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DELIVERABLE 2.3

Review of State of the Art: Predictive Policing

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1 Introduction

Sometimes referred to as 'crime forecasting', predictive policing is where mathematical and analytical techniques are used to identify—or predict—potential criminal activity.

> *"Predictive policing is the collection and analysis of data about previous crimes for identification and statistical prediction of individuals or geospatial areas with an increased probability of criminal activity to help developing policing intervention and prevention strategies and tactics."*
>
> Albert Meijer & Martijn Wessels, 2019, p. 3.

Predictive policing systems use data sources from the police relating to crime, but also other sources. The selection of data can cause a problem in itself and concern is growing about ethical issues related to use of predictive policing in the United States (Richardson et al, 2019).

This CCI report reviews the state-of-the-art of predictive policing. It begins by explaining how predictive policing was first developed in the United States, where law enforcement agencies (LEAs) have implemented predictive policing within their policing practice. The report then goes on to discuss the implementation of predictive policing in two contexts: Germany and The Netherlands. In Germany, predictive policing was introduced in 2014 and is being applied in different ways across the sixteen German federal states. In the Netherlands, predictive policing was piloted in several regions in 2013 and was rolled out nationally in 2017.

Predictive policing strategies are encouraging LEAs, their partners and other stakeholders in the prevention of crime to look more critically at the collection and potential use of different data sources. However, predictive policing does has raised ethical issues in US and there are concerns about its application in European contexts. The ethical, legal and social issues related to predictive policing will be discussed fully in the CCI report (D4.1).

2 Methodology

This report draws on information collected from four sources between October 2018 and April 2019:

- A review of academic and LEA operational literature on predictive policing – A selection of major knowledge sources on predictive policing were identified by Jaap de Waard, The Hague: Dutch Ministry of Justice & Security, Law Enforcement Department, Jaap de Waard, 9 January 2019. CCI consortium members gathered relevant background information and examples of existing toolkits (see CCI deliverables D2.2 & D2.3). Further literature identified by two LEA partners—German police in the federal state of Lower Saxony (LKA) and The National Police of the Netherlands (NPN). The literature was analysed by the LKA.
- A survey of English and German-speaking LEAs – The LKA in Lower Saxony contacted around fifty LEAs about predictive policing. LEAs were asked if they used predictive policing and, if so, since when and about their reasons for the implementation of predictive policing. Information was also gathered about the specific aim of the tools, who developed the software and police staff involved in using predictive policing. LEAs were also asked the about impact of predictive policing. Seven LEAs filled out the template, but others provided information via a telephone interview.
- Interviews with 'leaders in the field' of predictive policing – Twelve semi-structured telephone interviews are in the process of being conducted with identified LEA 'leaders in the field' in Europe and beyond (specifically the US). Interviews conformed to a common question route and were conducted in the language most appropriate to the interviewee. Interviews are being conducted in different languages by CCI partners, including LKA, INT, Efus and DSP.
- Workshop on state-of-the-art for predictive policing – A workshop with CCI consortium partners was held in Amsterdam (February 2019) to (i) discuss results and issues raised by the research; and (ii) seek to understand and explore different approaches to tool development and delivery relating to predictive policing. The workshop focused on current practice in Germany and the Netherlands.

The information was analysed and written up by the LKA and revised following input and feedback from CCI partners.

3 Background to Predictive Policing

Information-based policing has long been recognised as an important element of police work, be that from gathered intelligence or data. In the course of technical developments in the 1990s and early 2000s, the processing and visualisation of such information through new technologies became possible. With the help of Geographic Information Systems (GIS), existing information could be processed and visualised automatically, providing what are known as 'crime maps' (Shahidullah, 2014, p. 191) or 'heat maps', using different colours to signify areas of different crime risk. The first approaches were more computer-based crime statistical analysis software compared to current software. The COMPSTAT[1] system adopted in 1995 by William Bratton, then Commissioner of the New York police force, can be regarded as the pioneer of pattern-based "prediction" tools in which crime data became the main principle guiding policing strategies (Willis et al., 2007, p. 147). Drivers for change included the increased technical possibilities and the existence of an increasing volume of data available for potential police analyses, but also police budget cuts, which in turn led to the need to allocate resources more efficiently.

William Bratton pioneered the beginning of modern crime prediction in the U.S. and in general. As chief of police in Los Angeles, Bratton was a key proponent of "broken windows" policing and he transferred his experience from New York to the Los Angeles Police Department in 2008. At the LAPD, Bratton began to work with scientists from local universities who applied complex mathematical methods and findings from earthquake research to crime data (Ferguson, 2017, p. 1126). They focused on domestic burglary, vehicle theft and theft from vehicles. The algorithm used historical data in order to calculate risk areas where a crime was likely to occur in an area of 500x500 feet within the next hours or days. Predictions were made available for police officers to enable them to anticipate crime patterns and respond through patrolling and greater awareness. The first iteration was regarded a success and a subsequent study measured crime reduction in the risk areas (Mohler et al., 2015). Because of this successful project, the company PredPol[2] was founded and became one of the market leaders for predictive policing software within the next years. Shortly afterwards, the Memphis Police Department, in cooperation with Memphis University, developed the Blue Crush system, which is based on a geo-information system and the SPSS statistics software (Klausnitzer, 2013, p. 32-33). A first test phase proclaimed a reduction of criminal offences using Blue Crush (IBM, 2011), although this was not scientifically evaluated.

