The Utilization of Crime Hot Spot Mapping: Košice — a Case Study

Monika Blišťanová
University of Security Management in Košice, Slovakia

Abstract. *Exploiting the results of crime mapping for the needs of the police forces around the world is not new. Crime mapping is not used just to see the location of a crime on a map but mainly for various types of analysis. At the current time, inhabitants of some cities can themselves prepare a simple analysis when the outputs of crime mapping are published within the Geoweb. Several methodologies for mapping crime across the world are described. Mapping using hot spots is among the preferred methods, particularly in finding the problem locations. In Slovakia using crime mapping through hot spot analysis was implemented for the first time in Košice, which became the European Capital of Culture in the 2013. The aim of the research was the identification of crime hotspots as well as their changes over time. Data between the years 2011 and 2015 was prepared for the whole of Košice, a city with a population of about 240,000. This article focuses on the description of the potential uses of crime hotspot mapping as a means to detect changes in crime in both space and time. The results demonstrated the suitability of the methodology for tracking changes. There is no significant difference in the number of offences in the city during the reporting period but there is a significant difference in their distribution within the city in various years. The results also confirmed the concentration of crime in areas with the highest density of population. The results are useful in the prevention of crime in the selection of sites for the location of CCTV and monitoring changes after the implementation of prevention activities. A further possible use is possible sociological research of communities.*

Introduction

Crime analysis is an essential part of police work and involves systematic analysis for the identification and analysis of patterns and trends in crime and disorder. Crime analysis also plays an important role in devising solutions to crime problems, and preparation of crime prevention strategies.[1] In recent years, improvements in computer technology and the availability of electronic data have facilitated crime mapping. Modern GIS systems offer a wide range of tools for analysing crime. Crime mapping has advantages in the search for links between spatial characteristics or phenomena. There are dozens of studies focused on different kinds of problems related to crime around the world that confirm the suitability of mapping in crime analysis.

Background to Crime Mapping

Crime mapping is the process of using a geographic information system to conduct spatial analysis of crime problems and other police-related issues.[2]

---

[1] *See:* Blistanova, 2014.
[2] *See:* Boba, 2005.

Crime analysis maps are typically composed of two types of data — tabular and geographic. Tabular data sources contain information about phenomena that are not primarily geographic but often have a geographic component. Crime data and calls for service data are the types of tabular data most frequently mapped in law enforcement. For example, these data contain information primarily about crime incidents, and calls for service activity such as the type of activity, date, time, priority, and disposition, yet both types have at least one geographic component, such as address, beat, and/or district. Tabular and geographic data are brought together through the process called "geocoding," whereby tabular data are represented on a map based on a common geographic unit of analysis.[3]

The GIS retain spatial information in three main ways: data are stored as points, lines or polygons. A map of points could show school locations, bars or crime events. Lines can be used to map streets, railway lines, or routes that an offender might have taken between home and a crime location. Polygons are used to store all area information. One of the most common and innovative uses of crime mapping is to aggregate numerous crime events into hotspot maps.[4] The hot spot is an area that has a greater than average number of criminal or disorder events, or an area where people have a higher than average risk of victimization.[5]

Hotspot mapping is a popular analytical technique that is used to help identify where to target police and crime reduction resources. In essence, hotspot mapping is used as a basic form of crime prediction, relying on retrospective data to identify the areas of high concentrations of crime and where policing and other crime reduction resources should be deployed.[6] Hotspots allow local councillors to determine the areas of greatest need. In times of fiscal constraint, both crime prevention practitioners and police find appeal in a mechanism that allows them to focus resources on the areas of most need and to have a process for explaining their objective decision-making to others.[7]

A number of different mapping techniques are used for identifying hotspots of crime. The techniques fall into three different categories:[8]
1. global statistical tests, such as mean centre, standard deviation distance and ellipse, and global tests for clustering, including the Nearest Neighbour Index, Moran's I and Geary's C statistic;
2. hotspots mapping techniques, such as point mapping, spatial ellipses using hierarchical or K-means clustering, thematic mapping using enumeration areas, kernel density estimation (fig. 1), quadrat mapping (fig. 2), and;
3. local indicators of spatial association statistics, such as the Gi and Gi* statistics (fig. 3).

