters in Wroclaw. Also, at the level of each voivodeship, city police directorates are established, in terms of which county police directorates are distinguished. Each city or police directorate has at least one police station under its supervision. Police stations represent the lowest local police structure and are basic catchment areas for policing (International Comparative Study on Police Forces 2012).

Initial situation

In 1998, the Communication and Information Technology Office (Biuro Łączności in Informatyki) in conjunction with Oracle impemented the National Information Police System (KSIP - Krajowy System Informacyjny Policji). Over the past two decades, this system has gone through a marked development through several substantial milestones. This system, based on Oracle technology, was implemented in 2000, having been developed for two years. In 2006-2013, it went through a number of adjustments, implementing a number of new functions, changes to structure and in technologies, the work of the database is based on. Since 2013, when new modules for operations with maps were implemented, this system, as regards development, has been used without adjustments. This mapping module is implemented into all voivodeships.

This system is still functional and is the basic one for gathering data on felonies, misdemeanours and traffic accidents, including traffic offences or vehicle thefts. Afterwards, Oracle developed the National Information Police System (KSIP - Krajowy System Informacyjny Policji) for the Polish police force. Its used to gather, process and transfer information about crime across law enforcement agencies in Poland.

Main information systems used nationwide:

1. National Information Police System (KSIP)
2. Analytical system (SA)
3. Command&Control system (SWD)

Projects undertaken

In 2008, a module was added to the KSIP which enabled drawing information from the national system as well as other international systems used, such as the Schengen information system. This new approach thus allows police officers to acquire information from multiple sources via mobile devices in the field. In 2008, the National Police Force began using the Analytical System, also based on Oracle technology. This module localises high-crime areas with respect to the spatial component and optimisation of patrols. The module uses data from the national database of geodesy and cartography, supplied as a specific service. So far, the storage used by this system has reached the size extending 3TB of data.

Implementation of the "Command & Control" system began in 2010 ant the system was applied in 2011 with the aim to establish cooperation between and coordination of all police forces throughout Poland. In terms of the implementation of the system, web services were decided to be used. This gave rise to a system refered to as the PPU system (Police Platform Service), which allows for data exchange between police systems and external systems not administered by the National Police Force.

As mentioned, a significant milestone is the year 2013, when modules with work with mobile terminals and GIS systems were successfully added to the system. This extension is a follow-up to the implementation of the PPU system. The system also operates with the universal mapping module, provided by the main body for geodesy and cartography.

The universal mapping module is a set of applications supporting operating officers of emergency services in supplying spatial referential data and operational data. It therefore supports police systems by providing spatial visualisation of reported events and of police data. The supported analytical tools enable the police to process spatial analyses of selected places. It is also available to all police units which operate mobile devices in the field.

Case study / application

National Information Police System (KSIP)

The National Information Police System is the main central nationwide police system used for collecting and processing criminogenic data and coordination of police activities. This system uses the OracleForms technology, which connected more than 3,000 users. In the coming years, it was necessary to incrase the number of users in Poland, while working with the same hardware. Using Oracle ADF, the functionality was transferred from a form solution to website technology, with no changes to functionality. This resulted in a threefold rise in users compared with the previous version. This technology enables using KSIP on mobile devices, such as mobile phones and tablets, for which a special mobile version of the system was created. Currently, the Polish police is in possession of more than 5,000 mobile devices that police officers use during patrolling, granting them access to the KSIP system.

KSIP is equipped with various modules and extensions, which focus on specific tasks. An example is a system for planning and ensuring safety during risk crowd events, also the register of traffic accidents, a secret module gathering information about untrustworthy police employees and a module containing information about applicants to the police. Another important component of KSIP is a system for searching people and things, which is accessed to the Schengen Information System and other national systems (Central Citizens Registry, the Border Guard System, Companies Registry and others). The National Police Force expected a positive impact and it succeded in granting police officers an improved access to information. The results show a shorter time of investigating felonies and capturing perpetrators, which results in saving financial resources.

Analytical system (SA)

Originally, the analytical system in Poland was to use centralised databasae to draw data from. In its developement stage, however, it was decided to create a new database to administer both primary and secondary data simultaneously from one storage separated from the analytical database and a large amount of data from the National Information Police System (KSIP).

The implemented analytical system became a source of unified data, which serves as the basis for analyses important for an effective decision-making of the police management and the distribution of police resources. Comparatavie analyses are carried out, helping to analyse correlations between crime taking place in one place and aspects which are assumed to have an impact on where, when and whether crime is present. As a result, reasons causing offending are scrutinised, as well as spatial relations and trends associated with the occurrence of crime.

The environment of the analytical system enables its users to generate reports, maps and other output. Owing to elaborate search tools, it is possible to find information from different sources in one place. The system itself can provide police management with elementary crime statistics within a given area, which they can view in tables and graphs, having an immediate picture about the situation. This system thus provides an immediate response to an issue, reliable information, exchange of information, generation of partial data analyses and verification of decisions made by police units, including the evaluation of their effectiveness.

Command&Control system (SWD)

This system is used to establish cooperation and coordination between police forces throughout Poland. It provides a continuous acces to information about the situation in the field, localication and the state of individual police officers and units, which exchange information during their work. It is therefore an effective way of managing police forces. The system also enables an automated generation of reports and materials. A considerable contribution is also coordination among the individual units. Due to GPS and this system, the position and state of each patrol can be tracked and they can be sent orders via an application. Police officers in the field can receive data about perpetrators, about wanted people, confirmation of identity, permissions to hold guns and other information coming from police and non-police resources.

Users of the system at the police are people responsible for planning of patrols, commanders in chief at all levels of the police, patrols in vehicles and police officers (using mobile terminals), but also analysts.

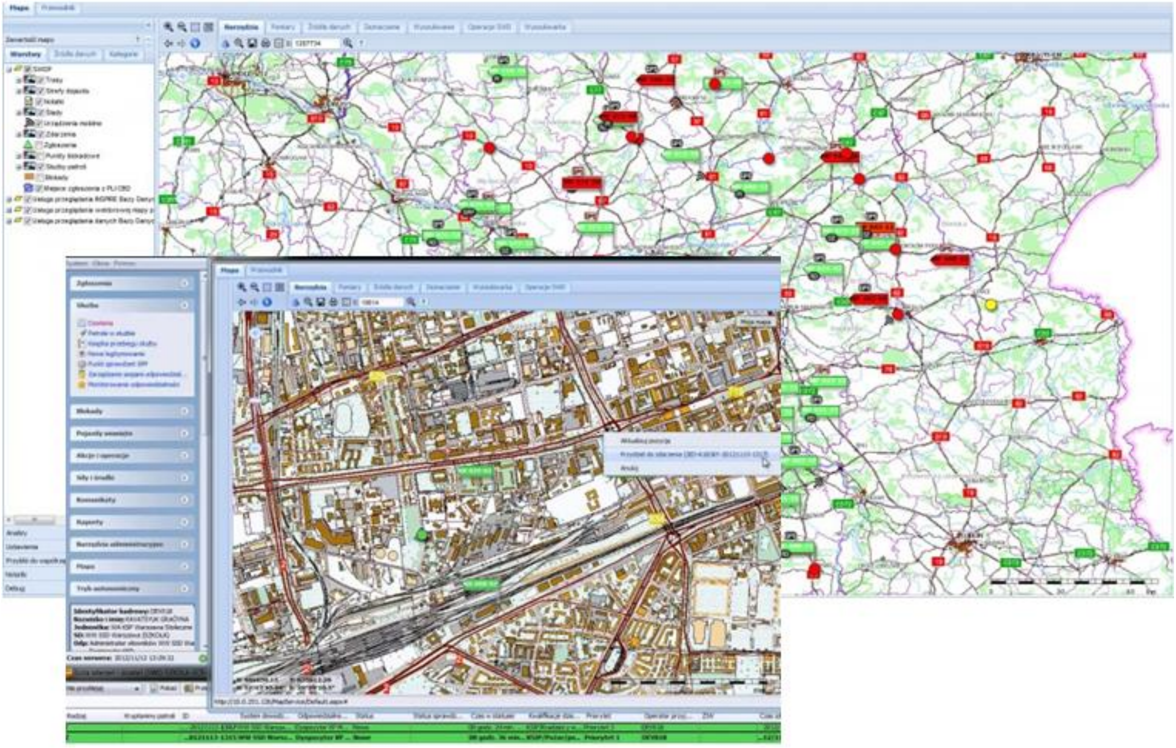


Figure 102: Example of a mapping module

Source: Biuro Łączności i Informatyki Komendy Głównej Policji 2011

Practical usage

Prior to implementation, the system was tested during a pilot run in specific areas where increased crime was localised. In total, 64 units were selected, as well as all regional directorates. Implementation of the pilot project took three weeks. Afterwards, operations with the system and analysis of occasional problems were monitored over two weeks. The pilot verification of the system being completed, the system was implemented in other units and individual stations.

The title "Krajowy System Informacyjny Policji" (KSIP) appears in the regulation by the minister of the interior from September 9th, 2007 in relation to police data-processing, where section eight states: Director of the main police headquarters ensures the existence of a set of centralised information titled "Krajowy System Informacyjny Policji (KSIP)".

The system was built up on the basis of internal regulations of teh main police directorate in conjunction with the Communication and Informatics Office. Further, agreements for sustainability and other support agreements were established.

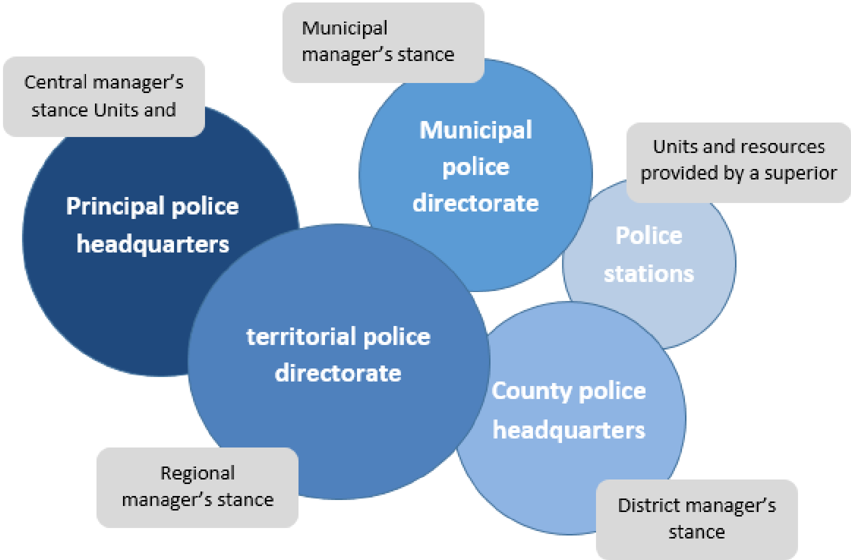


Figure 103: Plan of implementation

Source: Biuro Łączności i Informatyki Komendy Głównej Policji 2011

In terms of the system implementation, a series of training was held in each voivodeship in 2014. The aim was to introduce the potential of the system/module as well as the mobile terminals. The target group of the participants was composed of officers and local administrators assigned to the individual trained groups with jurisdiction in Radomia, Płock, Siedlce, Ciechanowie and Makowie Maz.

As regards crime data sharing with the public, general and selected statistics are officially available on the police website (*http://statystyka.policja.pl)*. Also, these websites provide assessment of the police work by the public. Crime maps with an accurate location of crime are not officially available. What is publically available in isolated cases, however, are maps generated by private organisations. One of these examples is a crime map of the city of Warsaw on websites *http://dobraulica.pl*. Data presented on this map comes from the police and relates to events registered in the vicinity in the first half of 2014. To prevent identfication of victims, concrete events are localised in the centre of a street, not in the area of the building where the event took place.

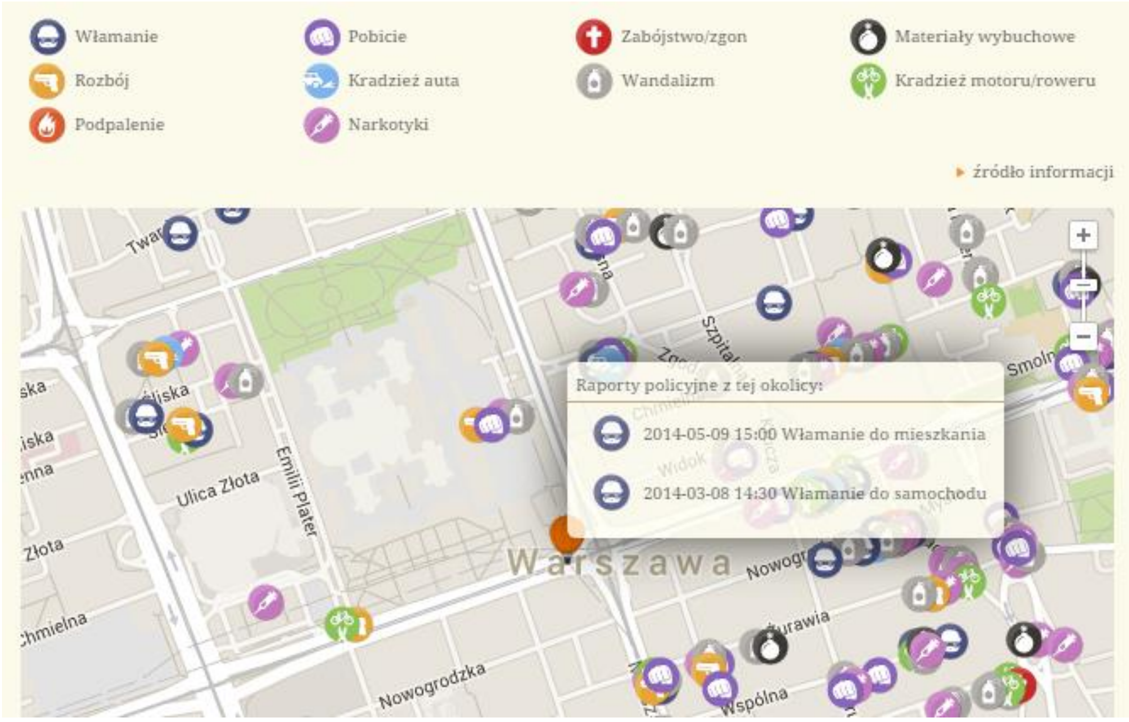


Figure 104: Crime map of Warsaw

Source: Dobra ulica 2015

Benefits, summary

KSIP as a central database in the ICT system provides a prompt search, access to information for a following data analysis. The main objectives of the project are mainly support of operating officers/commanders-in-chief in decision-making and allocation of resources. What is expected is a shorter response and an increase in the performance of police officers in the field. Also, some activities will be automated and mobile access to the system established.