In addition to these commercially distributed products, the National Institute of Justice has been supporting the development of several predictive policing approaches since 2009 by allocating public

[1] See https://www1.nyc.gov/site/nypd/stats/crime-statistics/compstat.page

[2] See www.predpol.com/about

funds to various projects (Nix, 2015, p. 278). As a result, several programs were developed and made available free of charge to law enforcement agencies worldwide.

Other law enforcement agencies added a person-based prediction model due to an epidemic in gun violence in the cities of Chicago, Boston and Kansas City (Ferguson, 2017, p. 1139). People most at risk of becoming involved in gun violence as an offender or a victim were ranked on a strategic subject list (SSL) generated by data based on their individual criminal records and their associate's criminal records (City of Chicago, 2017). Police measures include a personal meeting with a police officer, a social worker and community members (pastor, football coach, etc.) to reach out to the listed subjects (Gorner, 2013). Research of the first version of SSL came to inconsistent results concerning the reduction of gun violence (Saunders *et al*, 2016).

Several law enforcement agencies in the U.S. adopted Predictive Policing within their daily routine policing practice, for example Chicago, New York, Shreveport P.D. (Perry *et al*, 2013, p. 4). The evaluation[3] and public discourse on the validity and usefulness of these methods in the US is subject to ongoing public discussion[4]. It is certainly interesting to develop Predictive Policing methods and systems further, but the question of if and how they can work effectively and in a useful way is still open.

Although there is no universal definition, the basic characteristics of Predictive Policing can be summarised as follows. Predictive Policing is a police strategy in which a wide variety of crime-relevant data is usually analysed and visualised using software. This data is used for spatial-temporal or person-based predictions of potential future crimes. The aim being to predict a future crime as accurately as possible in time and place in order to counter the identified risks with adequate police measures and to prevent, reduce, deter or at best arrest criminals on site (Gluba & Pett, 2016, p. 2). While the focus is currently on deployment of police resources in relation to identified risks, ideally an intervention would be designed to tackle the specific causes and context of a problem, and to support multi-agency action. The wider use of data for multi-agency action would need of course to take into the concerns of specific groups and the impact on local communities and wider society.

Predictive Policing does not replace traditional policing. Instead, it provides an additional tool for the LEA and related stakeholders (e.g. local authorities, housing companies, etc.) by processing already existing data more efficiently and consistently.

According to Ferguson (2018), software-based analytic approaches to Predictive Policing can have different basic orientations: (1) targeting places of property crime; (2) targeting places of violent crime; and (3) targeting persons involved in criminal activity. The first is the most common Predictive

[3] See this publication: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3333423

[4] See this recent news article: https://www.latimes.com/local/lanow/la-me-lapd-predictive-policing-big-data-20190405-story.html

Policing approach focusing on burglary, automobile theft and theft from automobiles. Due to their incidence and the fact that most of these crimes are reported to police, they are currently considered to be the most predictable crimes. Relevant theories from criminology (e.g. van Eck's Crime Triangle) may also inform Predictive Policing (van Dijk et al, 2015, p.12). In addition, findings from social science research suggests that these types of crimes occur based on environmental vulnerabilities that could be identified and addressed with police measures, including police presence in the targeted areas (Ferguson, 2017, p. 1126–1127).

Furthermore, Predictive Policing evolved into a tool to predict violent crimes in urban areas. Violent crimes (such as robberies, aggravated assaults and shootings) are known, through traditional hot spot policing, to occur repeatedly in specific locations, such as areas of nightlife, where drugs and alcohol consumption is involved. Also, areas claimed by crime-organisations can give information about where gun violence is most likely to occur. To predict violent crimes and develop a broader approach, traditional factors from hot spot policing were adapted and supplemented with additional data (ibid., p. 1132–1133).

In order to make even more precise and specific predictions and to prevent crime at its core, the offenders and victims came increasingly into focus. Initially used to identify potential terrorist networks, the approach was adapted to Predictive Policing practice. The basic principle of predicting offenders or victims consists of a wide-ranging analysis of an individual's social networks, past criminal acts or connections to known offenders based on addresses, social media, telephone numbers, etc. Findings from victimisation research have also shown that a small proportion of the population has a higher risk of becoming a victim of a crime or being repeatedly victimised. Based on this, police strategies focus on a proactive approach directly addressing those at highest risk of becoming an offender or a victim (Ferguson, p. 1138). This approach supports the risk-assessment of people and places by the police. It tries to identify potential factors that might not yet have been considered in traditional police work to include them in the analysis (Ferguson, 2017, p. 1125). Perry *et al* (2013) state that based on predictions, appropriate measures to a specific risk need to be identified to ultimately have an impact on crime.

