

## **PREDICTIVE ANALYTICS:** A Critical Tool Supporting Evidence-based Decision Making



#### **IJIS Institute**

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**Advisory Committee** 

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#### ABSTRACT

Within justice and public safety, the adoption of business intelligence, as well as data analytics technology and techniques, is advancing rapidly. This white paper introduces predictive analytics, one of the newer developments in data analysis, and its application in several justice and public safety areas.

Predictive analytics is playing a key role in improving the ability to anticipate events in order to be proactive in many areas today, such as weather forecasting, supply chain logistics, and consumer marketing, and is now being adapted for use by justice and public safety agencies. With so many agencies facing budget pressures and reductions in personnel, the potential for this technology to help justice professionals work smarter and more effectively is gaining interest rapidly.

The purpose of this white paper is to clarify the meaning and intent of predicting future activity in the justice and public safety domain, provide insight into what predictive analytics can deliver, and highlight examples of predictive technologies being used in this environment today.

Specific attention will be paid to a relatively new approach to manpower deployment in law enforcement referred to as *predictive policing*, and how predictive analytics technology is supporting these programs in several cities today.

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#### INTRODUCTION

One goal of our criminal justice system is to reduce crime, which requires planning and corrective actions to prevent criminal behavior. The goal of information gathering activities is to uncover potential threats in time to take action to prevent them. But the patterns that point to these behaviors and threats are often hidden in massive amounts of data. To meet this challenge, one form of information analysis – predictive analytics – is particularly useful. Predictive analytics solutions apply sophisticated statistical, data exploration, and machine-learning techniques to available information that has value in predicting threats, behaviors, and outcomes resides not only in huge files of structured data, but also in vast amounts of textual or unstructured data – including narratives, email, and web-based content such as blogs and social media – that agencies must evaluate. By using predictive analytics, agencies can anticipate what types of intervention will be needed and where, enabling them to plan rather than react and make the best use of available resources.

In contrast to more traditional, rules-based analysis and detection methods, predictive analytics can identify relatively unusual behaviors, even those with subtle differences that other methods often miss. Predictive analytics techniques explore and learn from all dimensions of data, thus allowing analysts to combine human knowledge, first-hand experience, and intuition to guide the application of analytical techniques. Because predictive analytics allow for the combination of a wide variety of data dimensions, types, and sources on an ongoing basis, it is possible to quickly and reliably detect inadvertent signatures, or subtle characteristics, of hackers, criminals, or even terrorists.

Predictive analytics is being used today in several justice and public safety domains:

- In corrections and parole/probation, predictive models have been developed to more accurately predict behaviors and intervention outcomes, resulting in more effective rehabilitation and reentry with measurable reductions in recidivism.
- Several law enforcement agencies have employed predictive analysis to more effectively deploy resources in areas where, and at times when, crime is most likely to occur.

There are many other candidates for the application of predictive analytics, such as aiding in border security and immigration, preempting insider threats, or identifying fraud and money laundering, where so much of the pertinent information is hidden in substantial amounts of external data. Additionally, in the bio surveillance arena, predictive analytics may be valuable in looking at public health preparedness and response, whether it be for naturally-occurring events (disease outbreaks) or due to acts of terrorism.

#### WHY PREDICTIVE NOW?

Making predictions about potential criminal activity or program outcomes to determine an appropriate proactive or preventive action is nothing new, so why has the term *predictive* become so prevalent in public safety recently? It is due, in part, to the emergence of new technologies that improve predictions by combining the knowledge and intuition of experienced practitioners with today's processing power enabling the ingestion and analysis of huge amounts of data from widely disparate sources.

"With almost four million records on file, it simply wouldn't be feasible to trawl through this data manually in an attempt to identify those factors that may mean a prisoner is likely to reoffend," said a spokesperson for the United Kingdom's Ministry of Justice, also noting that, "predictive analytics technology provides us with valuable insight into offender data which helps us to predict who may reoffend and enables us to advise on preventative measures, such as appropriate programs addressing offender behavior before a prisoner's release date." This includes analyzing and modeling data on individual offender circumstances such as accommodation, education, relationships, financial management and income, lifestyle and associates, drug and alcohol misuse, emotional well-being, behavior, and attitudes.

IT systems would have struggled to ingest this amount of data for real-time analysis just a few years ago, but today the latest in predictive analytics technology can also extract meaningful data, such as external enabling factors and trigger events, from unstructured information sources such as case narratives, news feeds, and social media.

How far out into the future can/should you predict? That depends on the scope of the program and the models built to support it. If an organization is conducting long-term planning for facility needs, hiring programs, or the like, predictions can be made looking at annual trending and known events years in advance. On the opposite end of the spectrum, there are police departments that have developed predictive modeling programs which enable personnel deployment decisions framed by time windows of a few hours and locations to within a few city blocks. In between these strategic and tactical applications, agencies have developed predictive indicators to support weekly and monthly resource planning decisions, which can be used to support flexibility in geographic coverage and other staffing and skill requirements.

# PREDICTIVE POLICING AND LAW ENFORCEMENT APPLICATIONS OF PREDICTIVE ANALYTICS

Police departments have made great strides in recent years in adopting business intelligence and analytics technology in support of intelligence-led policing. Now, many agencies are looking at predictive policing programs to further enhance their effectiveness in reducing crime while facing the budget constraints that have curtailed the hiring of new officers, or, in some cases, reduced the size of the patrol force.