Still, some police officers keep warning about the faults and instability of the system stemming from problems with logging in and a short response to queries. In 2009, the first serious collapse of the system emerged. After this, the director of the main police headquarters announced a competition for the officers to suggest ideas how KSIP could be adjusted.

8.9. SLOVAKIA

This example describes the current state of implementation and the following use of GIS in an internal system used by the police force of Slovakia, the Ministry of the Interior of Slovakia and other actors. The approach in question is the last on the list of countries neighbouring the Czech Republic.

Main sources of information:	Personal meeting held on: May 22th 2015 - *Bratislava, Police Presidium* Internal documents provided by the reprentatives of the visited organisations
Persons involved:	Officers working with the implemented solution Analysts and GIS personnel Academy of the police force Representatives of software developers and suppliers of the system

Information about the city/region

Source: ESRI, basemap ArcGIS Online, 2015

Slovakia is located in the eastern part of Central Europe. It is a parliamentary republic with the size of 49,035 km^2 (Eurostat 2015). It borders five countries – Austria and the Czech Republic in the West, Poland in the north, Hungary in the south, and Ukraine in the east. As to March 2015, the population of the country was 5,420,011 (Statistical office of Slovakia).

According to Eurostat data (2014), majority of the population worked in industry (24.7%), followed by wholesale business, retail business, transportation and restaurant services (22.4%). The value of gross domestic product was € 72,134 in 2013 (Eurostat). Unemployment rate was 12.4% at the beginning of the year, seeing an internannual decrease. The highest regional rate of unemployment, 17.2%, has been in the region of Prešov for a long time (Statistical office Slovakia 2015).

The capital of Slovakia, Bratislava, occupies both banks of the River Danube. Bratislava and Košice are the only two Slovak cities with a population exceeding 100,000, namely the population of Bratislava and Košice was 418,534 and 239,630 in 2014 (Statistical office Slovakia 2014). Slovakia is currently administratively divided into eight regions named after their principal cities: Bratislava, Košice, Trnava, Nitra, Trenčín, Žilina, Prešov and Banská Bystrica. The most populous is the Prešov region (almost 820,000 inhabitants in 2014, Statistical office Slovakia).

Information about the organisation

The main law enforcement body at the national level is the National Police Force (**Policajný zbor SR**). In 2011, it comprised 21,407 police officers and 5,801 civilian employees, which indicates an almost 10% increase compared to 2009 (Krulík 2012). In addition, Slovakia has also approximately 750 voluntary guards at its disposal, who undertake certain police activities (order, traffic, etc.) on a voluntary basis. According to the International Comparative Study on Police Forces, Slovakia, following Germany, is the second most progressive country in the EU as regards the increasing number of police officers. The budget of the National Police Force is one of the lowest in the EU, amounting to € 455.3 million. Only Slovenia, Luxembourg, Estonia, Latvia and Lithuania have a lower budget. The National Police Force is under the authority of Slovak interior minister. The police is divided into eight regional directorates (Bratislava, trnava, Nitra, Trenčín, Banská Bysrica, Žilina, Košice, Prešov), which are further divided into county directorates and district departments at the lowest level.

Integrated police centres are established in each region. Some are established only on regional police directorates. At the central level operates the central operating centre.

The administration regarding information technologies, communication and security is authorised within the following framework: **The System and Communication Division of the Ministry of the Interior of Slovakia is in charge of the infrastructure support, database support, the general operation of the system and the infrastructure of the Ministry of the Interior and public administration agencies. The Department of Applications** is a group of project managers who authorise projects and information systems from the perspective of projects. Units such as the **Presidium of the National Police Force**, **Crime Management Section** or **Public Administration Section** have their individual systems and users. The technological administration of the systems is separate.

Initial situation

The National Police Force uses custom basemaps, updated in 2005. The only activity in terms of crime mapping and generation of analyses is the preparation of maps about the general state of crime on the regional level and processing data for sharing with the public. In terms of the Ministry of the Interior, these tasks are carried out by two works who create cartograms by use of ArcGIS tools. The maps illustrate violent, vice, property, economic and generally disclosed crimes, which can be viewed on the public website of the Slovak Ministry of the Interior (http://www.minv.sk) along with comprehensive statistics.

The only activity associated to crime mapping and generation of analyses is preparation of maps about the general state of crime in regions and processing of data for sharing with the public. In terms of the Ministry of the Interior of Slovakia, these tasks are carried out by two employees who generate basic cartograms in ArcGIS. Prepared are maps of violent, vice, property, economic and total disclosed crimes, which are, along with comprehensive statistical information, publically available on the website of the Ministry of the Interior of Slovakia, http://www.minv.sk.

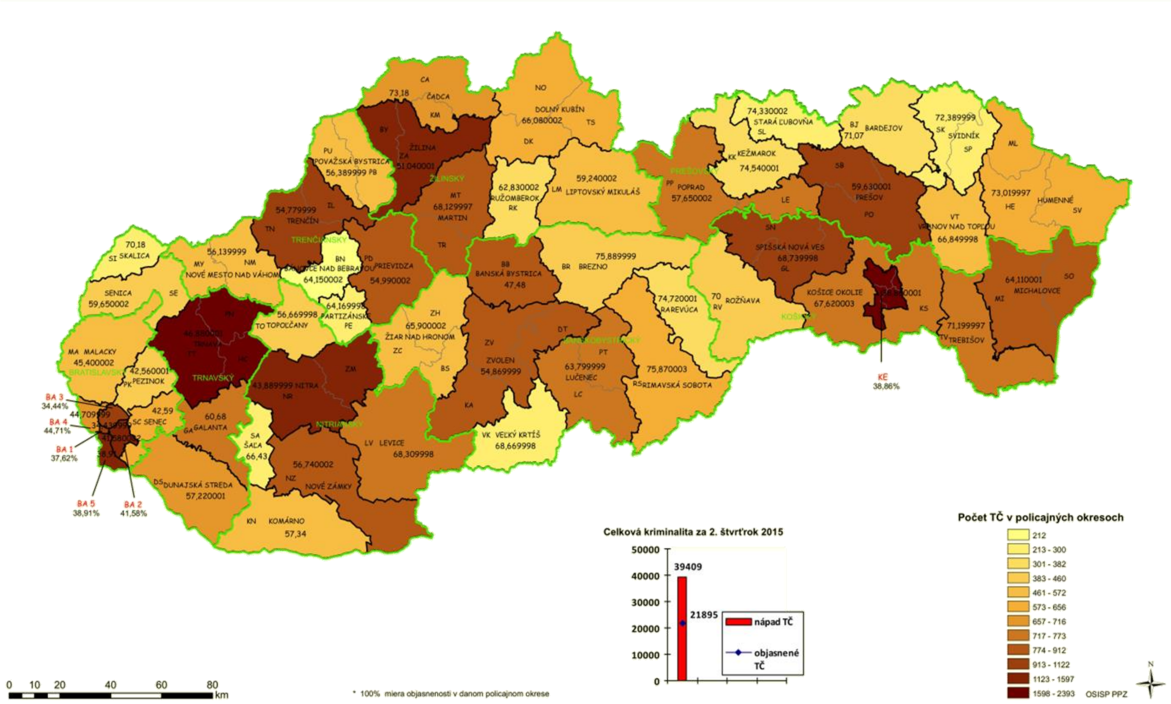


Figure 105: Crime map of Slovakia, second quarter of 2015

Source: Ministry of the Interior of Slovakia 2015

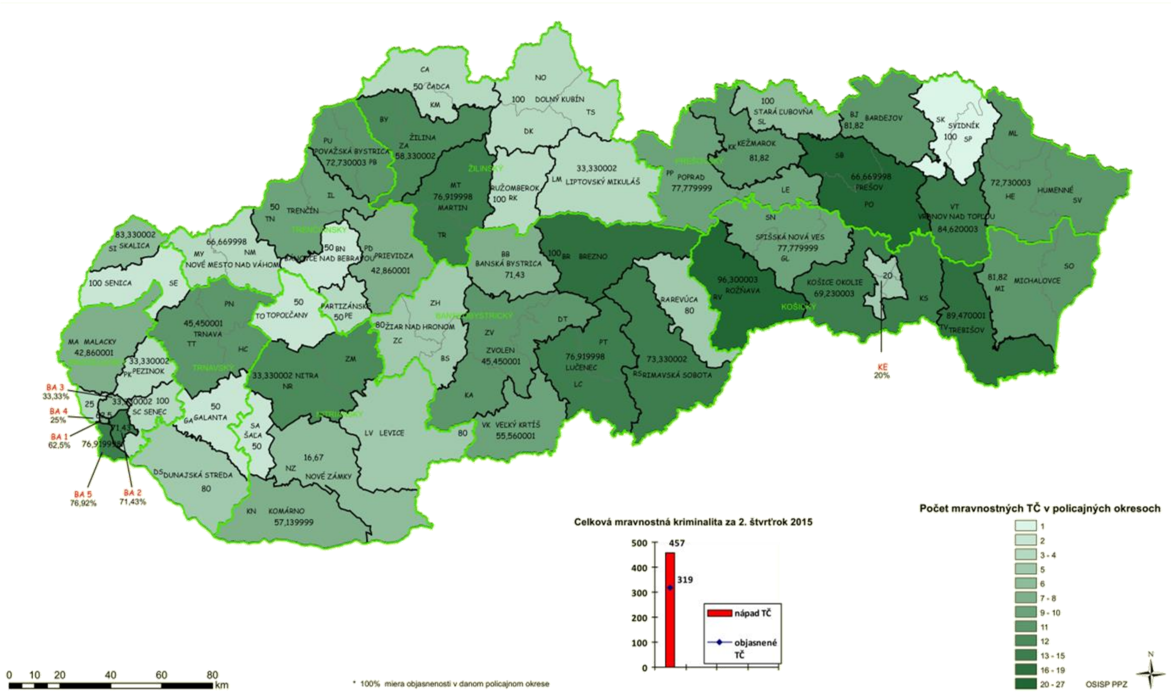


Figure 106: Vice crimes in Slovakia, second quarter of 2015

Source: Ministry of the Interior of Slovakia 2015

The need to embrace new technologies has become topical in operating centres, where it is necessary to localise the maker of the call, the crime scene, the place of reporting, and other aspects. Police officers are unable to view the position of patrols in the field online and to interact with them. Nor does the traffic police have any GIS tools which would register the locations of traffic accidents or limitations. Also the criminal police can make use of a GIS system. This situation leads to the establishment of a GIS solution which would increase the operating potential of future users.

Projects undertaken

Since 2013, the Ministry of the Interior has been carrying out an implementation project **Electronic Services of Information Systems of the Ministry of the Interior in the National Police Force** (Elektronické služby informačních systémů Ministerstva vnitra na úseku policejního sboru, ESISPZ), which aims to satisfy the needs of public-order, traffic and, partly, criminal police using GIS tools in managing activities. Financial resources necessary for the project are provided from the operational programme Public Informatisation. The project was to have finished in June 2015. However, due to an extension of the project, the finish has been moved to December 2015, with a gradual implementation of the system in regional directorates by July 2016.

The project is one part of a currently developed SAP system, which, after implementation, will enable managing the situation by individual units of integrated regional emergency services. Within this area a nationwide network of operating centres will be built. In terms of this SAP system, a **resort GIS system will be built**. The functionality of this system will enable using information from a wide range of data layers and basemaps, unified for the purposes of the whole integrated system. It will thus be possible to apply a centralised solution that will be the source of materials for a more effective crisis management.

This project was project was preceded by the project **smart cars**. Each police vehicle is equipped with an audiovisual device that records video and sound, and another device that records the location of the patrol and provides communication with the operating centre. Each patrol is assigned tasks and locations. By connecting the interim system and the new system, brought by the ESISPZ project, patrols – their movement and target – will be handled more effeciently depending on the specific requirements.

Building an **interaction centre** is another part of the project. It will be used for communicating with citizens through the emergency line (158)) and a new interactive portal used to acquire reports directly from citizens anonymously. This fact presumes that citizens would provide information otherwise unreported. Citizens can also report sudden events which pose threat in, for instance, traffic (traffic accidents, limitations, traffic jams). If the police records a situation which the interaction centre will validate as high-risk, it will be updated on the mapping portal and mobile devices. This will allow the citizens to know about such events not only in a textual form, but also through maps. The service of the interaction centre will be authorised by the internal operating centre of the police presidium.

Case study / application

The main part of the ESISPZ project is building **operating centres**, centres for emergency calls which will use a unified information system with different user roles. Since an integrated approach has been chosen for managing resources, GIS will be modified for each unit of the integrated system according to specific requirements. So as to ensure a continous service, the system will operate both online and offline. The users who have lower demands on its functionality will use a web application adjusted to the needs of the particular groups of users. Hierarchy of roles and restrictions regarding content will be defined.

GIS applications at operating centres will enable tracking police vehicles in real time and managing their activities, using mobile devices equipped with a communication platform. Through this platform, the patrol receives orders, fills in data about a given event and provides a briefing about their current situation. The vehicles are equipped with an GPS module, which localises the vehicle and sends out information about their positions to the GIS system every minute. It will thus be possible to view and track all these vehicles in a map field, as well as monitor and manage their activity. Using the portfolio of GIS tools, operating officers will create materials with information information about newly arisen events, which they will send to the patrol in the vehicle. Also, it will be possible to provide them with reports with direct orders. At this juncture, approximately 780 “smart cars” are equipped with a computer and a mobile unit. Police officers can also make use of screening module, all materials provided by the operating officer or a number-plate recognition system, which can carry out an immediate notification in the register of vehicles.

The system allows using various map windows upon consideration and working with different data layers and individual objects. The GIS application uses the functions of searching object, measuring distance and area, identification of objects and viewing attributive data, including basic statistics during the selection of a set of object with a polygon. Drawing tools for creating situational images enable drawing dots, lines and polygons, set colours, transparency and description. It also uses data export and print. Alternatively, such map compositions can be sent to patrol vehicles or via email to other potential users. Another function will be a search window for search addresses, buildings and persons.

An interesting point is using mobile networks, achieved through the cooperation with the providers. This will enable police officers to search persons through a mobile phone number, whose approximate position will be searched and viewed in the form of a triangle with the number in question in it. As the implemented solution is a service which the possibility of integrating other users in the future, the system is also prepared to be modified and complemented with specific functions (e.g. searching, map services, specific layers) which will depend on the requirements of its users.

Integrated resort GIS will use a number of data layers, such as land register, level crossings, flooding zones, address register, territorial division, road network, current traffic information, fire-brigade action points, etc. Also other data will be used in terms of the system, such as information from the statistical office. Layers included in the system will be updated regularly, depending on the type of the layer, requirements and technical possibilities.