Figure. 1 Prediction-led process (Perry et al., 2013)

The cycle of data collection, predicting and applying adequate police measures can be subdivided into four parts (see Fig. 1). The first part is the comprehensive collection of quantitative data, which is essential for accurate predictions; second is the actual analysis of the data; third the prediction of crime; and fourth, specific police measures / operations preventing crime through deterrence or arrests of offenders.

Prediction algorithms and the variables for these predictions are based on several criminological theoretical approaches and research findings like risk terrain modelling (RTM), which analyses spatial and environmental factors and their influence on the occurrence of crime (Caplan & Kennedy, 2011). Another popular approach is the rational choice theory, which describes criminal behaviour as a process of considering the costs and benefits of committing a crime. Therefore, probabilities for delinquency rise when the benefits (money, goods) of a crime are higher than the actual costs (arrest) (Cornish, 1986). According to Cohen and Felson (1979) and their routine activity approach, crime depends on the constantly changing lifestyles and behaviours of the population. Depending on time and place, three factors are responsible for the occurrence or absence of criminal behaviour: motivated offenders, suitable targets and lack of sufficient protection of these targets.

The most common approach, on which the majority of software-based predicting tools (Predpol, PreMap, Precobs etc.) are based, is the repeat victimisation theory (Farrel & Sousa, 2001), in particular the near repeat phenomenon. It states that after an initial offence (e.g. a burglary) the risk for another similar crime in close spatial and temporal proximity increases (Townsley et al., 2003). Based on research from the 1970s regarding the rates of re-victimisation of individuals and locations, it turned out that a small proportion of the population represented a large proportion of the victims of crime; the same was observed in terms of specific locations (Sparks et al., 1977; Hindelang et al., 1978). Previous studies have been able to prove the repeat victimisation phenomenon for a number of crimes, including burglary, domestic violence, bank robbery and theft from motor vehicles (Lamm-Weisel, 2005; Braga & Weisburd, 2010; Johnson & Bowers, 2007). A study in the Netherlands found

that previous victimisation is a risk predictor for the target (repeat victimisation) and also other potential targets in the vicinity (López, 2007). This is because certain types of crime tend to cluster in specific locations. Due to the high reporting rates, as well as the near repeat research findings, domestic burglary provided a sufficient database to predict crime patterns and address these with adequate police measures.

In the next section, Predictive Policing strategies and software are explored in the context of Germany and the Netherlands.

4 Predictive Policing in Germany

In the last years, mainly since 2014, six law enforcement agencies (LEAs) in Germany started to work on a Predictive Policing approach and are currently using an external or internal developed solution; also, several LEAs are planning to use Predictive Policing within the next years (Gluba & Pett, 2017, p. 435). All prediction approaches firstly focused on burglaries. This was due to rising crime rates of domestic burglary in Germany as a whole (Bundesministerium des Innern, 2016, p. 3) and the associated low clearance rate of those cases in the particular federal states. One additional reason for focusing on domestic burglaries was the fact that they have a high impact on society, as well as considerable financial and psychological consequences for the victims (Wollinger et al., 2014). Intensive media attention eventually led to increasing pressure on political and police leadership to address the problem and allocate adequate resources to burglary prevention.

In October 2016, the interior ministers of the Netherlands, Belgium, Germany and the federal states of North Rhine-Westphalia, Rhineland-Palatinate and Lower Saxony signed the "Aachen Declaration", in which they agreed to strengthen cross-border cooperation in combating property crime. Among others, Predictive Policing was a measure considered helpful and important to achieve this goal (Landesregierung Nordrhein-Westfalen, 2016). Software-based policing, the algorithm-based identification of potential areas at risk was seen as an innovative approach to address the public concerns and improve traditional policing methods with a software-based solution.

From 2014 on, several federal states in Germany, such as North Rhine-Westphalia, Berlin, Hesse, Bavaria and Baden-Württemberg began to work on Predictive Policing by developing their own solution or purchasing commercial tools (Seidensticker et al., 2018, p. 2). In 2014, the police of Lower Saxony started its first project in terms of software-based crime predictions. In collaboration with IBM and the Karlsruhe Institute for Technology (KIT), a first attempt was made to design a prediction tool for domestic burglaries with IBM's SPSS Modeler (Gluba & Pett, 2017, p. 436). The project ended in September 2014, until now there are no officially published results of this project, but it led to further research on the topic (see: Gluba, 2014; Gluba et al., 2015; Gluba, 2016). Furthermore, the start of a new project on creating an internal Predictive Policing system for the police in Lower Saxony called PreMap (Predictive Mobile Analytics for Police) was initiated.

Within Germany, different Predictive Policing systems have been developed due to different jurisdictions across the sixteen federal states. Precobs (Bavaria and Baden-Württemberg) and PreMap (Lower Saxony) follow the near-repeat approach. SKALA (North-Rhine Westphalia) KLB-operativ (Hesse) and KrimPro (Berlin) use a wider theoretical approach with more data like sociodemographic and/or infrastructural data (Egbert, 2018, p. 249).

Bavaria (since 2014) and Baden-Württemberg (since 2015) use a system called Precobs[5], which predicts domestic burglaries based on the near repeat approach. The Institute for pattern-based forecasting technology (IfmPt) in Oberhausen developed the system (Knobloch, 2018, p14). Precobs was tested in several cities and areas in Bavaria and is now permanently in use by the police (Bayerisches Staatsministerium des Inneren, für Bau und Verkehr, 2015).