There are many research and scientific articles focused on comparison of methods in terms of their accuracy and suitability. These reviews have demonstrated that different hotspot mapping techniques may produce different results in terms of the location, size and shape of areas that are defined as hotspots, but to date,

---

[3] *See:* Velasco, Boba, 2000.
[4] *See:* Ratcliffe, 2010.
[5] *See:* Eck E.J, Chainey S, Cameron G.J, Leitner M, Wilson R.E, 2005.
[6] *See:* Chainey S, Tompson L, Uhlig S, 2008.
[7] *See:* Ratcliffe, 2010_1.
[8] *See:* Hart C.T, Zandbergen P.A, 2012.

none of these reviews have determined which of these techniques is best for helping to determine where spatial patterns of crime may occur in the future.[9]

Fig. 1. An example of using Kernel methods to identify a hot spot

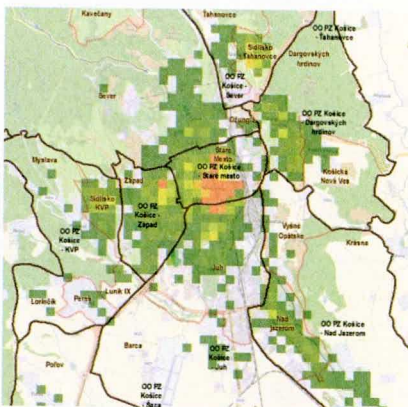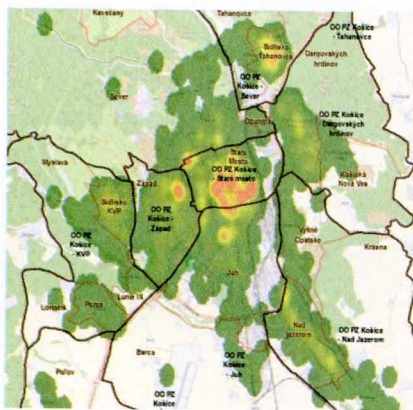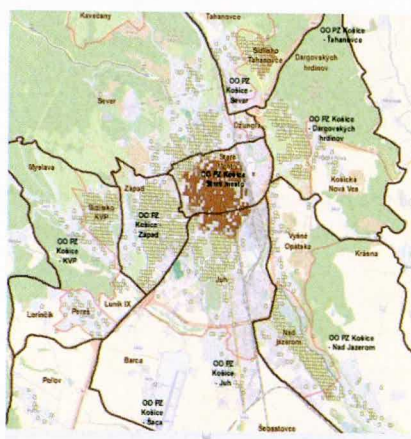**Fig. 2. An example of using quadrat mapping to identify a hot spot**

Fig. 3. An example of using Gi* statistics to identify a hot spot

Material and Methodology

Study area

Košice is the second largest town in Slovakia after the capital. It is situated in the eastern part of the country, close to the border with Hungary (20 km) in the south, Ukraine in the east (80 km) and Poland in the north (90 km) (see fig. 4). In 2013 it was the European Capital of Culture. Since 2013 it has been a city attractive

---

[9] Chainey S, Tompson L, Uhlig S, The utility of hotspot mapping for predicting spatial patterns of crime. *Security Journal,* 2008, Vol. 21, pp. 4–28.

for visitors. The number of tourists visiting Košice increased in 2013 by about 10 percent compared to the previous year, both in terms of domestic and foreign tourists. A further increase in the number of tourists continued after 2013.