For the purposes of implemenation and from the initial state of insufficient quality of basemaps, the **Fundamental GIS basis** (Základní báze GIS, ZB GIS) was created in 2014. It will be used as a basemap for applications and tools used by the National Police Force, the Presidium of the National Police Force, the Ministry of the Interior of Slovakia, but also the fire brigade, which will use it in terms of the integrated resort GIS portal. Periodical updates have for the upcoming period has not been arranged yet. Another useable material is ortophoto quadrangle.

The application server of the system is located in Bánská Bystrica, with a back-up centre in Nitra. Data servers ale located in regional data centres, used also in case of any problems with the central application server, when the system would switch to an offline mode, operating with a minimum functionality at the local server GIS applications on the regional data centres. This will ensure a continous operation of the server.

The main system administrators will probably be the workers who processed crime maps in GIS tools in terms of the Ministry of the Interior. They are the the only current employees to have dealt with the GIS and are thus the most suitable candidates to administer the central GIS solution. They will be trained for this work, so as will other employees, who will become the users with the highest authorisation and will administer the individual data layers for the GIS application, provide their update and communicate with the end users of the system. They will also instruct the users and cooperate during their training.

Practical usage

Users of the resort GIS will be the mentioned operating centres of regional police headquarters, the permanent service at local police departments, transportation authority, border and immigration office, rail police, authorised users in terms of the Presidim of the National Police Force and the Ministry of the Interior, and the fire brigade. Granting and systemic authorisation of the accession rights will be carried out by the Ministry of the Interior of Slovakia, where an entity responsible for decision-making, in accordance with the law and regulations, who and to what extent will use the data in the databases of the system, will be designated.

In terms of the above mentioned units, all end-users, mainly current staff, will have to be trained to use the system. Hiring new analysts and administrators will take place sporadically. With respect to the training, the profile of a police officer has been established. It renders the list of necessary training activities and defines the individual steps of training, in accordance with the given schedule. The training will be held by the supplier of the resort system, who will also provide a user-support line operating 24 hours a day.

The new information system will render, among others, the process of patrol administration and reporting more effective, as this agenda will be done in an electronic form. The report from the shift, which each patrol has to fill in, will be done automatically during the shift. Also the generation of instructing materials (schedule of shifts) will be carried out electronically. Superior officers will fill in the report about acquianting patrols with the instructions, which will automatically save in the system.

The police forces will be distributed according to the instructions, whilst all police officers have a particular expertise. In case of an unexpected event, the operating officer sees the available resources (how many patrols in the streets, in vehicles, who is present at an event, etc.) and other resources that can be utilised (e.g. dog handler, pyrotechnician and other necessary resources). The system automatically records the situation an officer was assigned to. After returning to the station, where report is automatically filled, he/she will have these pieces of information pre-filled, including the time. This principle saves time and resources.

Basic information about a reported event is fed into the system by the operating officer, including its location. The remaining information will be filled in by the assigned unit in the field, using the application and device in the vehicle connected to the Internet. Currently, the events are located using an address register. After the implementation of the system, it will be carried out using GPS coordinates.

In terms of the Ministry of the Interior, information and technology is secured by the Informatics, Telecommunication and Security Section. Consequently, all devices within the individual technical parts that the resort system is based on have been centralised.

Also, dislocation and decentralisation in security in low territorial units have been eliminated. County and regional directorates new use resort systems administered from the central computing centre. If data is therefore processed and saved, it is immediately available to other users. Absence of centralisation used to be an issue, since the delays between processing of a form about investigation and its sending not only have an impact on the costs, but also hamper the investigation.

Apart from the above mentioned purposes, the system will also be used to visualise historical data and statistics. As mentioned, general crime statistics and crime maps are processed in terms of the Ministry of the Interior. The new solution will introduce a new form, which will enable visualising not only currently used cartograms, but also basic information about crime (clearance, figures and rates of a particular type of crime, numbers of registered offences, or the rate of traffic accidents) via the map portal. It is therefore not only work with data or a map; rather an interactive visualisation of selected data, with the possibility of viewing custom thematic layers.

The implementation of the new portal for sharing information about crime is connected with numerous questions as to when and whether information should be publically available. In Slovak government resolution 50, from February 22nd 2012, addressing open government, among others, the Ministry of the Interior of Slovakia is obliged to disclose full data sets with comprehensive statistics about crime. This data is processed by machines and is therefore available to both citizens and legal entities which deal with crime. As mentioned, these are comprehensive statistics regarding counties and the whole of Slovakia. The location of the individual crimes is not detailed. Still, there are concerns about the sensitivity of the data, whose disclosure should thus be considered carefully. Also, some crimes are investigated over extensive periods of time and no details are known. As a result, the classification of the misdemeanour or felony can not be disclosed, nor the area where it happened, since often the only known place is the spot of reporting the crime, not the crime scene. When required by certain agencies of public administration, statistics on the municipal level are provided for the purpose of analyses pertaining to their authority.

Another current issue in Slovaka is the provision of data of the National Police Force to local police forces. Since local police forces tackle part of traffic-related misdemeanours, but also other types, they require online access to the register of inhabitants and vehicles. Currently, this exchange takes place based on a written requirement, or via phone through password authenticity, stated in an agreement.

This process is ineffective and a solution needs to be found on how local police forces could be granted access from the external network to the network of the Ministry of the Interior in order to draw information from the database in the online mode. It would require creating an independent role and defining accession rights to certain data, since local police forces can claim a limited range of data, as stated by the law.

There are several cities in Slovakia that create their individual information systems. To these systems are added modules for crime mapping and analysis used by local police forces. The level of cooperation with the National Police Force varies. Košice, for instance, plans to provide access to the CCTV system and operating centre to provide data to the national police, and it is also willing to built a communication channel which would serve as the means of sharing. This approach is individual, and no joint project regarding the cooperation between local and national police forces in Slovakia has not been carried out yet.

Case study / application effects

Since the implementation of the ESISPZ project has yet to be applied, its contributions can not be quantified. In addition, the future users will have to learn to use it. Afterwards they will be able to look for its shortcomings necessary to eliminate for a full use. It will be the end users who will have to define their needs, in order for future adjustments to be applied. However, some aspects regarded to have a positive impact can be summarised.

It is necessary to convince the officers that the implementation does not introduce any changes to processes they are used to following; it rather renders them more effective. Modern technologies will save time during the creation of reports, statistics and other administrative tasks. Therefore what is changed is not the process but the manner of work.

The trait of the system is that no individual systems are used on workplaces. Instead, a centralised GIS is applied, when one server will include multiple applications, each of which will be designated to a different unit or a group of users, whilst the maps will be shared and the work will comprise operations with specific layers. The whole system will thus be simple to modify. Operations with the system will require a thin application client and an access to the system.

As regards the monitoring of patrols, the aim was both checking but als analysing of their movement, eliminating the time spent in unproductive areas. In spite of a simple principle, the result is similar to using complex predictive systems, which by and large serve the same purpose – to identify high-risk areas.

It is presumed that the information acquired from citizens via the web portal of the interaction centre will be, to a large extent, a stimulus for police officers. Another form of motivation is the rise of trust in the police as well as the awareness of the police work. Besides, it is another form of communication with the public, or at least with some groups of the public. A potential secondary effect is also the elimination of fear to call the emergency line due to the precise identification of the calling person. Also negative impact is considered, which could be potential inaccurate or inapproprate comments.

Summary

ESISPS is a comprehensive project carried out throughout Slovakia. The implementation of the resort GIS includes other projects as well, such as *Electronic services of information systems at the division of public order, life-, health- and property saving*, and the project *Authorisation of infrastructure and information technology*. None of these projects has been finished. Therefore it is not possible to define the costs related to the implementation of the resort GIS. The assumed sum is in the region of tens of millions Euro. The costs cover complete implementaion, from the new server infrastructure and hardware equipment for the computing and operating centres, through the purchase of software licences, to the creation of documents and training of staff.

Despite the extent of the implementation, no legislative amendments need to drafted at the level of laws. These pertain to regulations which deal with the authority of elementary units, operating centres and emergency call units. It will therefore require new internal regulations to be written regarding the operations with the individual applications.

Implemenation of the new solution, resort GIS in this case, is a step forward from the viewpoint of integration of modern crime mapping and analysing tools. As mentioned, architecture the system is based on is adaptable; it can thus be adjusted and equiped with new functions and modules. Although this implementation does not relate to crime prediction tools, the possibility of implementing these tools in Slovakia remains open.

9. EVALUATION OF APPROACHES AND SUGGESTIONS FOR THE CZECH REPUBLIC

9.1. SUMMARY

Due to the diversity of approaches of the individual countries/cities/police forces in the implementation of tools in crime mapping, analyses and prediction, this section provides a comparison of the users' experience and the benefits of the tools. When comparing the described examples, it is important to consider the difference in social climate in each country, the size of the cities or previous experience with the given tools.

For the sake of comparison, the following tables provide a list of countries/cities dealt with in this study. Then, the benefits of the tools and methods are summarised in each example of the visited facility. All examples of workplaces consider the application of analyses, tools or predictive software in the work as contributive, which is supported by a marked decrease in crime *(e.g. Great Britain - Greater Manchester, USA - Lancaster).*

	Basic information	Software used	Other tools/approaches used	Parties involved	Miscellaneous
Czech Republic ***Kolín***	Patrols targeted to hotspots with burglaries	▪ GIS of the National Police Force	▪ Websites "Safe Kolín" ▪ Preventative measures of the City Police Force ▪ CCTV	▪ Manager of the territorial division ▪ City Police Force director ▪ Analyst of the territorial division ▪ "Safe Kolín" task force	▪ Pilot project "Simply quick" launched - use of tablets in the field ▪ Significant decline in offences ▪ Increase in clearance-rate
Czech Republic ***Uherské Hradiště***	Completion of the mapping portal - the project *E-analysis of security*	▪ Mapping server T-MAPY	▪ Websites "E-analysis of security" ▪ CCTV ▪ Coordination of the City Police Force with the National Police Force	▪ City Police Force chief ▪ GIS administrator ▪ Crime prevention manager	▪ Planned implementation of the pilot project, focused on testing of the application by field officers
Czech Republic ***Pardubice***	Localisation of misdemeanours with mobile devices - crime mapping.	▪ City Police Force manager	▪ Smartphones, tablets used in the field ▪ CCTV ▪ Cooperation between the City and the National Police Force	▪ City Police Force director ▪ Information-system administrator of the City Police Force	▪ Crime mapping focused on offences in individual areas

Table 5: Comparison of the cases in question in the Czech Republic

	Basic information	Software used	Other tools/approaches used	Parties involved	Miscellaneous
Great Britain ***Metropolitan Police London***	High Crime project, which compares predictive software from three suppliers	▪ *PredPol* ▪ *HunchLab* ▪ *Palantir* ▪ ArcGIS ▪ SPSS	▪ Time series of crime recorded over years ▪ Position located from patrol radios ▪ CCTV ▪ Cooperation with universities ▪ Inspired by LAPD	▪ Chief police inspector of the project ▪ Police-department manager ▪ Information-system administrators of the police	▪ Project High Crime has not been completed, no final evaluation is therefore available. It should take place in late 2015.
Great Britain ***Greater Manchester***	Project focused on burglaries. It is based on predictive analytics and the understanding where crime takes place, followed be preventative measures.	▪ Near-Repeat calculator ▪ Ordinary GIS tools	▪ Time series of crime recorded over years ▪ Socio-demographic data ▪ Position located from patrol radios ▪ Police interviews with citizens ▪ Cooperation with UCL ▪ Near-Repeat Victimization	▪ Police analyst ▪ UCL workers ▪ Police officers	▪ "Cocooning" implemented ▪ 2012 saw a reduction in burglaries by 38%, compared to 2010.
Great Britain ***Kent***	Implemented system added to the portfolio of policing, improving the system of analyses.	▪ PredPol ▪ ArcGIS ▪ SPSS	▪ Cooperation with LAPD ▪ Time series of crime recorded over years ▪ Position located from patrol radios	▪ Police chief ▪ Police analysts ▪ Police GIS specialists	▪ Crime records are sent to Los Angeles for processing ▪ Project planned for equipping field officers with tablets
Great Britain ***Cambridgeshire***	Project focused on location of risk areas by use of hotspots (for 12 months), followed by coordinated patrolling.	▪ Not used *(processing conducted by university)*	▪ Cooperation with the University of Cambridge ▪ Time series of crime recorded over years ▪ Position located from patrol radios	▪ Police manager of the project ▪ University workers ▪ Police officers	▪ Preliminary results show a 40% drop in calls for service and a 28% drop in the victims of crime.

Table 6: Comparison of the cases in question in Great Britain

	Basic information	Software used	Other tools/approaches used	Parties involved	Miscellaneous
USA ***Los Angeles Police Department***	Prior to the implementation of innovative tools for coordinated patrolling and crime prediction, no GIS are used for spatial data analysis.	▪ PredPol ▪ CrimeMapping ▪ Palantir	▪ Compstat (officer evaluation) ▪ Time series of crime recorded over years ▪ Recorded patrol position ▪ CCTV ▪ Vehicles equipped with information systems	▪ Captains of individual LAPD divisions ▪ Police analysts ▪ Police officers	▪ Optional use of PredPol ▪ LAPD Foothill Division statistics show a 20% decrease in crime in years 2013 and 2014.
USA ***San Diego***	Unified information system, supplemented with new tools. Effective cooperation of involved parties.	▪ ArcGIS ▪ CrimeView Dashboard ▪ Argus ▪ Insider	▪ Time series of crime recorded over years ▪ Position located from patrol radios ▪ CCTV ▪ Police vehicles equipped with information systems	▪ Department captain ▪ Police analysts ▪ Police officers ▪ ARJIS	▪ No effectiveness in relation to crime was measured. Time-related effectiveness can be observed, however.
USA ***Lancaster***	No police department - team of analysts hired by the town.	▪ ArcGIS ▪ IBM SPSS Modeller ▪ CrimeView Dashboard	▪ Time series of crime recorded over years ▪ Risk Terrain Modelling ▪ Analyses of demography ▪ Data of statistical office ▪ Weather forecasts ▪ Social events	▪ Hired team of analysts ▪ LA Sheriff´s Department (policing)	▪ Model and results of police work indicate a decline in crime by 35% in 2010, compared to 2007. In 2011, the drop was 42%.
USA ***Tempe***	One department of Tempe Police deals with crime analyses. It comprises two centres focused on different types of analyses.	▪ ArcGIS ▪ IBM SPSS ▪ CrimeView Dashboard ▪ Automated Tactical Analysis of Crime	▪ Compstat (officer evaluation) ▪ Time series of crime recorded over years ▪ Call from emergency line ▪ Position located from patrol radios ▪ Field mobile devices	▪ Department captain ▪ Police analysts ▪ Police officers	▪ In 3-6 months since the implementation of these strategies, the rate of burglaries in risk areas dropped by as much as 12%.