The implementation of Precobs in Baden-Württemberg was evaluated by the Max-Planck-Institute for Foreign and International Criminal Law, which came to inconsistent results concerning the impact of Predictive Policing due to the problem of being able to attribute causal effects solely to the use of Predictive Policing—a general problem in evaluating Predictive Policing practice (Gerstner, 2018, p. 134). Saxony started a pilot project with the IfmPt and their Precobs system in December 2018.[6] Hesse's in-house development called KLB-operativ started its pilot phase in 2015. Based on the near repeat approach KLB-operativ focuses on domestic burglaries and was tested during winter because of rising crime rates during this time of the year. The program was initially only usable as a web app but was further developed during the project period for mobile phones. The app provides an interactive map that displays burglaries over the last ten days and specific information about each burglary. The data fed into the system on a daily basis, and the predictions based on the data enables the police to deploy police forces according to current risks and choose adequate measures for the following 24 hours (Polizei Hessen, 2017a). Besides crime related data from police sources, socio-economic census-data is also implemented in the process (Anbau. 2016, p. 45).

The police in Berlin started their Predictive Policing project KrimPro in 2016 by testing it in two police districts in collaboration with Microsoft. After a development phase until 2017, the police launched KrimPro throughout the city of Berlin (Seidensticker et al., 2018, p. 3). The system predicts crimes in 400x400m areas based on police data and freely accessible infrastructural and demographic data (Graupner, 2017; Dinger, 2019). North Rhine-Westphalia (NRW) uses their also in-house developed tool SKALA since 2015. The system predicts domestic burglary, commercial burglary and automobile related offences (car-theft and theft from cars) with spatiotemporal predictions. In its pilot phase, SKALA was tested in six cities in NRW. The probable risk of the predicted offences was provided for each district in the pilot cities (Landeskriminalamt NRW, 2018, p. 1–3). SKALA applies, like KrimPro, a wider socio-scientific hypothesis-based approach beyond the near repeat phenomenon. In addition to police data, socioeconomic data was purchased in order to create links between crimes and infrastructural as well as socioeconomic data. Predictions are made for residential areas consisting of the official electoral districts to a number of 400 households within each district with possible variations. SKALA was scientifically evaluated during and after the project phase (Landeskriminalamt

[5] See https://www.ifmpt.de/

[6] See https://www.ifmpt.de/project_sachsen.html

NRW, 2018) and was rolled out in 16 police departments in NRW by the end of the project in 2018 (Seidensticker et al., 2018, p.5).

Since 2014, the State Office of Criminal Investigation of Lower Saxony (LKA) conducted a first pilot project on Predictive Policing in cooperation with IBM. Despite promising results, it took some time until Lower Saxony's police launched the next development phase – this time without external partners. One reason for this was that the LKA did not want to share police data with external companies and another was the wish to understand the exact functionality of the predictions and algorithms. The LKA was concerned, that a purchased commercial tool would be some kind of "black box". Besides, the personnel resources for the realisation of the project were internally available and therefore there was no need to involve any external companies in the process. This resulted in the still ongoing PreMap project, starting in 2016 within the police of Lower Saxony. The aim was to develop a mobile software application that would provide up-to-date information on potential risk areas for near-repeats in domestic burglary, as well as daily updated information on crime rates in specific areas. Initially, the software was tested in the police departments of Salzgitter, Peine, Wolfenbüttel and the city of Wolfsburg. After a short time other areas in Hanover and Osnabrück were included in order to have a broader database available.

In addition to the predictions, PreMAP also provides a so-called Crime Radar that offers a map with all offences relevant for public spaces from the last four weeks. Additional information on these crimes can be accessed. PreMap's prediction process is divided into several stages: First, a burglary has to occur, based on the near-repeat approach, all relevant prediction parameters are recorded by the police officers and entered into the case management system of Lower Saxony police (NIVADIS). In particular, the time of the crime, the location, stolen goods and the type of intrusion into the object play a relevant role in order to make a prediction in the sense of near repeat. Burglaries in which the specific time of the crime could not be precisely defined were not included in the prediction modelling in order to avoid bias in PreMap's risk assessment. Additional investigation findings from NIVADIS concerning cases that have already been processed by PreMAP are retrieved to provide the prediction with more content. Based on the characteristics of an initial burglary, PreMAP calculates a score that represents the probability of a near repeat in a radius of 400m around the observed burglary within the next 72 hours. The basis for the calculated scores was conceived from empirical police data of over 70,000 burglaries from 2008 to 2013 in Lower Saxony. If the calculated score exceeds a pre-set threshold, a risk area automatically activates and visualises on an interactive map in PreMap. At the same time, specially trained officers have the opportunity to revise the automatic prediction by manually deactivating or activating a risk area (veto function). This process repeats as soon as the risk relevant factors change, and new scores and risk areas are provided by the system. An additional map provides an overview of the reported crimes in general, which sorts by place and time according to the specific offence. Based on this additional data, the officers-in-charge can assess current crime trends and consider these in addition to PreMap's predictions. Following these predictions, specific measures are taken to reduce the risk of near repeats in the risk areas. In particular, coordinators deploy police

forces as needed to ensure focused police patrolling in these areas and either deter offenders or arrest them attempting burglary.