Fig. 4. Location of Košice

Fig. 5. Map of the study area highlighting the population of the municipalities (the dark red is the area with the largest population)
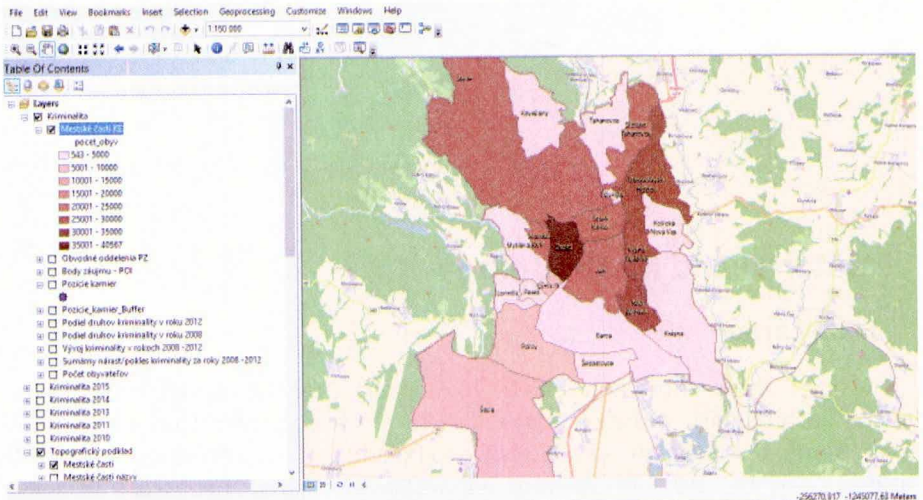
Administratively, the city of Košice is divided into four districts: Košice I (covering the centre and northern parts), Košice II (covering the southwest), Košice III (east),

and Košice IV (south) and then further into 22 municipalities. Figure 5 shows a map of the study area highlighting the population of the municipalities of the area. Table 1 presents selected statistical information about the Košice municipalities from 2014.

Table 1. Selected statistical information about Košice municipalities
(Statistical Office of Slovak Republic, data as of 31 December 2014)

District	municipalities	area (km²)	Inhabi-tants	economi-cally active population	Popu-lation density (per km²)	Unem-ploy-mend	registered unem-ployment rate (%)
Košice I	Kavečany	10.46	1,254		119.85	77	
	Ťahanovce	7.27	2,456		337.71	54	
	Sever	54.71	20,303		371.06	833	
	Staré Mesto	4.34	20,391	32,072	4,698.12	1,419	9.81
	Sídlisko Ťahanovce	8.3	23,047		2,776.55	891	
	Džungľa	0.47	671		1,427.77	210	
Košice II	Lorinčík	2.87	543		188.93	22	
	Pereš	1.3	1,665		1,281.65	336	
	Myslava	6.92	2,016		291.38	105	
	Západ	5.55	40,567	37,664	7,310.34	54	9.39
	Šaca	47.83	5,693		119.02	56	
	Poľov	12.91	1,127		87.31	1,350	
	Sídlisko KVP	1.8	24,858		13,844.5	309	
	Luník IX	1.06	6,193		5,827.38	1,689	
Košice III	Dargovských hrdinov	11.12	26,955	15,808	2,424.02	1,388	8.56
	Košická Nová Ves	5.72	2,637		461.32	121	
Košice IV	Barca	18.03	3,445		191.06	192	
	Šebastovce	4.98	670		134.58	949	
	Krásna	19.78	4,739	26,146	239.57	238	9.37
	Nad jazerom	3.66	25,447		6,953.42	1,198	
	Juh	9.79	23,180		2,368.81	32	
	Vyšné Opátske	3.89	1,940		498.67	88	
Total		242.76	239,797	111,690		11,611	9.28

In addition, the Košice region has more than 152,000 students and pupils. Roughly 51% of these are elementary school pupils, while 30% attend high school and more than 19% study at universities.