Table 7: Comparison of the cases in question in the USA

	Basic information	Software used	Other tools/approaches used	Parties involved	Miscellaneous
Austria ***Vienna***	Currently, there is no independent team focused on analysis, only specialists located in separate police units.	▪ ArcGIS	▪ Time series of crime recorded over years ▪ Specialised databases ▪ Safety monitor system	▪ Police director and his deputies ▪ Director of the criminal authority ▪ Police analysts ▪ Police units	▪ Analysts generate tables and maps that reflect current situation and particular offences.
Austria ***Styria***	Analysts and other involved police officers deal with crime mapping, generating hotspots, GPS mapping, analysing distances in terms of problematic areas, geographic profiling and other analytical methods.	▪ ArcGIS ▪ Geotime	▪ Time series of crime recorded over years ▪ Specialised databases ▪ Safety monitor system	▪ Police units ▪ Police analysts	▪ Modern analytical methods are evaluated as beneficial, confirmed by general reduction in crime after implementation.
Switzerland	Since 2008, weekly and monthly reports are generated for internal, individual purposes.	▪ PRECOBS ▪ ArcGIS	▪ Time series of crime recorded over years ▪ Near-Repeat Victimization	▪ Police management ▪ Police analysts ▪ Police officers	▪ In areas where PRECOBS was used, 2014 saw a 15% decline in burglaries compared to the year before.
Germany	Inspired by Zurich, which implemented the predictive system PRECOBS	▪ PRECOBS ▪ ArcGIS ▪ PAD Mobifilter	▪ Time series of crime recorded over years ▪ Near-Repeat Victimization	▪ Police management ▪ Police analysts ▪ Police officers	▪ Result of testing PRECOBS was a decrease in burglaries, as well as an increase in arrested offenders, by as much as 42%.
Italy	Due to an insufficient condition of the IS of the police, the SIGR project	▪ IS SIGR based on Oracle	▪ Centralised police database ▪ Specialised databases	▪ Police management ▪ Police analysts ▪ Police officers	▪ The most expected is saving costs related to administration and

	Basic information	Software used	Other tools/approaches used	Parties involved	Miscellaneous
	was carried out (Integrated System for the Georeferencing of Crimes).	technology			identification of high-risk areas.
POLAND	Development of the national information police system (KSIP).	▪ National Information Police System (KSIP) ▪ Analytical system (SA) ▪ Command&Control system (SWD)	▪ Centralised police database ▪ Specialised databases/modules	▪ Main police headquarters ▪ Territorial police directorate ▪ Regional police headquarters ▪ Municipal police directorate ▪ Police stations	▪ The main objectives of the project are mainly support of operating officers/commanders-in-chief in decision-making and allocation of resources.
Slovakia	Since 2013, realisation of the project Electronic services of information systems of the Ministry of the Interior in police forces (ESISPZ)	▪ Building-up of a custom GIS system ▪ ArcGIS	▪ Interaction centre ▪ Operating centres ▪ Smart vehicles ▪ Basic GIS base	▪ Police analysts ▪ Operating centres of regional headquarters ▪ District department	▪ As the implementation of the project has not been applied yet, potential benefits can not be quantified.

Table 8: Basic comparison of European examples

9.1.1. Basic summary of benefits of each example

CZECH REPUBLIC – Kolín

CONTRIBUTIONS	
	▪ Since 2015, crime decreased by 39% compared to 2014, and by 50% compared to 2013. ▪ In property crime, the first quarter of 2015 saw a 57% decrease compared to 2014, and a 68% decrease compared to 2013. ▪ In burglaries, the first quarter of 2015 saw a 56% decrease compared to 2014, and a 85% decrease compared to 2013. ▪ In thefts, the first quarter of 2015 saw a 64% decrease compared to 2014, and a 71% decrease compared to 2013.

CZECH REPUBLIC – Uherské Hradiště

CONTRI-BUTIONS	
	▪ City Police Force does not observe how the system contributed to crime reduction. ▪ Effectiveness is assessed by generating a schedule where patrols should be targeted.

CZECH REPUBLIC – Pardubice

CONTRIBUTIONS	
	▪ City Police Force does not observe how the system contributed to crime reduction. ▪ The main contribution is seen in the elimination of administrative work, enabling officers to spend more time in the streets and a more effective planning.

GREAT BRITAIN – Greater Manchester

CONTRIBUTIONS

- In 2012, compared to 2010, when the methods were established, burglaries dropped by 38% and burglarised vehicles by 29%.
- Public trust rised from 7% to 97%.
- Project using similar methods was implemented in West Yorkshire, where burglaries in high-risk areas declined by 65%.

GREAT BRITAIN – Cambridgeshire

CONTRI-BUTIONS

- Preliminary results show a 40% decrease in calls for service, and 28% decrease in victims in high-risk areas.
- During the project, each officers responded to on average four calls for service more and their response time improved by 25%.

GREAT BRITAIN – Kent

CONTRIBUTIONS

- Over two years, when Kent Police have been using the PredPol system, a successful prediction was generated in 25-30% of real criminal activity.
- Measures based on analyses helped reduce anti-social behaviour by 7-10%.
- Violent crime decreased by 7%, general crime by 4%.

GREAT BRITAIN – Metropolitan Police London

CONTRI-BUTIONS

- Project High Crime has not been finished yet.
- Better monitoring of patrols and automation of obtaining and processing of crime data in real time

USA – Lancaster

CONTRI-BUTIONS

- Crime declined by 35% in 2010, compared to 2007. In 2011, the drop was 42%.

USA – Los Angeles Police Department

CONTRI-BUTIONS

- In a four-month period after the implementation of the system, crime decreased by 13%.
- Between 2013 and 2014, crime dropped by 20%.

USA – Tempe

CONTRI-BUTIONS

- During 3-6 months since the implementation of these strategies, burglaries in high-risk areas decreased by 12%.

USA – San Diego

CONTRI-BUTIONS

- Effectiveness regarding crime of the system was not measured. However, effectiveness regarding time savings can be observed with respect to activities carried out during analyses.

SWITZERLAND

CONTRI-BUTIONS

- The year 2014 saw a 6.8% decline in burglaries, compared to 2013. The observed areas, where PRECOBS was used, show a 15% decrease in reported burglaries, in comparison to the previous years.

GERMANY

CONTRIBUTIONS

- Testing of PRECOBS resulted in a decline in burglaries and an increase in captured offenders. In particular, Munich saw a drop by 29%, in areas strongly beset with this issue by as much as 42%. In Middle Franconia, the observed decline in burglaries was 17.5%.
- By appliying preventative measures, the Ministry of the Interior wants to attain that 40% of burglaries would end as an attempt.

AUSTRIA – Styria

CONTRI-BUTIONS

- Based on analysis of and increased police presence in high-risk areas in 2013, burglaries dropped by 20%.

AUSTRIA – Vienna

CONTRI-BUTIONS

- After the implementation of GIS tools in the Vienna Police Force, no steps were taken to measure the increase or decrease in work efficiency or costs. According to police management, it is not even needed as the benefit of this approach is evident during the work and its simplification.

AUSTRIA – CriPa

CONTRIBUTIONS

- Final results yet unavailable (August 2015).
- Preliminary results of the retrospective analysis of the number of burglaries which could be potentially prevented showed that using CriPa it was possible to prevent 30% of burglaries in hotspot areas, and in a county with a low occurrence of burglaries approximately 5% could be prevented.

ITALY

CONTRI-BUTIONS

- The most expected contribution of the impelementation is financial savings connected with administrative tasks, partially eliminated due to a simplified access to data.

POLAND

CONTRI-BUTIONS

- What is expected is a shorter response and an increase in the performance of police officers in the field.
- Also, some activities will be automated and mobile access to the system established.

SLOVAKIA

CONTRI-BUTIONS

- Implementation of the project has not been applied yet, potential benefits can not be quantified.
- Modern technology will save time in generating reports, statistics and other administrative tasks.

9.2. INITIAL REMARKS

9.2.1. Summary of the situation in the Czech Republic and abroad

Involved parties from abroad

In case the experience from abroad were summarised from the view of the cases described, police officers, analysts and university scholars from these countries highlighted and recommended focusing on the following points. These provide a description of basic principles to follow when new analytical/predictive systems will be implemented.

Give it a try!

Experts from the countries in question highly recommend trying to work with analytical/predictive tools, in any of the described varieties.

Predictive tools do not replace traditional police work, they complement it.

Neither predictive tools nor traditional analytical methods aim to replace conventional police processes, but rather add to the knowledge of police officers and chiefs. These modern systems introduce additional information, not information replacing already acquired knowledge.

Police officers are encouraged to work with new analytical tools / predictive software.

Increasing the availability of data, and the tendency to improve their quality go hand in hand with the development of statistical methods, useful for policing purposes. In connection with the latest trends, predictive analyses are beneficial to be implemented and developed in policing.

Still, analysts, GIS specialists and other experts should not be underestimated.

The experience of foreign units shows a positive influence on the work of these employees. It has been proved that the new methods and the engagement of specialised analysts leave a positive mark on policing, which supports safety and sustainable security of the population significantly.

Training staff

When implementing these systems, it is vital to explain the purposes and benefits of the reasons for application properly. Users need to be adequately briefed about the new methods, including those where analyses have no particular impact. It is the only way to prevent misunderstanding and scepticism. Proper undestanding of purposes/benefits of new methods is crucial for their effective use. Users of the new system have to undergo appropriate training to their particular role.

Cooperation with universities

Experience also shows cooperation with universities whose top-level scientific resources are able to give advice or even assistance during the implementation of new tools and methods.

Involvement of other aspects in analytical work

Data analysis should not be associated solely with data on offences, i.e. with the type of offence, its time and location. Other, seemingly insignificant aspects are connected with crime occurrence. Still, complementary data allow for new views and in combination with special techniques can facilitate finding new relations. This is due to data about phenomena associated with offences or resulting from it.

Current, up-to-date data

Analyses and materials require top-quality data. Quality depends on the way of obtaining the data. The process needs to be defined precisely, with respect to the aim of the data. In case adequate attention is paid to this phase, high-quality data can be assumed, in terms of both their content and structure.

Hierarchy of staff (analysts, GIS specialists, etc.) should be established.

Competencies and tasks should be clearly defined in the personal structure in police forces where crime mapping, analyses and predictions are to be implemented. People and their duties and responsibilities need to be clearly defined at all levels, from police officers to top management, which should bear responsibility for the sustainability of the implemented methods. Thus a system of hierarchical responsibility should be established.

Summary of the authors

As has been mentioned, the main goal of the study is to assess individual approaches in a given organisation which uses modern tools for crime analysis and prediction. Based on advanced analytical methods and high-quality data, these tools enable locating areas with high probability of crime. From the commercial tools dealt with in this study (*PredPol, HunchLab, Palantir, CrimeView)*, none can be considered to be used extensively in the Czech Republic. Prior to the implementation, it is necessary to test the product in the area of focus and to answer the matter of suitability of the product within that area.

It is also important to realise that in cases such as Los Angeles Police Department, where no such analyses were carried out prior to the implementation of PredPol, considerable reduction in crime takes place. By contrast, units which are experienced in using spatial/predictive analyses fail to see any marked changes in the development of crime after predictive tools were implemented.

It is the users of this commercial system who tend to follow the outcome in blind trust, failing to study and interpret the results. There is an inherent risk behind commercial "appealing" software. It creates the impression that anyone can operate it. As a result, situations may be misinterpreted should the numbers of analysts be reduced and replaced by these systems since these are incapable of providing a fully-fledged outcome without analysts' complementary interpretation. The most adequate form thus appears to be the connection of commercial or tailored software and analysts' work.

Functionality of such systems is meaningless mainly in regions and cities with low crime-rates, where outcomes of analyses of such systems would lack any potential. Another downside of these tools is the high price and maintenance-related costs. Were these tools to be used equally throughout the Czech Republic, a soar in financial requirements would be expected, compared to an implementation involving a nation-wide system using standard analytical and GIS tools. In such a situation, it is not recommended to invest large amounts of money in predictive systems with no guaranteed benefit. Users of these systems purchased them for an attractive price or even obtained them free of charge. This was due to the fact the software companies provided their products for testing purposes or in exchange for data to develop predictive models.

Still, functionality of this system could be beneficial to selected regions and larger cities of the Czech Republic in tackling preventive and safety measures. In comparison with commercial tools, a free product is being developed which will have identical functions as, for instance, the PredPol solution, although it would be possible to obtain it “for free” (except for the costs of the service and maintenance). Owing to the current development of the software, no detailed information is available. It is, however, known that it should be available by the end of 2015.

In addition, the role of traditional role of analytical and GIS methods can not be dispensed with should new predictive software be implemented. Predictive systems can not be a replacement for experienced analysts and their use should be regarded as a complement to their work, whose pillars are analytical skills, knowledge of local situation and experience in policing. Provided these systems are used, their benefits must not be overestimated, but taken as an additional source of information.

Traditional analytical and GIS tools are software products enabling administration of spatial data, statistical data analysis, spatial data analyses, generating reports and outcomes, or data mining. The most frequently used, traditional tools are products from the ESRI company (ArcGIS Desktop, ArcGIS Server, ArcGIS Online...), SPSS and MapInfo. These are commercial products whose appropriate combination enables creation of a complex portfolion of statistical materials and base maps in paper and digital form, including interactive mapping portals, which can be further used by police officers for their different requirements in a variety of user modes.

9.2.2. Summary of target groups' opinions obtained during workshops

In panel discussions, held on the second day of the project workshop, the following topic were discusses with the representatives of target groups (see section OBJECTIVES AND METHODOLOGY).

- Target group needs, requirements and expectations
- Conditions for application of tools and processes for crime mapping, analysis and prediction in target groups (legislative, technical, financial, personal conditions)
- Availability and quality of data on crime and related phenomena
- Sharing of data and outcomes with other subjects, disclosure of data on crime
- Motivation and involvement of target groups in the work with crime-mapping, -analysis and -prediction tools

Motivation and engagement of target groups in the work with crime mapping, analysis and prediction tools is diverse. City police force and self-administrative bodies regard such analyses/tools as contributive, as they clearly monitor the situation and therefore generate effective materials for decision-making. In the National Police Force, various stances can be observed at all levels, from enthusiasts and followers to pessimists and sceptics. Police officers often doubt the benefit of new technologies against the backdrop of their experience and knowledge. In this respect, there are opinions that not in all local divisions would such analyses/tools be useful and beneficial. Should these analyses/tools be implemented, attention would be paid to a sufficient explanation of the goal, benefit and manner of implementation of the systems in question at all levels (top management, ordinary users).