In Germany, specifically in Lower Saxony, the pilot phase of PreMap has shown that there is still leeway for PreMap's further development in order to be effective as an additional tool in the strategic alignment of the police. The risk areas were partially incomprehensible to police officers during the pilot phase, because only a single factor led the system to a prediction. Sometimes the system contemporaneously identified and displayed a number of risk areas, because of which an appropriate deployment of police forces based on the areas could not always take place. There is also a need for optimising and finding adequate measures in response to the identified risks. With regard to personnel resources, it is not always possible to cover all areas as required.

Nevertheless, the communication and implementation of PreMap within the departments was satisfactory. The simple design of the program and its predicting approach ensured a high level of communicability and thus a high level of acceptance of the tool among police officers. The development and implementation of a software-based policing approach has a high potential of breaking out of traditional policing patterns and contributes to a positive development of policing practice. Especially the internal police processes of data collection and management can be improved within such a software implementation. This has been demonstrated both in other countries and in Germany, in particular. During the PreMap project, internal communication between the forces strengthened and the informational supply of police-relevant data was also improved. The development of new prediction approaches must always be guided by both theory and practice. Knobloch (2018) sums up the status in the field of Predictive Policing in Germany as follows:

> *"First, experience shows that predictive policing, as it is currently practiced in Germany, does not violate civil rights. Secondly, it becomes clear that predictive policing, apart from the prevention of crime, which can hardly be proven to have an effect, unfolds so much positive potential that it is worth continuing to pursue this approach with due consideration."*
>
> (Translated by Maximillian Querbach)

> *"Die Erfahrungen zeigen erstens, dass Predictive Policing, wie es derzeit in Deutschland praktiziert wird, keinen Eingriff in die Bürgerrechte darstellt. Zweitens wird deutlich, dass Predictive Policing abseits der Verhinderung von Verbrechen, was sich als Wirkung kaum nachweisen lässt, so viel positives Potential entfaltet, das es sich durchaus lohnt, diesen Ansatz mit Bedacht weiter zu verfolgen."*
>
> (ibid., p. 5)

The PreMap project has already achieved significant value in its relatively short duration. For further development and exploitation of the contained potential further evaluations need to be made in order to answer open questions and finally implement new findings in the process.

5 Predictive Policing in the Netherlands

Intelligence-led policing was adopted in the Netherlands in 2007. Its implementation was supported by the formation of a national police force and development of standardised central national crime database. This development led to the creation of the Crime Anticipation System (CAS). This data-driven system attempts to predict crime through analysis of statistics from three data sources: Central Crime Database (BVI), Municipal Administration (GBA or BRP since 2014) and Demographics from Statistics Netherlands (CBS) (Oosterloo and van Schie, 2018, p.33). Three type of data are used by CAS:

- Socio-economic data from the Central Bureau of Statistics (CBS) – people's age, incomes and the amount of social benefits in an area.
- Basisvoorziening Informatie (basic information provision, BVI) – information gathered by the police on previous crimes, locations and known criminals
- Municipal Administration – information about streets and addresses, used to structure for the map whereon predictions are made (BAG).

CAS can be classified as a "spatiotemporal prediction system" (Oosterloo and van Schie, 2018, p.33) in that it identifies crime 'hot spots' and 'hot times' — rather than high-risk individuals. CAS presents the data in the form of 'heat maps', highlighting places at risk of high-impact crimes (represented with a colour that increases in intensity, with the risk). The size of the squares, selected after testing, is 125m x125 m and better suited to urban areas. In rural areas, the number of people and households might not be statistically valid (Oosterloo and van Schie, 2018). Different types of crime are represented by colour coded squares. The top three percent of high crime areas are mapped by CAS. The map resulting from the CAS system influences the advice that the intelligence organisation gatekeepers give during an operational briefing. In combination with known activities of police, as well as emerging or continuing trends that have been found, the predictive heat map is used to allocate police resources. Moreover, the results are used in meetings with stakeholders and other partners in the prevention of crime.

Dick Willems initially constructed CAS for the Police of Amsterdam in 2013. After testing CAS in Amsterdam, a pilot project was undertaken in the Dutch cities of Enschede, Hoorn and The Hague-Hoefkade and Groningen-Noord. The pilot testing apparently produced "non-conclusive results with respect to user-experience of police officers in the four previously mentioned cities" (Oosterloo and van Schie, p.34). However, some police forces believed that CAS supported organisational improvement. CCI partner, and ethics expert, Oskar Gstrein notes that one police force improved police culture when implementing CAS and engaged more with the community. As a result, the police

force considered CAS a success. In his view: "The advantage of Predictive Policing is that it presents an opportunity to question existing patterns of behaviour and make them more visible" (Oskar Gstrein, RUG, personal communication, 10 April 2019)

CAS was rolled out to all police teams in The Netherlands in May 2017. In 2017/18, CAS was being used by 110 base teams, out of a total of 167, in 6 out of 10 districts (Willems 2017c). The data generated over a relatively short period is mapped by CAS—currently for one week. On 8th April 2019, CAS is being used in 164 of the 167 base teams (Armando Jongejan, 10th April 2019, personal communication). As CAS is based on locations, it is only suitable for certain types of crime, such as burglary, robbery and theft (specifically pick-pocketing) (Oosterloo and van Schie, 2018).