Data and data processing

Crime mapping in Košice was carried out in two stages in two projects supported by the State Council for Crime Prevention in the Slovak Republic during 2013 and 2015. The goal of the first phase was to confirm the possibility of mapping based on the existing statistics from the police force or municipal police.[10] The research results showed that municipal police statistical data is more suitable for processing.[11]

Input data can be divided into spatial and attribute. Spatial data were obtained by geocoding. Attribute crime data were obtained from the municipal police of Košice and the databases consist of data from 2010 to 2015.[12] The average number of violations is 42,000 per year. The difference in total number between years is not more than 10%. A total 203,056 offences were processed. They were divided into 4 categories and 55 subcategories. The largest part — 64% consists of the transport offences. The remaining offences fall within the field of violation of generally binding regulations and violation of the Act No. 372/1990 Coll. on offences. Among these, the most abundant:

— *violation of generally binding regulations — GBR 2006–78 Alcohol — 7.38%,*
— *violation of generally binding regulations — the collection of waste — 15.14%*
— *violation of the Act No. 372/1990 Coll. on offences — disturbance of night calm — 1%*
— *violation of the Act No. 372/1990 Coll. on offences — pollution of public space — 5,73%*

The data were processed in software ArcGIS 10.1 from ESRI. ArcGIS is a universal geographic information system with a number of tools. In Slovakia, this software is also used in public and government organizations. To identify hot spots the method of Kernel density estimation was used.

The quartic kernel density method creates a smooth surface of the variation in the density of point events across an area. The method is explained in the following steps:[13]

1.   A fine grid is generated over the point distribution. In most cases, the user has the option to specify the grid cell size (see fig. 1).
2.   A moving three-dimensional function of a specified radius visits each cell and calculates weights for each point within the kernel's radius. Points closer to the centre receive a higher weight and therefore contribute more to the cell's total density value.
3.   Final grid cell values are calculated by summing the values of all circle surfaces for each location.

---

[10]   In the Slovak Republic, there is one national police force. The tasks of the Police, the powers and responsibilities of police officers are stipulated in the Act No 171/1993 Coll. of Laws on the Police. There is also municipal police in Slovakia, municipalities can set up their local units (Act of the National Council of the Slovak Republic No 564/1991 Coll. on Municipal Police).

[11]   *See:* Blišťanová M, Blišťan P, Križovský S, Mapovanie kriminality v meste Košice. Košice: Vysoká škola bezpečnostného manažérstva v Košiciach, vydanie prvé, 2013, p. 88.

[12]   Except for the data from 2012 and December of 2015.

[13]   *See:* Eck E.J, Chainey S, Cameron G.J, Leitner M, Wilson R.E, 2005.

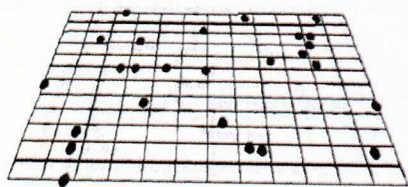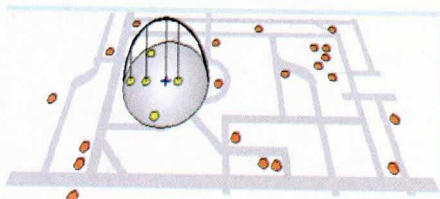**Fig. 6. Fine grid (Eck E.J, Chainey S, Cameron G.J, Leitner M, Wilson R.E, 2005)**

Fig. 7. A search radius (or bandwidth) (Eck E.J, Chainey S, Cameron G.J, Leitner M, Wilson R.E, 2005)

Results and Discussion

Hotspots have been identified in various location of the city Košice. Figures 8, 9 and 10 illustrate hot spot maps for the years 2011, 2013 and 2015. The figures show that the distribution of offences has changed over time. In 2010 a very significant hot spot was in the Old Town (red colour).