Representatives of target groups perceive implementation of new tools and methods as an adequate step to render police work more effective. Currently, the National Police Force takes steps to their implementation. Modern analytical work is not an exception in some police forces in the Czech Republic. It is the members of this group, however, who consider the size of some territories a challenge for the implementation. It is necessary to think through where and whether local conditions enable the use of advanced tools.

Another discusses matter are human resources in the National Police Force. The majority of members of target groups, mainly analysts, came to the conclusion that analysts are so occupied (mainly by working on case analyses) that they are unable to cover and develop other activities, such as the area of predictive and other criminal analyses. Moreover, the level of education/training is connected with this issue, considered as insufficient in this area, and should the new tools be implemented, it would become an indispensable part. It is vital to establish an adequate system of training in statistical data processing, spatial analyses, data mining, IT and other specialised methods immediately.

The point at issue of the National Police Force is the extent of disclosing details on public crime, for instance crime maps at the street-level. There are concerns about misuse of data by third parties or infringing on privacy of victims of crime. In this respect, the officials generally keep their distance from providing data to, for example, universities, city police force or the public, and consider the current situation as sufficient. The reasons is also shortage of staff in charge of issuing data and its preparation, which, as scholars and other organisations say, could solve the issue of allocating a separate group to deal with data provision and public relations. Representatives of universities and other organisations regard the provision of data on crime as a duty of the law-enforcement agencies, considering the level of information provided to the public as insufficient, which raises mistrust in the National Police Force.

Police representatives feel the urge to work with data of the National Police Force at least to a limited extent. It was also mentioned that the cooperation in data provision is not ideal, mainly because of a convoluted process in their issuing. Some opinions say that one solution could be a development of a joint IT system, where police forces would be accessed to the data. The problem, however, consists in the distortion of currently used IT systems in police agencies in the Czech Republic, and financial demands for their centralisation. As a form of data disclosure and its spatial aggregation, i.e. generalisation which prevents actual localisation of an offence, or aggregation based on offences.

9.2.3. Assessment criteria

When the approaches applying different processes and tools were scrutinised, mainly those from abroad, three most critical aspects, mutually intertwined, were considered, namely **spatial**, **personal** and **functional**.

From the **viewpoint** of **functionality** of individual approaches, it is important to focus on the purpose the approach should serve. It is necessary to take into consideration the fact that many crime-prediction and -analysis applications and software tools provide pre-defined functions, whose weakness is that they may not be in line with the demands of potential users. Each workplace where these tools are to be implemented has its specific requirements depending on the situation, which is why the local modification is a crucial criterion for the fulfillment of the aim a tool should have. It is also important whether such alterations can be made by the client, or exclusively in collaboration with the developer of the tool.

Another significant criterion is **the personal aspect**. In the case of standard analytical and GIS tools, which generally are not intuitive, a group of specialised workers is generally allocated – analysts with sufficient training in data processing and data mining, geoinformatics, statistics and IT. In the case of automated functions, which can be operated in an intuitive user environment, there is no need to allocate highly qualified personnel, as in the previous example. Automatied tools require lower proficiency, which, in turn, can be the downside of this approach. Even in such approaches, the level of knowledge in the given areas should reach a certain level beyond the skills of the so-called “naïve” user. That is due to risk of incorrect processing of data/analyses and the following interpretation of results.

From the **spatial viewpoint**, approaches can be divided into two groups. The first are tools usable as a whole in areas of any size. Such can therefore be used nationwide, or locally at lower administrative levels. The second group of approaches and tools is applicable locally, at the regional or city level. This division, however, is dependent upon the the presumed purpose of the system. The majority of the systems is used at the level of cities whose police units are typical customers of companies which develop tools for crime analysis and prediction. It can not be said that these tools can not be modified for the use in a larger area. It can be, however, assumed that such adjustments would entail high costs. In the case of traditional methods and GIS tools, the selection and setting of particular analyses depends on the ability of a user/analyst.

9.3. RECOMMENDATIONS FOR THE CZECH REPUBLIC

The recommendation for the Czech Republic is divided into the following subsections, which provide a description of crucial principles, advised to abide by, during the implementation of new analytical/predictive systems. Part of the recommendation is a section of the expert proposal of a pilot solution, based on the described experience and consultations with selected experts. Some issues of crime mapping, analysis and prediction (register of accidents, unreported crime, map documents, etc.) were also addressed by Dr Jiří Horák in his presentation at the first project workshop at Police Academy of the Czech Republic in Prague (December 2014).

9.3.1. Organisation

1) To focus on adequate motivation of the staff at all levels (top management > ordinary police officers). To highlight and explain the purpose, benefits and manner of implementation of the given tools/systems. Ordinary police officers who report particular incidents should be allowed to actively use spatial data to understand their benefits. To create an information campaign for managing staff of regional directorates and territorial divisions. To create and ensure dissemination of information to all interested parties. Alternatively, to create websites with this information, which would also serve as a means of feedback from the users/interested parties. To acquaint political representatives of municipalities with the benefits of these tools/methods and motivate them to cooperate and support the National Police Force.

2) To establish an evaluation system of police officers which should not be based solely on statistical indicators (e.g. clearance-rate), but also on a proactive approach in and reduction of crime in a given area.

3) From the viewpoint of territorial hierarchical distribution of new analytical staff, and filling their positions with adequate candidates, it is recommended to consider territorial division, used by the National Police Force, and thus clearly define the territorial jurisdiction of a specialised analyst or their group. In such a case, it is recommended to assign one specialised analyst to a territorial division.

4) Preventative staff at both regional directorates and territorial divisions should be trained in criminology and familiarised with analytical work/tools in criminal analyses, mainly for the requirements of planning preventative measures and for long-term strategic planning processes.

5) In terms of the engagement of territorial divisions, the fact needs to be taken into account that the described predictions/analyses are not suitable due to the size or low crime-rate. Alternatively, to have the option to use the built GIS system or commercial software (e.g. CrimeView Dashboard), where basic tactical short-term analyses (statistics) can be created in an intuitive environment for patrol targeting and other preventative measures. Without any necessity for complicated operations, they would obtain supplementary information about the current situation and predicted situation in near future.

6) What is key is the adequate focus of analysts on different types of tasks concentrated on statistical data processing, spatial analyses, data mining. Unlike these days, analysts' work should not be focused on case analyses only. They should support investigation of specific cases, operative planning of resources – short-term predictions, long-term predictions and crime prevention.

The work of a specialised analyst at the territorial division should consists in processing analyses focused on particular preventative measures of a given department and in providing methodological support in targeting police patrols in terms of the developed GIS or implemented predictive software in the National Police Force.

Also, advanced data processing/evaluation and its visualisation in geo-IT tools within a particular area. Materials which should become standard output of specialised analysts are, for instance, specialised data analyses focused on particular crime and their visualisation, hotspot maps, geographic profiling, Risk Terrain Modelling, statistical reports, thematic maps with specific content, observation of criminogenic patterns in space, time, etc.

Also, specialised analysts should cooperate closely with members of the GIS group of the National Police Force.

7) Closer cooperation between the National and local police force Involvement of local police forces should be taken into account during the implementation of the tools and systems. Related to this is the amendment of the Data-Sharing Act between the National and local police force (553/1991, section 11a). Local police forces could use the system based on its role with rights to access, enabling them to share data with the National Police Force.

8) Proposal for a legislative amendment pertaining to sharing data with external subjects, such as labour office, the ministry of social affairs and others.

9.3.2. Technological recommendations

1) The use of predictive tools is connected with an adequate time series of localised information about incidents registered by the National Police Force and local police forces according to the type of prediction (short-, mid- and long-term). In pre-prepared commercial predictive models, at least a five-year time series is advised.

2) Not implement a solely predictive software. To obtain an effective analysis and data processing, it is recommended to work with tools based on traditional methods of statistical data-processing, spatial data analyses, data mining and other methods. Such non-predictive methods are suitable for the generation of materials witch facilitate understanding the development of crime in time and space.

All analytical departments should be equipped with identical tools/software so as to attain compatibility among individual territorial divisions. A specific selection of software is recommended on the basis of the evaluation of the pilot project. Basic tools should provide mainly analytical processing of spatial/thematic data and their visualisation.

Some requirements for appopriate GIS software:

- A graphic, user-friendly environment with customer settings.

- Visualisation of vector and raster data.
- The options to select, define and transform coordinate, projection and altitude-coordinate systems.
- Basic vector, raster and topological operations.
- Spatial analyses.
- Simultaneous visualisation and work with vector, raster and descriptive data.
- Support of remote map services according to the OGS standard (WMS, WFS, WPS).
- Creation and editing of vector and raster data.
- Saving and export of vector data to different formats (ESRI Shapefile, AutoCAD DXF, DBF soubor, GPS eXchange Format GPX, Generic Mapping Tools GMT, GeoJSON, GeoPackage, GeoRSS, Geoconcept, etc.).
- Saving and export of raster data to different formats (GTiff, GeoPDF, Tiff, PDF, PNG, JPG, ASCI, …).
- Generation of maps conforming to fundamental cartographic rules.
- The possibility to operate offline.
- Windows (and alternatively Linux and Mac OS) compatibility.

Some requirements for an appropriate software for statistical and analytical data processing:

- Graphic, user-friendly environment with customer settings.
- Loading of different input formats (XLS, XLSX, XLSM, XML, TXT, SAV, SYS, DBF, DAT, CSV, TAB, DTA, POR, PLK, etc.).
- Saving and exporting data in standard formats (xls, xlsx, txt, csv, sav, dbf, tab, xml, etc.) for the possibility to process data in other software.
- Loading data from databases (Oarcle Database, MS SQL, Postgres, Microsoft SQL Server, SQLite, FireBird, etc.).
- Basic operations with data (order, aggregation, definition of duplicity, transformation of variables, restructuring, data division, etc.).
- Transformation of data (operations with chains, numerical values, date and time, type conversion, replacement of values, etc.).

- The possibility to obtain descriptive statistics (average, standard deviation, mode, mean, skewness, kurtosis, quantiles, percentiles, range, etc.).
- Generation of graphs (histograms, line graphs, boxplots, area chart, radar charts, pie charts, graphs of variance, etc.).
- Obtaining of elementary and advanced statistic analyses (comparison of means, correlation, regression, classification, neural networks, non-parametric testing)

Description of tools used in the analysed areas is provided in section 7.

3) Acquisition of adequate technolgy for collecting data and mapping in the field. Equipping patrols with mobile devices (tablets, smartphones) in the field, including GNSS transmitters, alternatively devices of police vehicles to serve as “mobile offices”. Establish an adequate system of crime mapping in interior premises (e.g. shopping malls) and other specific situations (e.g. public transport) – recording of a given incident. At the same time, it is important to avoid connecting individual cases and differentiate between individual spots of such incidents.

To ensure adequate data connection of a given device in the field. Alternatively, definition of places for patrols with a free access to the Internet, such as banks, authorities, post offices, where officers could process and send information without the need to return to their station.

4) Engage support data sources in the generated analyses. To begin a close cooperation with external parties, such as statistical office, ministry of labour and social affairs, ministry of the interior, labour office, and setting the implementation of data in selected databases into the infrastructure of the National Police Force. This sort of data included socio-demographic data of the statistical office, data registered by the ministries (social benefits, unemployment, data on housing, etc.). It can be data of local authorities on points of interest, such as gaming houses, pawn shops, stops, educational and cultural facilities. This is also related to current, good-quality maps and aerial photographs. In some predictive systems, data on weather needs to be available also.

9.3.3. Methodological recommendations

1) To establish an adequate system of training in GIS, statistical data processing, geoinformatics and other specialised methods in terms of the Police Presidium of the Czech Republic. This process should be initiated immediately, prior to the implementation of specific tools and approaches.

Users of the new system have to undergo training appropriate to their particular role. Ordinary police officers, who are the end users of the product, or participate in the generation of the materials, should undergo regular trainings on operations they carry out. Concerning the top management of the police, it is necessary to emphasise and understand the benefit of the tools, and the roles of their users in the process at all levels.

2) Prior to the implementation of the crime mapping, analysis and prediction tools, meeting with experts from the IT, GIS or professional training should be held. In the Czech Republic, there are universities, research institutes and companies whose top-level scientific resources are able to give advice or even assistance during the implementation of new tools and methods.

3) To cooperate with the citizens of the given area in terms of preventative measures, making use of, for instance, the experience from Great Britain addressing the neighbours (cocooning). To conduct surveys no less than once a year, which would deal with the security in the given area, the feeling of safety and the evaluation of police work. Alternatively, to consider gathering ideas from citizens on an ongoing basis (example of the Slovak Police). At the same time, the public should be more informed about the situation in the given area, via, for instance, websites by providing information about planned preventative measures. To focus on work with citizens in the media.

4) Following the example from Great Britain – Home Office (section 8.2.5), to provide access to maps of crime to the public via websites of the Ministry of the Interior / the National Police Force, thus gaining the public trust in the police work. Afterwards, to assess public response to this information.

9.3.4. Draft pilot run

Based on the former recommendations and described experience, the section deals with draft of the pilot project in the context of the Czech National Police Force. The stated pilot solution is divided into several basic points.

Definition of pilot areas

In terms of the definition of areas suitable for the pilot project, basic criteria for the selection of these areas are stated. Such areas should be included in the territorial division of the National Police Force, as the police can effectively target their measures. The selection of the particular areas should consider:

- Motivation of the local police management. Involvement of representatives, mainly of the National Police Force, who regard the implementation of modern technologies into policing as beneficial.
- Crime intensity in an area. Focus mainly on areas with high intensity in observed crime.
- Occurrence of specific/critical type of crime within an area. Depending on the type of crime in an area, to opt for an adequate response (see next subsection), e.g. an area with a high intensity of residential burglaries > the method of repeat victimisation.
- Sociodemographic factors. Selection of homogeneous areas for further comparison.
- Number of police officers. To account for the number and performance of officers in a given area; whether they will be able to devote adequate time in terms of their current activities and to spend enough time in the defined areas.
- Possibility/existence of cooperation between local police force and the National Police Force. Beneficial might be the cooperation between the National and local police forces based on separate agreements regarding data-exchange, preventative measures and other aspects.

- Whether crime analyses/predictions have been applied in an area. Broadening of current experience through complex work. It can also be beneficial to compare the pilot solution in areas where such tools have already been used with those where it has not.
- Availability of time series of localised data. Area with a sufficient time series is appropriate for an implementation of a complex system provided by commercial subjects, where, for instance, a five-year time series may be required.
- Geocoding of historical data In cases where adequate time series are unavailable, geocoding of historical data should be considered. There is the option to involve external partners, such as universities.
- Hardware and software of the police. Equipment can play a vital role from the financial perspective. In case of appropriate hardware in place, no financial resources need to be allocated on equipment during the pilot project.