While CAS is currently used to identify crime risks and support the allocation of police resources, intensity of use various across police districts. NPN is interested in its use to prevent crime and to catch criminals in the act of offending.

CAS is an example of a system that is mainly focuses on predicting crime hotspots, although it also uses information about offenders. The Dutch police, and Dutch national and local authorities, also use other instruments that are more offender-oriented—i.e. concerned with identifying repeat offenders. In some cases, the tools also seek to identify individuals at risk of victimisation. Referred to as "risk taxation instruments', such instruments try to predict the probability of an individual (including young offenders) committing a crime or terrorist attack.

There are about twenty different Risk Taxation Instruments (RTIs), reviewed by the DSP-groep in 2016 (DSP, 2016, private report). In a follow up report in 2018, DSP concluded that Risk Taxation Instruments should focus on persons that are a real actual danger to others and/or themselves and should result in a decision about treatment. The police should work together with other partners—ie. adopt a multi-agency approach—and ensure continuous learning through adoption of ISO 31000 and Quality management (e.g. ISO 9000 standard)

A multi-agency data analysis system on crime incident in public transport exists in large parts of the country (TRIAS). The system is a combined system using police data as well as data from public transport. Research commissioned by the ministries of Justice and Security and infrastructure concluded that different data sources may be combined, reducing research bias through triangulation. Importantly, the system supports a multi-agency approach to reducing risk. According to some studies, simply increasing police patrols may not significantly reduce crime or deter offenders. For example, Summers and Rossmo (2018) found from interviewing 137 chronic offenders who had multiple convictions for burglary, robbery and/or vehicle crime that:

> *"When encountering police patrols, criminals were initially more likely to displace (e.g. committing crime elsewhere and/or later in the day) than to desist from offending."*
>
> (Summers and Rossmo, 2018)

6 Research: Interview results

This section reports on the findings of interviews conducted by the CCI consortium with twelve LEAs that are currently using Predictive Policing, have used it or are considering using it in the future.

Concerning the implementation of Predictive Policing within LEAs, six of them started testing Predictive Policing between 2014 and 2015 and three started in 2018. Two were about to start a project within the year (2019) and one LEA was only using traditional hot spot policing and no Predictive Policing tool due to insufficient crime rates for software-based predictions. The majority of the predicting tools being used by LEAs are software-based, two tools are more or less police management strategies and concepts and no actual Predictive Policing software. Almost all of them use an externally developed software, either purchased from a company or developed in cooperation with scientific institutions. Only two of the LEAs use an in-house developed software.

The main reason for LEAs implementing Predictive Policing concern about rising crime rates and a low clearance rate in the different countries or states, especially in relation to domestic burglary, car thefts or theft from cars. In addition, the software was expected to provide comprehensive information about crime rates and risk areas by visualising and classifying this information in order to deploy police forces more efficiently—i.e. to be 'at the right place at the right time'. By establishing Predictive Policing within the police, the LEAs wanted a framework for systematic analysis, measurements and evaluation of crime data to improve and support daily police practice.

When asked about internal use of Predictive Policing, all LEAs named their analysis unit, which analyses the data and provides officers in command with additional information in order to deploy police forces according to the given information. Finally, police officers patrol the predicted risk areas or tackle these risks with other police measures. In some of the LEAs, researchers constantly evaluate the software and provided police with current research findings.

Concerning the aims of Predictive Policing, most LEAs named arresting offenders and reducing crime as a priority of the tool. An early identification of rising crime rates and constantly updated information about crime relevant connections should lead to better internal communication and greater efficiency in analysing crime patterns. Police interventions and their effectiveness based on crime predictions should be evaluated in order to tailor police measures to specific offences and places. To date, only one German LEA had evaluated their Predictive Policing project scientifically.

Eleven LEAs stated that the impact of Predictive Policing on crime prevention had yet to be evaluated, which is consistent with current research results. Nevertheless, the implementation within the agencies is positively assessed. Predictive Policing is seen as a valuable support and extension of existing analysis methods and police strategies. Furthermore, internal communication within the different police sections improved and the police force deployment was regarded as more resource saving and efficient.

7 Issues related to Predictive Policing

Although the different software tools in use are much alike, the public discussion around Predictive Policing products in each country focuses on specific aspects and national concerns. For instance, the main concerns among citizens and human rights activists in the U.S. are discrimination mechanisms, which are reproduced by the input of already biased police data into the software—especially in terms of racial-profiling and police controls of Afro- and Latin-Americans (Knobloch, 2018, p. 12). Crime hot spots resulting from these biased data sources result in a higher police presence leading to rising recorded crime rates in these areas. The likelihood of being checked by the police and getting caught for even minor offences rises and reproduces discrimination of certain socially deprived areas (Ferguson, 2018, p. 1145-1148).