Fig. 8. Hotspot maps of offences generated in 2011 using kernel density estimation
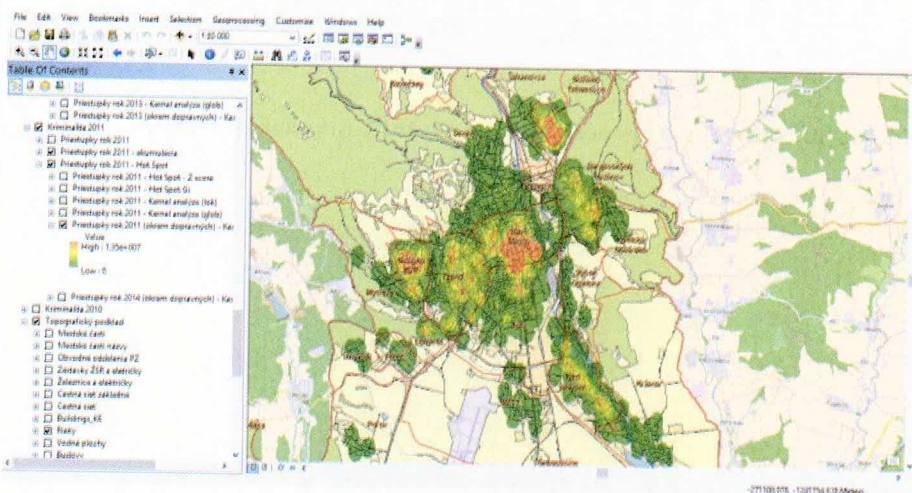
The results of 2015 (see fig. 10) show a relocation of the hot spot area from the Old Town to municipalities with a high population (see fig. 5). These are the municipalities with the highest number of young people aged from 16 to 25 years old.[14]

The comparisons of hot spot maps for the above-mentioned years show the differences in the location of hot spots within the city, but the calculations show the minimal differences in the total number of offences within the years in the research. The reason for this change in the location of the hot spot may also

---

[14] Blišťanová M, Blišťan P, Križovský S, Mapovanie kriminality v meste Košice. Košice: Vysoká škola bezpečnostného manažérstva v Košiciach, vydanie prvé, 2013, p. 88.

be a consequence of installing six cameras in the Old Town during 2013. Hot Spot mapping results clearly show the problematic localities. On this basis it is possible to optimize the placement of the CCTV systems in the city and evaluate their effectiveness. The results of mapping the offences are useful for mapping social communities.

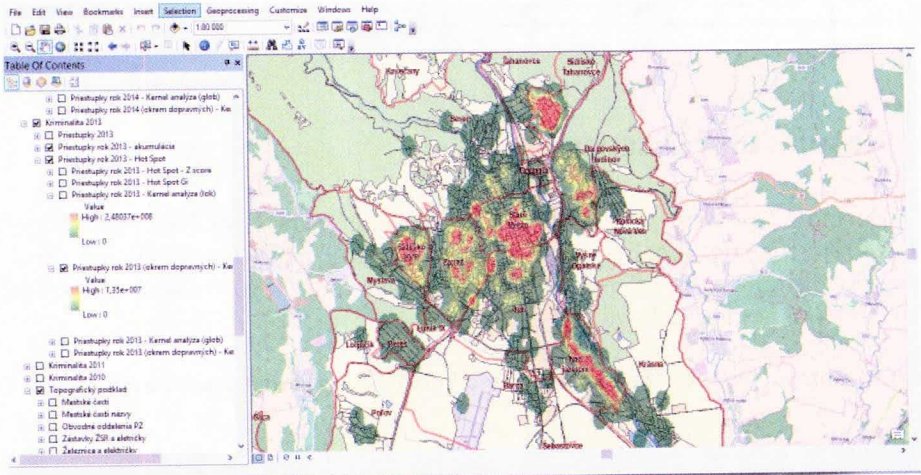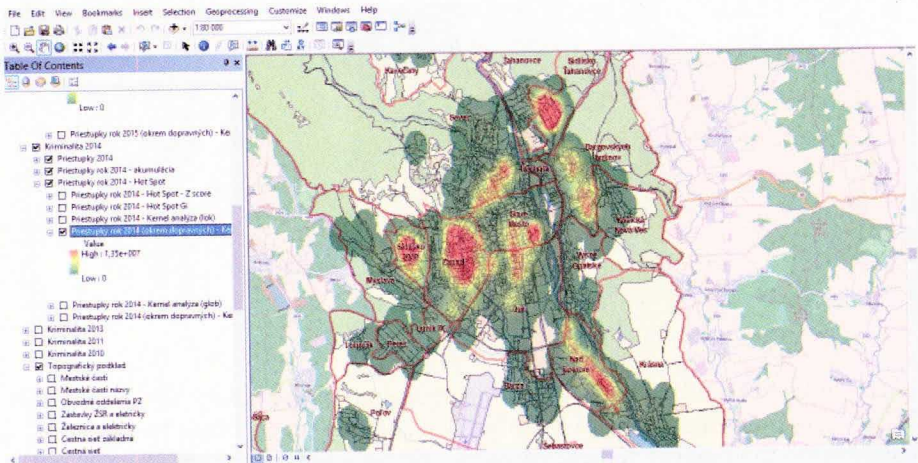**Fig. 9. Hotspot maps of offences generated in 2013 using kernel density estimation**