Implemented tools/approaches

As regards the implementation of particular tools, it is recommended to test multiple systems/approaches, which could take place in the defined territorial divisions. It is recommended to compare more solutions, from traditional methods to a complex commercial solution. The information obtained from the cases make it possible to focus on the following solutions:

1) Application of a currently developed predictive software which should be available free of charge by the end of 2015 and which has not been used in practice yet. According to available information, it should allow similar functionalities as the commercial system PredPol.

2) Implementation of the software that would be regarded "the most suitable" out of the systems mainly described in this study (PredPol, HunchLab, Palantir, PRECOBS, or others).

3) Usage of repeat victimisation.

4) Creation of a personalised model which might be implementable into the current GIS environment of the National Police Force. Potential cooperation with Austrian experts, along with sharing of their experience of their own model developed in terms of the CriPa project.

5) The use of traditional methods (e.g. hotspot analyses, risk terrain modelling) and tools for data analysis and processing (see sections 6 and 7).

It is recommended that each selected territorial division should have one person assigned to “specialised analytics”, a coordinator of a given solution for the sake of pilot testing.

Part of the pilot project should also be a pilot version of a crime map of a given area, which should provide detailed information about crime to the public. Afterwards, public response would be assessed.

Also, it is important to mention that other projects carried out by the Ministry of the Interior of the Czech Republic partially deal with the issue in question, namely GIS as a support for national security and rescue forces. It would therefore be appropriate to wait for the conclusion of this project prior to the final decision about the pilot run. This is also related to some projects currently carried out abroad, such as Cripa in Austria or HighCrime in Great Britain, whose conclusions might be suitable to assess. Due to their deadline, nevertheless, it was not possible to include their results in this study (written in August 2015).

Involved parties

Other territorial divisions should be involved in the pilot project, such as local police forces or municipalities.

Purchase of commercial predictive programs can mean financial demands on the implementation in terms of the pilot project. This is why the foreign experience favours beginning cooperation with the providers of the software. These companies often participate in the pilot projects (for a limited time), where they could test their systems with real data. High costs related to the purchase of software for pilot tesging would thus be eliminated. In the Czech Republic, it is possible to mainly begin cooperation with local representative of foreign and Czech companies in the given field.

As regards the development of the prediction model, it is advisable to cooperate with academic and research institutions in conjunction with GIS experts of the National Police Force.

In accordance with the requirements of the particular predictive systems, as many institutions as possible should be involved that provide supplementary secondary data, for instance sociodemographic data of the Czech statistical office, data of the ministries (social benefits, unemployment rate, data on housing, etc.). Also data of local offices about points of interest, such as gaming houses, pawn shops, stops, scrap yards, educational and cultural institutions or data about weather.

10. FINANCIAL ANALYSIS

As the examples show, GIS and analytical software play an important role in the work of law-enforcement agencies. This section provides information about the financial costs connected with the purchase of these tools and analyses. **There is a wide range of products available on the market, therefore those products that were implemented mostly in terms of the solutions described in this study have been selected.** All prices (as of July 2015) are merely approximate and have been established on the basis of consultations with suppliers for the purposes of this study. They have been transferred based on the exchange rate of the American Dollar ($) as of 13th July 2015, **CZK24.5/$1** (**CZK38.1/1£**, **CZK27.1/1€**). The results have been rounded to the nearest thousand). The prices include the purchase of the software, and in some cases also including 12-month maintenance. The final price can be influenced by many factors, such as a different type of licence, bulk pricing discounts or system-support costs.

When choosing commercial or open source software, demands on the personnel should be considered. Some systems require highly qualified operators, which may entail higher costs. On the other hand, some systems are intuitive to such an extent that processing of analyses can be carried out by trained, less qualified user, which results in a reduced financial burden. What should be also included in the price of the implementation are costs on training and salaries of the users of the software.

10.1. PREDICTIVE SYSTEMS

10.1.1. HunchLab

One of the predictive systems is HunchLab, developed by Azavea (Philadelphia). At the beginning, the product is consulted with the beneficiaries and adjusted to their needs. Afterwards, the client is provided with the system for the a three-month trial period free of charge to test its functionalities. A one-year subscription enables access of unlimited users, and a device for the access to the application. Over the subscription period, all updates are available free of charge.

Usually, the implemented system in tested in real conditions for three years, which is the period calculated in the figures below for three types of cities. Using this calculation, it can be assumed that this application could be provided as a software-as-a-service solution, hosted on Amazon in the EU, namely Ireland and Germany. It is the primary company strategy used in European clients. Costs on a solution implemented in the client's infrastructure would be considerably higher, depending on particular requirements.

Table 9: Basic price calculation of HunchLab

	City population 30-50,000	***City population 50-100,000***	***City population 200-300,000***
First year	CZK600,000	CZK800,000	CZK1,400,000
Next years	CZK500,000	CZK750,000	CZK1,300,000
Total amount per three years	**CZK1,600,000**	**CZK2,200,000**	**CZK4,000,000**

Note: prices do not include VAT

10.1.2. CrimeView Dashboard

Below are described current costs (CZK, VAT excluded) on the implementation of CrimeView Dashboard in terms of the client hardware infrastructure (server solution). It is a solution in terms of an existing police network or a network the police are accessed to and where environment suitable for the exclusive use of CrimeView is available. Second form is hosted, which can considerably reduce initial costs on implementation. In such a case, however, individual meeting with the supplier is necessary.

Table 10: Basic price calculation of the system CrimeView Dashboard

	City population 30-50,000	*City population 50-100,000*	*City population 200-300,000*
First year	CZK900,000	CZK1,050,000	CZK1,200,000
Next years	CZK50,000	CZK75,000	CZK100,000

Note: prices do not include VAT

The implementation of this solution would require the organisation to provide: a suitable server, SQL server, ArcGIS Desktop Standard and ArcGIS Desktop Standard. Standard version of CrimeView Dashboard uses two data sources (dispatch centre and incident numbers), five operating layers, ten spatial-query layers and as many as 400 interactive features organisations can configure and provide an access to via “Briefing Books”. Other data sources can be added (arrests, fines, accidents, etc) by paying a one-time fee of CZK93,000 per one data source added beyond the two involved in the standard version.

It is also worth considering the translation of CrimeView Dashboard into the Czech language and the way of training. The price of the translation in collaboration with the Czech experts is approximately CZK300,000. As regards training, the offered form is “the training of trainers”, when a selected group from the Czech Republic would be authorised to lead training on Dashboard in the first run of the implementation. The assumed price of this service is approximately CZK250,000 for the training of the team of a given organisation, which would in turn train members of law-enforcement agencies.

10.1.3. PredPol

Since the company does not provide the prices of its products, financial costs were assessed based on information obtained at the meetings.

A number of organisations cooperate with PredPol on an individual basis and pricing conditions. For instance, LAPD uses the software free of charge in exchange for the data, or Kent Police, which uses the service for GBP 125,000 per year throughout its territory. Another example is Seattle Police Department, which obtained a 12-month licence for $ 45,000 in 2013.

Generally, it can be said that the basic/minimal price for a single licence for 12 months is approximately $ 20,000, and $ 5,000 for the basic implementation.

10.2. GIS SOFTWARE

One of the most frequently used GIS products in terms of the given solutions was ArcGIS from ESRI. This company offers several GIS programs. One of the basic ones is a desktop client, ArcGIS for Desktop Basic, which has a single-use licence, i.e. an installation on one computer/for one user only. Price of this product is approximately CZK45,000 without VAT. Also, extensions can be purchased for this version. Each costs, in the basic ArcGIS version, about CZK75,000, introducing a new set of tools and functions. The price always includes a 12-month maintenance (it is not necessary to extend it after the period).

A different type of licence of the GIS in question is application server, the ArcGIs for Server product, with a licence for four cores, whose price begins at CZK600,000 (without VAT; this price is dependent on the performance of the server and the number of users' accesses).

The last type of licence is the portal solution, the product ArcGIS Online (cloud), or Portal for ArcGIS, which can also be installed in an individual hardware infrastructure. This product has a user-bound licence, with the price beginning at CZK6,000 (without VAT) per year.

Currently, software companies or other educational institutions on the market provide training on different levels of GIS and other softwares. Prices of these training range from CZK5,000 to 50,000 (excluding VAT) depending on the focus and intensity.

10.3. STATISTICAL AND ANALYTICAL SOFTWARE

One example of statistical/analytical software is SPSS, from IBM; mainly IBM SPSS Modeler, which was presented at the first workshop, and IBM SPPS Statistic, used by analysts in the described examples as a supplementary product. The pricing below shows individual installation. Should a customer require a server solution, the price is calculated on the basis of individual requirements and server performance.

The price of the basic IBM SPSS Statistics Standard package (IBM SPSS Statistics Base, IBM SPSS Advanced Statistics, IBM SPSS Regression, IBM SPSS Custom Tables), including maintenance (12-month technical support) is approximately CZK130,000 (excluding VAT). This option consists of individual installations, i.e. authorised user licence. This type of licence aims at users who do not use server applications.

By purchasing IBM SPSS Modeler with a permanent type of licence, cost efficiency is guaranteed from a long-term perspective. This offer consists of individual installations, i.e. authorised user licence. This type of licence aims at users who do not use server applications. The purchase price including 12-month maintenance begins at CZK400,000 (exluding VAT).

Another option is extending the automation of the complete solution on a regular basis. With predictive analyses having been created and verified, the next step is automation of the whole process and connection of data analyses to current processes. The full automation requires a server form of a datamining tool and components ensuring automation and deployment into current systems. The purchase price (200 licences) of IBM SPSS Modeler Professional Server and IBM SPSS Collaboration and Deployment Services including 12-month maintenance is approximately CZK3,000,000 (exluding VAT) per product.

The whole system can be enriched with risk analysis in real time. This requires the Real Time Scoring Services component (2 licence), worth CZK2,500,000 (excluding VAT).

As regards the public courses of software, statistics, data analysis and data mining, the market price is about CZK5,000 per day (exluding VAT) on the market. Mostly, these courses are held over multiple days, divided according to the level and participants' focus.

11. CONCLUSION

Based on the experience from abroad, the impact of predictive and traditional analytical tools can be considered positive. On the one hand, the tools and their benefits should not be overestimated. This, however, must not lead to negligence of their role. It has been proved that the new methods and the engagement of specialised analysts leave a positive mark on policing, which supports public safety.

Crime analyses need to be created in line with different types of responses by law-enforcement agencies. Correct way of law enforcement and effective reduction of crime involves three types of measures. First and foremost, actions taken during immediate operating responses need to be proposed, e.g. targeted patrols during the following shift. Then, actions should be defined for medium-term reponses, e.g. in cooperation with other organisations possibilites for offending should be defined. Last but not least, actions should be adjusted to support long-term strategic responses, e.g. in tackling long-term causes through regeneration plans and legislative changes. So far, predictions have been focused on the operating potential of the police. This comprehensive approach enables thinking about intended outputs in connection to crime prediction. It therefore does not used solely to an immediate operating reaction of the police. It is also used in prevention of situations which result in crime, and in determining strategies focused on the causes of crime. Moreover, it is expected predictions for different time frames (immediate, near and distant), different data and analytical and modelling techniques would need to be used.

Neither predictive tools nor traditional analytical methods aim to replace conventional police processes, but to rather add to the knowledge of police officers and chiefs. These modern systems introduce additional information, not information replacing already acquired knowledge. When implementing these systems, it is vital to explain the purposes and benefits for the application properly. Users need to be adequately briefed about the new methods, including those where analyses have no particular impact. It is the only way to prevent misunderstanding and scepticism.

Emphasis should also be put on public relations, which the experience from abroad also confirms: to cooperate on preventative measures directly with citizens and other actors in the area of interest, obtaining feedback and supplementary information for the reduction of, among others, unreported crime. Besides, citizens should be more informed about police work in a given area.

All activities in this respect should be based on the principles of an integrated approach. Integrated approach in crime prevention is a tool for attaining higher quality of planning in a given area, management and a more efficient allocaiton of financial resources. Generally, this approach requires certain connection of time, area and causality of each type of intervention. Integrated principles of process management, which combine housing, crime prevention, community planning and other strategies, are, in the case of effective collection and use of data, its processing, creation of analyses, followed by a recommendation, a suitable approach leading to the reduction in social and security risks.

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13. LIST OF FIGURES, GRAPHS, TABLES, APPENDICES

14. APPENDICES

Appendix 1:

14.1. STRUCTURE OF INTERVIEW / list of questions

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MAPS OF THE FUTURE – a modern tool to increase the effectiveness and quality performance of public administration in crime prevention based on crime analysis and prediction

For the sake of the "Maps of the future" study for the Ministry of the Interior of the Czech Republic, which aims to garner experience in mapping, analysing (using GIS tools), and crime prediction, comparing approaches and particular solutions applied abroad, the following queries/areas have been compiled, which the visit of the author will deal with. These queries aim to gather extensive information about the implemented projects, tools and solutions used for mapping, GIS analyses and crime prediction.

In describing the previous experience, the study will focus on the conditions (legal, organisation, technical, etc.) required for an implementation and use of the mentioned approaches and solutions, the associated expenses, and their benefits. Also, the objective is to define whether crime maps created abroad are publicised and, in case they are, which information and experience (positive or negative) are connected with them. The study will conclude by providing recommendations how, based on experience and knowledge from abroad, similar solutions and tools can be most effectively applied in the Czech Republic.

Hereby, we would like to acquaint you with the issues we want to focus on in more detail during our visit to your organisation. We will appreciate it if you would prepare answers to these questions beforehand and if you would send them back prior to our visit. We would be grateful should you be willing to share other materials for the study in question, besides the information mentioned in this document.
Having said that, it is by no means our aim to disseminate non-public information, but merely to inform about your experience for the purposes of the study and potential future implementation in the Czech Republic.

Thank you for your time and willingness.

A. GENERAL INFORMATION ABOUT YOUR MUNICIPALITY / REGION / COUNTRY

Supply general information (socio-demographic situation, security situation, the size of the area in question, etc.) about the municipality/region/country in which the described case is implemented and about its law-enforcement agencies. What was the initial situation at the time you commenced using mapping solutions and tools, spatial/geographical analyses, and crime prediction, and compare these with the status quo.