The main problem with historic police data is that these data sources are not only used for place-based predictions, but also for person-based predictions, which is even more alarming when individuals are directly affected by biased data. However, even in terms of place-based predictions and the police measures that address these identified risk areas, discrimination is not excluded. In certain rural areas, the postcode highly correlates with socioeconomic factors, such as income, education, colour of skin etc. Even without person-based factors, this can lead to further discrimination and criminalisation of socially deprived areas (Shapiro, 2017, p. 460).

Furthermore, purchased non-police data or implementation of online social media sources, surveillance footage etc. and lack of transparency raise concerns in terms of data privacy (Shapiro, 2017, p. 460).

There are some major problems when predicting crime based on historic crime data. While the reporting rate of burglary and car theft is consistently high, violent crimes tend to have a much lower reporting rate and therefore remain hidden. The data quantity and quality is not sufficient for certain prediction models, especially in terms of predicting violent crimes.

In addition, the biggest problem with Predictive Policing is proving its effectiveness. Falling crime rates may not be associated with the implementation of Predictive Policing. The reductions in burglary rates across Europe are most commonly associated with better home security (van Dijk, 2012). In Germany, the fall in burglary rates is being reported alongside the introduction of Predictive Policing, giving the impression that the new technology is helping to prevent burglaries.

8 Lessons Learned

8.1 Review of current studies on the effectiveness of Predictive Policing

Since the rise of predictive technologies and the application of Predictive Policing in daily policing practice across the globe, several studies have been conducted on the topic and have assessed the kinds of Predictive Policing approaches that do or do not have an impact on crime. Even though Predictive Policing software is being used by many police forces, there remains a limited number of studies measuring the effectiveness of the different Predictive Policing approaches and systems applied within police practice. The few studies conducted, however, have found mixed results concerning the real-world preventive and deterrent effect of Predictive Policing.

One of the first evaluations, conducted by Hunt *et al* (2014) assesses the Shreveport Police Department's property crime Predictive Policing approach. This study used an experimental design to compare districts using Predictive Policing with those using more traditional policing approaches. The research found no statistically significant difference between the crime rates in the different districts studied. The authors conclude that the lack of statistical power of the predictions combined with a partially failed implementation of the systems being evaluated within the studied police districts led to the insignificant results (Hunt *et al* 2014, p. xiii–xv). Mohler *et al* (2015) compared predictions made by a Predictive Policing system and those produced by crime analysts. This study conducted randomised controlled trials for the Los Angeles Police Department (US) and Kent Police (UK), which showed a decrease in crime volume within the system predicted areas, whereas areas predicted by analysts showed no significant crime reduction effects (Mohler *et al*, 2015, p. 1400).

Results of further non-experimental studies focusing on the effectiveness of Predictive Policing on property crime are mixed. Gerstner (2018) found a decline in domestic burglary in one of the city districts where Predictive Policing was applied but also found rising crime rates in other cities where Predictive Policing was used. The State Office for Criminal Investigation of Lower Saxony (2018) found similar results — while some cities showed a higher decline in domestic burglary compared to those where Predictive Policing was not used, other cities showed rising crime rates despite Predictive Policing being used by the police.

A study conducted by the State Office for Criminal Investigation of North Rhine-Westphalia (2018) measured a decline in domestic burglary in districts using Predictive Policing compared to other districts. The most recent study by Ratcliffe *et al* (2020) assessed the impact of different patrol strategies on violent and property crimes in predicted areas within a randomized controlled trial experiment. Only one of three interventions, where officers were briefed about the risk area and at least one or two police cars were dedicated only for patrolling predicted risk areas, showed a reduction in property crime as well as temporal diffusion of benefits. Concerning violent crimes,

researchers found an increase within treatment areas compared to the control areas was not significant, due to lack of violent crimes differences within the district.

As well as spatio-temporal predictions focusing on property crime, human-oriented prediction models (identifying potential offender and/or victims) have also been evaluated. Saunders *et al* (2016) evaluated the Strategic Subject List (SSL) approach of the Chicago Police Department (US) in a quasi-experimental design. The SSL estimates the risk of an individual likely to become an offender or victim of gun violence. However, researchers found no significant evidence of individuals on this list being at higher risk than others, but a higher probability of them being arrested when listed on the SSL (Saunders *et al*, 2016).

8.2 Lessons learned — Implications for policing practice

While there have been a few studies and experiments conducted on the effectiveness of Predictive Policing there remains a need for rigorous, long-term studies assessing the benefits and drawbacks of implementing Predictive Policing and applying the right measures to specific types of crimes. Such studies are required in order to build a reliable research base of potential use scenarios and identify the effects and impact of Predictive Policing.

When first launched in the US and later applied in Germany, Predictive Policing was seen as a panacea for reducing and preventing property crime and violent crimes. Driven by political pressure and the hope that new technologies would rapidly enhance traditional policing techniques and elevate policing into a new technological century, several Law Enforcement Agencies (LEAs) developed or purchased Predictive Policing systems and implemented them within their daily policing routine. Among these LEAs were the two CCI partners, NPN and the LKA, with their inhouse developed approaches respectively named CAS and PreMAP.