Fig. 10. Hotspot maps of offences generated in 2015 using kernel density estimation

Conclusion

In summary, the primary objective of crime analysis is to assist the police in reducing and preventing crime and disorder. Visual displays of crime locations (maps) and their relationship to other events and geographic features are essential

to understanding the nature of crime and disorder. The results of the research on mapping crime in Kosice confirmed the possibility of their use in practice. The results of the mapping can not only be useful for the police but also, amongst others, for further sociological research.

References

1. Blišťanová M, Blišťan P, Križovský S, Mapovanie kriminality v meste Košice. Košice: Vysoká škola bezpečnostného manažérstva v Košiciach, vydanie prvé, 2013, p. 88.
2. Blišťanová M, Mapovanie kriminality — história a súčasnosť [in:] *Košická bezpečnostná revue*. Roč. 4, č. 1, pp. 3–7. Košice: Vysoká škola bezpečnostného manažérstva v Košiciach, 2013.
3. Boba R, Crime Analysis and Crime Mapping, 1. ed. Thousand Oaks: Sage Publications, Inc., 2005.
4. Chainey S, Tompson L, Uhlig S, The utility of hotspot mapping for predicting spatial patterns of crime. *Security Journal,* 2008, Vol. 21, pp. 4–28.
5. Eck E.J, Chainey S, Cameron G.J, Leitner M, Wilson R.E, Mapping Crime: Understanding Hot Spots. Report to National Institute of Justice, 2005, pp. 1–15.
6. Hart C.T, Zandbergen P.A, Effects of Data Quality on Predictive Hotspot Mapping. CreateSpace Independent Publishing Platform, 2012, p. 90.
7. Pecková Ľ, Crime prevention Strategy in the Slovak Republic [in:] International Perspectives of Crime Prevention Contributions from the 1st Annual International Forum Forum Verlag, Volume 1, 2008, pp. 91–98.
8. Ratcliffe H.J, Crime Mapping: Spatial and Temporal Challenges [in:] Piquero A.R, Weisburd D (Eds), Handbook of Quantitative Criminology. Springer Science+Business Media LLC, 2010, pp. 5–20.
9. Ratcliffe H.J, 2010_1. The Hotspot Matrix: A Framework for the Spatio-Temporal Targeting of Crime Reduction. *Police Practice and Research,* Vol. 5, No. 1, March 2004, pp. 5–23.
10. Velasco M, Boba R, Manual of Crime Analysis Map Production. Report to the Office of Community Oriented Policing Services, 2000.