SUBQUESTIONS:

1.	What activities in terms of mapping, spatial/geographical analysing and crime prediction are you involved in *(projects, development, specific implementation, etc.)*?
2.	State which occupations exist on your workplace, their tasks, competences and mutual connection of their activities in using mapping and crime-predicting tools. *(e.g. manager - analyst - officer)*
3.	What the political/legislative situation in the given area is, with respect to the police and crime data filing/processing.
4.	What is the structure *(which exist, how they work)* of the IS in your country? How do you work with them and how do you utilise them in terms of the described implementation?
5.	Is the output and input data shared with collaborating organisations, such as municipalities, municipal agencies, governmental agencies, NGOs? What rules are established among these entities? What are the benefits of data and output exchange?
6.	Do you have any experience with publicising crime maps and information on crime rates? If so, elaborate on the associated experience - both positive and negative. What information do you publicise in this way?
7.	Are you aware of any other projects connected with mapping and crime prediction implemented in your institution/municipality/region/country? Which, in particular?
8.	How the members of law-enforcement agencies are evaluated *(officers, investigators, officers of the metropolitan police), and how is the law-enforcement agency evaluated as a whole*? What criteria do you set *(evaluation based on solved crimes, on the number, increase or decrease in the crime rate, outcomes of public polls, etc.)*, what had a positive proof?

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B. DESCRIPTION OF A CASE STUDY / APPLICATION

What mapping, spatial/geographical-analysing, and crime-prediction tools are used in the example you are referring to? Provide a description, please *(name, functionality, way of controlling, benefits, shortcomings).*

SUBQUESTIONS:

1. What was your source of information and inspiration for implementing innovative mapping, GIS-analysis and crime-prediction tools? What was the key factor in the choice of the selected implementation?
2. What data is utilised in the work with the described tools? What is their source, how are they obtained and visualised? Are in any way ordinary citizens involved in the data-gathering process? Are citizens' reports, inputs or complaints considered? Do you use mobile gadgets/applications for data gathering and analysis?
3. Do you work solely with data on crime (offences, misdemeanours), or do you also make use of data and information on other criminally risky phenomena - socio-demographic data, localisation of areas of interest *(restaurants, gambling houses, bars, bus stops, banks and ATMs, foreign exchanges, pawnbroker's shops, carparks, malls, schools)*, public-transport lines, weather, significant events *(sport, cultural, social)*?
4. Which analytical functions do you utilise? In the case of crime prediction, what is your prediction model based on, how do you visualise the prediction and work with it further?
5. What Business Intelligence tools for presentation of data to managers/politicians do you use?

C. UTILISATION - IMPLEMENTATION OF A CASE STUDY / APPLICATION

How long has the implementation in question been utilised? How long was it developed, who participated in it and to what extent? Are or were you directly involved in the implementation in question? Is any further development of the implementation presumed?

SUBQUESTIONS:

1. What were the initial expenses of the implementation in question? What expenses are required from the service of the implemented solution?
2. How is the work with the tools in question organised?
3. Who works with the tools in question? What training does this job require?
4. How were the staff trained for working with the tools?
5. Does your workplace provide technical equipment for work with mapping and crime-predicting tools? Along with software, was it also necessary to invest in hardware? If so, what were the associated expenses?
6. Was the implementation in question preceded by legislative measures which prevented its commencement? Did the legislation limit the competence of the parties, who are using the mapping, GIS-analysis and crime-predicting tools? Have any other legislative changes been implemented that would adjust the competences and rights of the parties involved in crime-prevention and ensuring safety?
7. What kinds of crime do you focus on terms of the implementation in question?
8. Do any legislative measures restrict the work with criminogenic data? Is obtaining data and results, their sharing with other workplaces or their publicising limited in any way? Have any legislative changes been adopted that would facilitate obtaining, sharing and/or publicising data and results? Which, in particular?
9. Based on your consideration, state any other information, recommendations and inputs what one should focus on during a new implamantion and what to beware of.

D. PROS (BENEFITS) AND CONS OF THE CASE STUDY / APPLICATION

Describe how and to what extent did the implementation in question contributed to solving crimes and prevention?
What are the shortcomings of the implementation in question?

SUBQUESTIONS:

1.	Can any decline in crime rate resulting from the implementation be observed? To what extent?
2.	Has the solved-crime rate of reported crimes increased? To what extent?
3.	Has the latent-crime-rate decreased? To what extent?
4.	Has the citizens' trust in law-enforcement agencies increased? To what extent?
5.	Has the activity of law-enforcement agencies and/or collaborating parties been made more effective, less time-consuming and less costly? To what extent?

Were you to have utilised other resources in filling up the above-mentioned questions, please name and recommend these if you are of the opinion that they could contribute to the study Maps of the Future. Also, we would also like you to provide any materials associated with the implementation in question that could also be an adequate source for the purposes of the study. What could be of great benefit as well are samples of particular outputs of the implementation, i.e. crime maps with results of analyses and prediction. We will be grateful should be willing to share any such materials.

Appendix 2:

14.2. Briefing from a trip abroad held in relation to crime mapping, analyses and prediction in the USA authorised by the Ministry of the Interior of the Czech Republic

Michal Barbořík, October 2014, www.prevencekriminality.cz

The text below was written by Michal Barbořík (Ministry of the Interior of the Czech Republic) on the basis of a business trip to the USA, made in terms of the series of visits described in the preceding sections of the study. As a result, notes from this visit are used as an appendix in this study.

The trip was made on 21st-27th October 2014 in the cities of Memphis (Memphis Police Department) and Orlando (IACP Conference and Expo Orlando 2014). Members of the group were Ms Jitka Gjuričová, head of the crime-prevention division of the Ministry of the Interior of the Czech Republic, Mr Michal Barbořík, employed in the same division, Ms Zuzana Pidrmanová, national crime-prevention coordinator of the National Police Force (department of the press and prevention, Police Presidium of the National Police Force), Mr Jiří Fejfar, head of the Territorial division of the National Police Force Kolín, and Mr Radek Nezbeda, member of the regional directorate of the Police Force of the Central-Bohemian region.

14.2.1. Memphis Police Department (MPD), Blue CRUSH, RTCC – Oct 22nd 2014

City and MPD

The city of Memphis covers a total area of 839 km^2 and has a population of approximately 650,000 (with an agglomeration of approximately 1,250,000). More than 50% of population live on meagre income, 26% of population live on incomes below the poverty line.

In 2010, MPD comprised 2,480 police officers, as opposed to the current state of 1,800, 1,400 of whom work in the field. Annually, approximately one million calls for service are received, 52 thousand arrests for serious offences are made, and about 46 thousand petty offences without an arrest are solved. Apart from this, about 28 thousand traffic accidents are dealt with.

In years 2005-2006, Memphis was facing a significant rise in property and violent crimes, including murders. MPD was using obsolete equipment, facing organisational issues, failing to use modern IT technologies and to work with analyses. At that time, it was in the top ten most dangerous cities in the USA *(note: even these days some sources state that Memphis is found in this category, which, however, the MPD denies, due to a multiple ways of giving the reason of multiple, distorted ways statistics on crime in the USA are prepared: while Memphis records all offences, other cities do not).*

Changes to workflow

It was then that the MPD decided to introduce substantial changes. The department joined forces with university scholars, involved the public (project Cyber Watch – regular newsletters about crime rates and local police activities; project Crime Stoppers – reporting crime, dubious behaviour and other activities anonymously), began analysing information and sharing it to a larger extent with the public and other agencies and institutions (however, data about victims and sexual offences is not presented).

Lower management levels (down to the level of heads of department) began being responsible for results, which led to their greater participation.

Analyses are processed by software tools (IBM SPSS Statistics, ESRI maps) which work in the real-time. In addition, police officers are equipped with mobile devices (Android PDA) which enables them to input, as well as acquire data in the field.

As regards the cooperation with the public, the police highlight that despite their unability to be always at the right place in the right time, contact with the public is crucial. People must know that the police are attending to their needs. Not necessary do they have to be permanently in the streets; however, their interest and activity must be tangible.

Citizens can subscribe to email newsletters, which notify them about crime rates in their neighbourhood, the surroundings of their workplace, school of their children and other places. This service is called Cyberwatch and enables setting a radius of the area of interest to an address. At this juncture, this information is provided on the MPD website. There also exists a module where citizens can provide their comments and information about individual offences. In the database, this data is processed by operating officers during less hectic periods of time, and then verified by shift commanders. This information can also be entered anonymously and with a possible reward from Cybertip, an NGO, which provides an anonymous transfer of information from the citizen to the police, an anonymous transfer of money to the citizen, who need not attend the proceedings, interrogations and other actions. Head of this foundation is a former director of the MPD.

The MPD is accessed to various databases of law-enforcement agencies, but also energy companies, social authorities, and cooperates closely with educational institutions. Were a child to be absent from school without excuse for three days, the police would focus on this person for preventive purposes, comparing data from his/her whereabouts in connection with offences, namely burglarised houses, car thefts and car burglaries, which are the most frequent crimes commited by juvenile offenders in Memphis. Analysts carry out GIS analyses of crime incidence and compare the data with the database of repeated offenders, since research and experience support that crime is frequently commited by this group. By contrast, research fails to provide any evidence that the unemployed commit more crime, which is worth the interest. In general, work with juvenile offenders is currently in a bad condition since they are almost impossible to punish (note that this the view of the police, however, the author of this section got the impression that preventative projects focused on youngsters fail to fit their purpose as well). The structure of the crime incidence differs from Czech conditions in statistical output: the assessment criterion is not clearance, as in the Czech Republic, but the development of crime incidence.

What plays an important role is not only what data is processed but also what output is generated for police officers, i.e. the extent to which Business Intelligence is managed. Police chiefs and commanders thus work with structured data in the form of tables, graphs, maps, which enable them to get the picture about a situation, which facilitates a prompt, qualified and right decision-making.

Blue CRUSH programme

Blue CRUSH (Crime Reduction Using Statistical History) is a proactive predictive apprach towards policing based on historical statistical data and their projection into maps. It was created by the MPD in 2015 (this year marks the initial work on the approach) and these days it is emulated as an example of best practice by police corps in the USA and outside. Its aim is not only to solve, but also prevent crime more effectively. At that time, it was one of the first cases of the police cementing their ties with the public and enterprises, which form the pillars of the success of the project.

In the pilot run of the project, in 2005, the police, on the bases of behavioural patters derived from historical statistical data, defined places with an increased probability of crime occurence. There, patrols were allocated and during the first 120 minutes made 70 arrests, which was an amount usually reached over a weekend. Over a period of three days, 1,200 people were placed under arrest. Driven by the success of the pilot run, this strategy was implemented across the whole city in 2006. It aims to not only disclose more offences but also, and mainly, to prevent it.

The strategy does not consist in an increased volume of police work, but in a smarter approach, as it identifies patterns and spots of frequent occurrence of crime. In line with these pieces of information, the police allocate their resources. Research shows that police presence (be it a local police force or traffic police force) on a place for at least 15 minutes reduces crime rate within the radius of a quarter to a half of a mile.

Crucial for the program to be successful was not only data, IT systems and analyses, but also changes to the "corporate" structure, to workflow and to the understanding of the MPD and mainly their chiefs. Monthly meetings were changed to meetings on a weekly basis attended by district commanders called TRAC (Tracking for Responsibility, Accountability and Credibility), where each participant explains fulfilling his commitments, targets, accountability and trustworthiness. What was important was head of the MPD managed to convince, rather than force the other commanders. (For more information about Blue TRAC, see the next day).

RTCC

Later, the RTCC (Real Time Crime Centre) was built for $3.5m, where the current situation in the city (using the city CCTV comprising 800 static and mobile cameras; however, other cameras can be added, not only in the city, but also in schools, car parks and other areas)is monitored, each incident, reported crime or a call for service is reported.

The majority of cameras are statically mounted, with the option to zoom and turn to sides. Most of these devices are equipped with a gunfire locator, when a camera is promptly turned in the direction from which shooting was detected, using a direction microphone, and an operating officer is immediately sent a warning. Apart from the mounted cameras, also mobile cameras are available, located on a trailer and applied when necessary. Their application is based mainly on results of data analyses in cases of, for instance, increased crime rates in some areas. Also, they are used in special actions and measures. Part of the recorded material is detection and evidence of speeding and driving through a red light. Some vehicles are equipped with mobile cameras recognising number plates of passing and parked vehicles, instantly providing the crew with information about stolen plates a vehicles, expired driving licences or vehicles without a current MOT. The crew acquires results of browsing in about 20 categories in total, which stem from search results and their relation to the vehicle owner but also his neighbourhood.

Police officers in the field are also equipped with mobile devices (PDAs) which provide access to necessary databases and send processed information to the central workplace. This data is processed by analysts. In a matter of minutes, the commander is provided with broad information, including solutions.

Having logged into a PDA, an officer acquires comprehensive information about a searched person, including his history of offences, records in databases and photographies, as well as his whereabouts and the current safety situation (with the option of connecting to the CCTV). The officer also enters all newly acquired data, including photographies, and sends them directly to the database, where it is stored. Such images are not taken in cases of murders and sexual offences, where these materials are collected in a different way. On-the-spot data acquisition significantly reduces the margin of error. Since the output, including the offender’s statement, are recorded directly at the location, it is more difficult for the offender to re-interpret his statement. This information is thus usable in other steps of proceedings due to a confirmation and an agreement of the arrested person in the form of a finger print.

RTCC is an operating centre where dispatchers work next to analysts. The fulfil four tasks: they share data, supervise CCTV, train crime analysts and conduct statistical analyses. The essential part of their occupation is work with data from various resources, across different authorities and institutions in Memphis and Tennessee (as well as neighbouring states of Mississippi and Arkansas) with which they work in one data store. All information can thus be mutually interconnected (in real time), and no time needs to be waisted on searching through multiple databases. RTCC is equiped with more than 40 fifty-inch monitors and more than 20 computers.

Results

The result of the programme was that in 2013, six after its launch, serious offences dropped by 30% and violent crimes dropped by 20% in Memphis. The clearance rate of the department of serious robberries raised from 16% to 70%.

Whilst in the pilot run, analyses were conducted by the university, since 2006 this very institution concentrated on training of educated analysts with the MPD who will be able to carry out analyses identical to those by university criminologists.

Recently, MPD initiatives, which have been improving the programme continously, focus on cooperation with the communities, on more effective measures applied in problematic areas. This is reflected on in the commander meetings (TRAC), where representatives of the city and other partners who participate in preventative measures, are invited.

As they, however, notify, Blue CRUSH is not and has never been intended as a universal cure. It is a tool opening doors for multiple solutions. Thus the solution does not consist in targeted patrols but, for example, in projects with the community. Everything is hence based on principles of community-oriented and problem-oriented policing.

Future

Despite this favourable result, the MPD is still trying to hone its programme. The primary focus in the future should be a general application of predictive models. The department strives for a comparison in a broader context (weather, public events, data from schools) and it also aims for more sophisticated analytical tools (replacing the basic IBM SPSS Statistics with the more advanced IBM SPSS Modeler).