By reviewing current practices and academic studies and conducting the requirements capture research phase within the CCI project, several constraints of trying to predict crime with software by using police data — and with implementing new technologies within policing in general — have been identified. Firstly, and most importantly, is that Predictive Policing is not a panacea for crime reduction and prevention. In its current state and with its current approach, it contains many flaws. These relate to, for example, data quality, accuracy of predictions and implementation and poor integration within operational policing — leading to what is termed by IT people "user acceptance" issues. Internal as well as external studies reveal the limits of Predictive Policing systems.

An adequately sized and accurate database is necessary to minimise false-positive predictions and enable a sound prediction model that can provide police with relevant information on which they can deploy resources more efficiently. Given that the 'perfect database' is unlikely to be achieved, Predictive Policing might instead act as a supporting risk assessment tool that can help the structuring and assessment of large amounts of police data, and support problem identification and decision making. However, if such a system is not integrated within the structures of everyday policing, as part

of crime analysis and assessment, as well as within internal communication and decision-making processes, it will never become an accepted part of "policing".

8.3 Future development and implementation

In order to implement Predictive Policing within a police institution, the potential use scenarios need to be considered. Benefits and drawbacks of Predictive Policing systems need to be understood, and the needs and perspectives of end-users analysed and addressed. What has been learned through the research phase of CCI and reviewing academic literature within the project is that Predictive Policing tools need to be tailored to meet the specific needs of police officers and to fit the institutional culture and infrastructure. Furthermore, new technologies and new ways of policing and thinking need to be regularly communicated and consistently implemented as a model of professional 'routine policing' in order to be implemented and applied effectively. Lessons learned from the CCI research phase will be applied in the development of tools for Predictive Policing in Lower Saxony, Germany, and the Netherlands.

9 Conclusions

Predictive Policing will continue to be one among many policing strategies. The excessive expectations of this comparatively young discipline must be tempered with pragmatic realism. In addition, the implementation of Predictive Policing must be scientifically monitored, evaluated and adapted to gain maximum benefit from the required investment in technology. Crime is a complex phenomenon affected by various factors, all of which must be taken into account by Predictive Policing models and can impact the quality of predictions. Predictions made from police data (and other data sources) do not provide a direct view into the future and can only be regarded as risk probabilities.

> *"The computer is not a crystal ball — it creates an algorithm that predicts risks of possible events."*
>
> (Smith, 2014, cited by NPN)

The accuracy of risk probabilities depends in turn on the quality and quantity of the data. Improvement of the predictive power requires that everyday data management inside the police must be improved significantly. During the pilot phase of PreMap in the LKA, the quality of data input and its preparation for use to inform police practice improved. While this success was not related to preventing or reducing crime itself, it did improve the processing and management of intelligence within the police — competencies that support both proactive policing and policing in general.

The analysis and preparation of police data provided by a Predictive Policing program can significantly reduce the workload of police officers and enable shift managers to reallocate resources based on current need. However, the ability to direct those resources is limited by the autonomous and responsive nature of the police officer role. Deployment of police resources is unlike that of military resources to an extent that developers of Predictive Policing sometimes overlook.

In terms of crime prevention, it is important to examine the response to increased risk and to consider whether it adequately addresses one or more causes of crime. Unfortunately, the standard approach to risk appears to be the allocation of police resources to the area. The cost-effectiveness of police patrolling in preventing burglary is a matter of debate. For example, potential offenders may change their *modus operandi* and / or seek opportunities in locations not being patrolled (Summers and Rossmo, 2018).

It remains uncertain whether preventative, multi-agency approaches are being adopted in response to Predictive Policing, such as better security for at-risk dwellings, greater surveillance by Neighbourhood Watch schemes or development of partnerships with relevant stakeholders (e.g. housing associations, residents' associations, etc.).

The fundamental problem with Predictive Policing lies in proving its effectiveness and return on investment — a link between measures implemented and declining crime rates (burglary, etc.). The

LKA suggests that Predictive Policing should come with an iterative evaluation process analysing the effects — if possible — and constantly improving the program based on these evaluations. DSP recommends drawing on current good practice for evaluating the impact of interventions, used by organisations such as the World Bank (NoNIE Guidance on Impact Evaluation).

To be successful, Predictive Policing should be clearly explained to the media and to citizens, and associated expectations and concerns addressed. Predictive Policing raises ethical concerns, which is impacting its implementation in both the UK and US. The selection of data and also the methods and values underpinning the analysis raise important human rights issues (Gstrein, 2016). These issues are discussed in the CCI deliverable on ethics, legal and social issues related to the CCI Predictive Policing Toolkit. If these significant issues are able to be addressed, however, Predictive Policing may support positive outcomes. Predictive Policing could actually lead to better informed decision-making processes and potentially, if the method has been properly tested and data selection and analysis continue to be improved, less biased and 'standardised' decisions. This may be an improvement on the 'hidden' bias in a human — that can also be a 'black box'.

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