About the author

Monika Blišťanová, Ing., PhD. is a university teacher at the University of Security Management in Košice. She is interested in the research of the security environment using GIS. Correspondence: University of Security Management in Košice, Košťova 1, 040 01 Košice, Slovakia. E-mail: monika. blistanova@vsbm.sk

Streszczenie. *Wykorzystywanie wyników mapowania przestępczości na potrzeby sił policyjnych na całym świecie nie jest niczym nowym. Mapowanie przestępczości służy nie tylko lokalizacji przestępstwa na mapie, ale głównie do przeprowadzania różnego rodzaju analiz. Obecnie mieszkańcy niektórych miast mogą sami przygotować prostą analizę, jeśli wyniki mapowania przestępczości zostaną opublikowane w Geoweb. W artykule opisano kilka metodologii służących do mapowania przestępczości*

na całym świecie. Jedną z najbardziej popularnych metod jest mapowanie za pomocą Hot Spot, szczególnie przy określaniu lokalizacji problemowych. Na Słowacji użycie mapowania przestępczości z punktu widzenia analizy Hot Spot po raz pierwszy zostało wykorzystane w Koszycach, które stały się Europejską Stolicą Kultury w 2013 roku. Celem badań było określenie kryminogennych punktów oraz ich zmian w czasie. Dane w latach 2011–2015 zostały opracowane dla całej miejscowości Koszyce, centrum administracyjnego z populacją około 240.000. Autorka w artykule skupia się na opisie potencjalnych zastosowań przestępczości mapowania z wykorzystaniem Hot Spot jako narzędzia do wykrywania zmian w przestępczości zarówno w czasie, jak i przestrzeni. Przedstawione wyniki wskazują na przydatność metodologii śledzenia zmian. Nie ma istotnej różnicy w liczbie przestępstw na terenie miasta w okresie sprawozdawczym, ale istnieje znaczna różnica w ich rozmieszczeniu na terenie miasta w różnych latach. Wyniki potwierdziły również nasilenie się przestępczości w obszarach o największej gęstości zaludnienia. Przedstawione wyniki mogą zostać wykorzystane w sferze zapobiegania przestępczości w wybranych miastach do rozmieszczenia kamer monitoringu po wdrożeniu działań profilaktycznych. Kolejnym możliwym zastosowaniem danych jest socjologiczne badanie miejscowych społeczności.

Резюме. Использование результатов отображения на карте совершенных преступлений для нужд полиции уже не новость. «Карта преступности» используется не только для того, чтобы локализовать конкретное преступление на карте, но главным образом в иных видах анализа. В настоящее время жители некоторых городов могут самостоятельно подготовить простой анализ, используя данные опубликованные на Геовеб (Geoweb). В статье описано несколько методов отображения преступности на карте по всему миру. Нанесение с использованием «горячих точек» является одним из наиболее популярных, особенно при определении проблемных зон. В Словакии использование «карты преступности» с точки зрения анализа «горячих точек» было применено в первый раз в городе Кошице, провозглашенном европейской столицей культуры в 2013 году. Целью исследования было определение «горячих точек» преступности, а также их изменение с течением времени. Данные для 2011–2015 годов были подготовлены для всего города Кошице, административного центра с населением ок. 240 000 человек. Автор ставит своей целью представить потенциальные возможности использования карты «горячих точек» преступности в качестве метода выявления изменений преступности как в пространстве, так и во времени. Результаты доказывают пригодность данной методики для определения изменений. В течение отчетного периода количественная кривая преступности осталась прежней, однако в распределении преступлений по территории города произошли значительные изменения. Итоги также показывают концентрацию преступлений в районах с самой высокой плотностью населения. Эти данные могут быть использованы при профилактике преступности в избранных городах для размещения камер мониторинга после проведения профилактических мероприятий. Еще одним возможным способом использования этих данных может быть социологическое исследование местных сообществ.