14.2.2. Memphis Police Department, Blue TRAC meeting – Oct 23rd 2014

As mentioned above, Blue TRAC is a form of MPD meetings, where chiefs of police districts (nine in total) meet on a weekly basis, individually presenting results of their work within their area along with actions planned for the upcoming period.

They discuss plans, tactics and strategies, administrative and analytical approaches. Colonels and chiefs from all districts, specialists and investigators have a joint discussion about what has proven to have good results, what has not, and what will be necessary for actions planned for the following week to be successful.

The system is based on an analysis of frequency repeated weekly. Four weeks (28 days) are compared with hindsight, and a hypothesis is stated for the next week. In their presentation, each chief presented the following information: comparison of crime development (mainly violent and property crimes) in the observed week to the preceding year; over the four preceding weeks; tracking of patterns and areas worth focusing on or those which have been solved; special focus on offences committed with a weapon; budget financing; crime maps with an accurate location of offences divided into smaller area according to perimeters of individual police stations; numbers of arrested individuals and other performed actions within observed areas; number of cases handed over to other agencies and institutions; delineation of areas to be observed in the upcoming week, including the reasons (predictions based on empirical data and other relations); announcing dangerous or captured felons, who are likely to have committed crime in other beats; other information based on current situation and affairs – in the week in question, the central issue was crime committed by offenders of the age 21 or younger.

Other parties to take part in the meetings are representatives of the city representatives (deputy mayor), public prosecutor and other institutions, who take part in the discussion and propose their solutions to specific topics. This issue is thus discusses in a complex manner. Causes of these offences committed by offenders no older than 21 were analysed, and potential preventative measures proposed by the individual actors.

Each presentation is followed by questions for and a discussion with the presenting chief; questions or remarks are also rendered by head (or deputy) of the MPD.

At the end of the meeting, the company Integraph (note: its subsidiary in the Czech Republic is also engaged in the project Geoinformatics as a Tool for the Support of National Security and Rescue Forces, in terms of security research conducted by the Crime Prevention Division of the Ministry of the Interior of the Czech Republic, and is one of the expert parties in this project) presented possibilities of extension of the current operating SW, which nevertheless contains a number of statistical and analytical functions, used in the MPD. Novelties occurred mainly in mobile connection between police officers (both in the streets and in vehicles) and operating officers, in work with data in the field and monitoring of patrols, also in processing complete data on the basis of reports (per day, within an area, per officers), or Business Intelligence (automatic daily reports, hotspots, routes of movement, offenders' points of interest, and others).

14.2.3. Orlando, IACP Conference and Expo 2014 October 24th-26th 2014

About the event

IACP (International Association of Chiefs of Police) was founded in Chicago in 1893. Its fundamental goal is to strengthen cooperation and data exchange between law-enforcement agencies, to spread new methods and processes (created on the basis of good practice or scientific work) among agencies promoting law and education. Since 1970s, the IACP has held the status of a consulting agency in the United Nations, as at that time it worked as an organisation in the United States of America, but also used its intelligence and experience to assist other UN member countries.

This year, the IACP has held its 121st annual conference. It is an international event with exposition, where hunderds of companies and institutions render presentations and display their products, attended a thousands of visitors from all over the world (in 2014, the conference comprised 12 training sessions, amounting to 247 lectures; 820 companies presented their products, and the exposition was visited by 16,007 individuals, all participants altogether coming from 84 countries).

Participants from the Czech group strove to attend at least some lectures and presentations on crime mapping, analyses and prediction, and new approaches and tools (mainly IT and communication technologies) in this area. Presentations and lectures that appear most beneficial and inspiring for the Czech purpose are described further.

PredPol, revolution in crime prediction and prevention

The presentation was conducted by Dr Jeffrey Brantingham, an anthropology professor at the University of California in Los Angeles and a PredPol co-founder, and his colleagues, George Turner, head of Atlanta Police Department, and William Heim, head of Reading Police Department, who talked about their practical experience with this predictive tool.

In terms of predictions, four areas can be focused on: individuals, places, risk factors and historical events. PredPol concentrates on interrelations between places and historical events: in the context of crime, it analyses the correlations between past offences and places where they were committed, and using mathematical models it predicts when and where further crimes are probable to be committed. Besides statistical data containing past offences, the model also works with factors pertaining to crime scenes (whether offending is repeated in short periods of time, whether repeat victimisation is typical of this place, the environment the location is found in) with added offenders' behavioural patterns. The model does not operate with other risk factors; however, the model can be rendered more accurate with police officers' knowledge and experience.

To carry out crime predictions in real time, current data about crime in real time need to be available.

The outcome of a prediction is in such a case the definition of a specific areas about, for example, 500x500ft (approximately 150x150m) where an increased probability of crime occurrence at a specific time is probable. Consequently, this place is where resources are targeted.

The idea of PredPol does not consist in ordering the police what to do, but rather where to do it, i.e. to warn them about places and times with an increased probability of offending behaviour. It is the police officers and their chiefs who take the appropriate steps.

The city of Atlanta (500 thousand inhabitants, 5.5 million inhabitants as a metropolitan area) carried out a test run of PredPol in July-October 2013, where they focused on robberies, burglaries, vehicle thefts and burglarised vehicles. Two districts, where PredPol was applied, saw a decline in crime by 7% and 9%, as opposed to the remaining districts, where crime was rising. Using PredPol, Atlanta currently experiences a drop in selected offences by as much as 20%.

The city of Reading (approximately 100 thousand inhabitants) was forced to tackle an unpalatable situation when 20% of the staff had to be made redundant due to budget cuts. They therefore started seeking ways to prevent an increase in crime. Still, at that time, they had been working with data, processing crime maps including hotspots, doing community policing. They decided to join the PredPol programme and achieved remarkable results in collaboration with its creators, when despite the reduced staff they also saw a drop in serious offences (robberies, burglaries, violent crime, car thefts, burglarised cars) by 23%.

Experience with predictive models in other areas (mainly in Los Angeles and its surroundings, where the implementation of PredPol began) shows about crime reduction by 30%, or even 40%.

Long-term usage of the system shows a soar in crime reduction in the initial years after the system was applied, followed by a gradual decline in the pace. However, even maintaining low levels of crime achieved in the initial years can be considered a positive achievement.

For the predictive models to function for long periods of time, they need to be revised and enriched according to changing circumstances. Regular checks and evaluations need to be carried out, not only of the system proper (predictive model and its setting) but also of the related police processes, for instance whether appropriate measures are taken, how much time should officers be patrolling in a specified area to do an effective work (not to spend there a time too short without any effect, or by contrast too long, when their presence is unnecessary and might be crucial in another area).

Increasing the Volume of Resources for Analysing Crime in Your Organisation – discussion about the importance, feasibility, challenges, instruments and processes

Presenters from the Bureau of Justice Assistance (BJA), the Department of Justice of the United States of America Along with academic and research work, the BJA also does crime analyses on request, and in the field of crime analyses it conducts a variety of trainings.

Crime analyses have become the key interest of this institution recently, as it realises its major contribution to law-enforcement agencies. BJA therefore works on numerous projects through which trainings, guidance and technical assistance in crime analysing is offered.

Its research also deals with the theory of crime analysis, using analyses in different approaches to policing, their effectiveness, contribution, and their utilised potential.

As the basis of successful policing is highlighted the evidence-based principle, i.e. policing should be based on available empirical, confirmed material. Policing is thus compared to medical treatment, where the following approach is applied: the community (patient) – data, SW, methods (check-ups carried out with up-to-date devices) – results of crime analysis (radiologist's report) – the police (doctor) – selection of optimal response based on evidence and results of analyses (selection of appropriate treatment) – response implementation (commencement of treatment) – crime reduction (patient is healed). Crime analyses are possible/appropriate to use in most approaches to policing, although the BJA, based on its research, considers the most effective: problem-oriented policing, hotspot policing, and focused deterrence. The bottom line is that targeted approaches are the most effective.

To make the most of what crime analyses provide, management's attitude is crucial. These days, however, they face major budget cuts (not only in the USA), an ever-increasing volume of information, and pressure for enhanced effectiveness. What will be necessary in the future is: to use crime analyses as a fundamental tool for effective crime-reducing strategies; to apply information from research; to monitor current processes and challenges; and implement organisational models which would work with evidence-based strategies (research, analyses).

The main weaknesses of current crime analyses are that: work with accurate and timely data tends to be frequently neglected by the management; analyses are considered pedantic; they fail to be integrated into everyday policing; many analytical tools can be purchased on the market, not all of which fit the purpose; where used by force, thus without proper attitude, the results are weak and unconvincing.

It will therefore be necessary that: the acquisition of (quality) data becomes priority; different actions will require different analyses and response; analytical approach will become part of everyday policing; chiefs will be trained in asking right questions.

The appropriate attitude to analyses has to come from the top management, who should claim that analytical approach needs to be intergrated at all levels of management as a long-term vision, with clearly defined standards and ways.

The BJA created a manual on how evidence-based policing and crime analyses within an organisation should be implemented (*Buidling a Model Crime Analysis Capacity: 40 Steps for Law Enforcement Professionals*).

Smart cameras, videoanalyses, 3D visualisation

Some lectures presented benefits and achievements of these tools which process video-records and extract necessary information out of them, which human individuals either can not spot or find relations between in real time, so as to acquire the sought evidence.

More about this technology is described in the presentation of IBM tools below. It needs to be said that CCTV is considered the best tool to acquire current situational information as well as evidence in the USA. The number of police video cameras in cities is in proportion with this fact (besides mounted devices, emphasis is put on various mobile cameras). The latest trend has been the use of drones for monitoring purposes.

A interesting way of processing video recordings are 3D visualisations. These can be serve to identify people or vehicles, also in cases of low-quality materials (e.g. when a person's face can't be recognised or a number plate can not be read). A sample was presented when 3D visualisation identified a vehicle using a modelled spread of light from the headlights (different in each vehicle). The suspect vehicle (including the properties of its lights) was scanned in a real situation by a laser scanner and compared with images from the crime scene (collision with and killing of a young boy) and another recorded spot, where the number plate was recognisable and thus the vehicle identifiable. Similarly, 3D visualisations can be applied on people (e.g. a visualisation of one's figure when the face is not visible). To conclude, even police forces in the USA are not in possession of this technology but use it as a service from private companies (expending approximately $ 20,000 per a single case).

14.2.4. Summary

The goal of the trip abroad was to mainly acquiant oneself with particular examples of application of functional mapping and analytical tools, mainly crime prediction, for the purpose of crime prevention, security and public order at the local level. The objective of the trip is closely connected to the project Maps of the Future - a modern crime-analysis- and crime-prediction-based tool to increase the effectiveness and quality of public administration performance, and Geoinformatics as a tool for the support of integrated action of national security and rescue forces.

During the visit, two approaches to crime prediction came across.

Memphis bases its approach on precise work with statistical and other relevant data, its integration and its processing by means of statistical, analytical and mapping tools. For the purposes of the police chiefs (of individual districts), regular weekly overviews are generated and meetings held, attended by district chiefs and the MPD commanders. On the bases of an analysis of available data, actions of the individual districts are planned for the following week. No specialised mathematical predictive models generate predictions; instead, statistical analyses, maps, knowledge and experience, corroborated by criminologic research are used. Nevertheless, even in Memphis, when considering further effectiveness of their work a analytically-predictive activities, they seriously consider purchasing analytical tools, which would generate predictions automatically.

Second approach was presented at the IACP conference in Orlando, where representatives of the PredPol company, Atlanta police forces and Reading police forces (altough used in multiple places in the USA, mainly California) introduced crime predictions generated by means of devised mathematical predictive models. These work with historical data on crime, with information about crime occurrence, and others. Using a mathematical formula, they predict the area and time with high probability of crime. These models operate in real time, which enables them to generate predictions for planning policing on a daily basis. The model then reflects areas (each of the size of 150x150m) in maps which the police should focus on (e.g. send patrols; however, a specific measure depends on knowledge and experience of the police; in this respect, the model has no intention of ordering the police what should be done).

Both approaches enjoy notable success in places where implemented. They contribute to a reduction of crime incidence by 20-30%, mainly in serious public offences, such as aggravated robbery, burglary, assaults, car thefts, burglarised vehicles. Both approaches are not only implemented in large cities, with extending hundreds of thousands inhabitants, but also work in cities and districts of considerably smaller sizes.

An important part of fighting crime in Memphis (and other cities in the USA) is a thought-through use of CCTV (such as interconnection with cameras from other institutions, gun-shot detection devices) and work with mobile PDAs, which enable police officers in the field to update current information about security situation, and to be updated about current situation (including camera footage) or figures of interest. All data is processed in a sophisticated operating centre in real time, used for both dispatches and analyses. Analysis of current data generated in real time increases the success of the MPD in preventing and eradicating crime. Another crucial feature is an elaborate system of public involvement, building up trust and the resulting cooperation in the acquisition of vital information and the adoption of preventative measures. Also, the statistical output differs from the Czech Republic: the assessment criterion is not clearance, but the development of crime incidence.

The experience of the Bureau of Justice Assistance (BJA) of the United States of America Department of the Interior (presented at the IACP), and of concrete cities using analytical-predictive tools makes it clear that analytical work – evidence-based policing – is a crucial condition for a successful fight against crime, and a more effective and less costly police-force service. To exploit the potential of analyses, thus improving the results, the attitude of the police chiefs towards analytical work is crucial. The management must pave the way by believing in the beneficial nature of analyses, creating conditions for analytical work (access to necessary and current data, necessary analytical tools, training of analysts and chiefs) and mainly integrating analytical approach in the everyday actions of the police force and across all management levels.

Maps of the future – a modern crime-analysis- and crime-prediction-based tool to increase the effectiveness and quality of public administration performance in crime prevention

The aim of the study is to describe, mainly on the basis of experience gained by foreign countries, fundamental conditions for an implementation of modern approaches and tools based on crime mapping, analysis and prediction, in order to increase the quality and effectiveness of public administration, strategic management, crime-prevention planning and ensuring security and public order in the Czech Republic.

Foreign research as well as experience comes down to the fact that approach based on analysis and prediction is a useful tool in cutting crime. It is estimated that law enforcement agencies applying predictive analyses can reduce some forms of crime by as much as 50%, on condition that demographic and social changes, strategies of law enforcement, cooperation with local community and other crime-related trends are involved.

The study provides a description of tools and approaches used in EU countries, Switzerland and the USA, countries which are experienced in crime mapping, analysis and prediction. It focuses on different conditions, such as organisation, technology, or expertise, necessary for their implementation and application.

This international comparative study aims mainly at the management of the National Police Force in the Czech Republic, the Ministry of the Interior of the Czech Republic, elected municipal councillors or local police forces, as a source of information about domestic and foreign experience in crime mapping, analysis and prediction.