It usually takes years for police officers to gain a deep understanding of a city's crime patterns or even crime patterns in the patrol areas for which they are responsible. But the adoption of

predictive analytics software compliments experienced officers' knowledge and allows rookie officers to wield veteran-like knowledge.

Perhaps the earliest experiment in predictive policing using predictive analytics software was conducted in 2005. The Richmond (Virginia) Police Department developed a program using predictive analytics to support patrol resource deployment decisions in small time intervals, and put it to the test during a time that historically saw a spike in crime: New Year's Eve. By plugging historical crime data into the software, this department generated forecasts that pinpointed where officers should be most strategically positioned to prevent crime. The test was a success, as evidenced by the big drop in crime that night: the number of weapons seized increased 246% and random gunfire incidents decreased 49%. And because the department was able to more efficiently deploy its resources, it saved \$15,000 in overtime costs.

Richmond Police Department deployed predictive analytics in other areas of the department as well. By analyzing police dispatch data, the software helped the department build effective, long-term deployment plans for specialized tactical units. For example, predictive analysis helped one unit identify certain types of property crimes that were likely to escalate into aggravated assault – and then developed predictive policing strategies in response. The unit also developed predictive modeling tools to expedite ongoing investigations, many of which were time-sensitive and required quick action to capture suspects.



FIGURE 1: PREDICTIVE MODELING MAP DEPICTING POTENTIAL CRIME HOT SPOTS.

Another early adopter of predictive analytics technology is the Memphis (Tennessee) Police Department (MPD). Memphis' program, dubbed Blue CRUSH (Criminal Reduction Utilizing Statistical History), is about gaining advantage through insight and agility. At the heart of it is an analytics model that incorporates fresh crime data from sources that range from the MPD's records management system to video cameras monitoring events on the street. In the realm of crime-fighting analytics, there's a fine line between the *interesting* and the *actionable*. It is strength in the latter that makes Blue CRUSH stand out from other initiatives. Blue CRUSH lays bare underlying crime trends in a way that promotes an effective, fast response, as well as a deeper understanding of the longer-term factors (like abandoned housing) that affect crime trends.

At the precinct level, looking at multilayer maps that show crime hot spots, commanders can see not only current activity levels, but also any shifts in such activities that may have resulted from previous changes in policing deployment and tactics. At each weekly meeting, commanders go over these results with their officers to judge what worked, what didn't, and how to adjust tactics in the coming week. They might see, for example, how burglaries are down in one ward, but up another, or that thieves are stealing cars in one ward and dumping them in another. What's striking, says Larry Godwin, former MPD director of police services, is the granularity. "We're catching this immediately and we're doing it every day," he explains. "On short notice, we're able to shift officers to a particular ward, on a particular day, right down to the shift level. It's a bit like a chess match and it's enabling us to make arrests we never could have before."

Both of these cities have seen marked improvement in operational efficiency and a corresponding drop in violent crime through the development of predictive policing programs supported by predictive analytics technology. Also important in the current, fiscally-restrained environment is that the jurisdictions accomplished these results without a corresponding increase in patrol headcount. Yet another similarity is that both agencies achieved their success through partnering with academia to collaborate on predictive models. Dr. Richard Janikowski, a professor of criminology at the University of Memphis, worked with the Memphis Police Department to put into practice the simple yet powerful principle that, "if you focus police resources intelligently by putting them in the right place, on the right day, at the right time—good things are going to happen. You'll either deter criminal activity or you're going to catch people." Janikowski, who is director of the University's Center for Community Criminology and Research, went on to say, "the 30 percent reduction in crime the MPD was able to achieve through intelligent policing is not just a number. There are thousands of people who did not experience crimes, who didn't have a gun put in their face, or have their homes burglarized. That makes a big difference in people's lives."

More recent examples of predictive analytics aiding predictive policing strategies in cities such as Los Angeles and Santa Cruz, California, have provided operational examples of officers in the right place, at the right time, informed for improved situational awareness.

The Santa Cruz and Los Angeles programs were also developed through partnerships with academic institutions – Santa Clara University and UCLA respectively. Rather than using commercial off the shelf (COTS) predictive modeling software, the unique approach Santa Cruz used was to adapt a prediction model built to forecast the location and timing of earthquake aftershocks. This adaptation of an existing prediction capability for seismic activity to predict property crime was based on research that showed these activities had similar patterns of predictability, and there has been early success reported.

#### Predictive Analytics



FIGURE 2: A GRAPHICAL DEPICTION OF PROACTIVE FORCE DEPLOYMENT USING PREDICTIVE ANALYTICS. PREDICTIVE ANALYTICS IS SHOWN HERE AS BOTH A PLANNING AND TACTICAL LAW ENFORCEMENT TOOL.

#### SPREADING THE WORD ABOUT PREDICTIVE POLICING

In recent years, gatherings have begun related to predictive analytics in law enforcement, including 2009's Predictive Policing Symposium in Los Angeles, California. At this symposium, John Morgan, Ph.D. (formerly of the National Institute of Justice), presented a working definition of predictive policing: "Predictive policing refers to any policing strategy or tactic that develops and uses information and advanced analysis to inform forward-thinking crime prevention."

While concise, this definition doesn't expand much beyond current thinking in effective policing strategies. In defining *predictive policing*, one of the most interesting and compelling applications for predictive analytics, it's important to differentiate the concept from a close relative to which it is often compared: hot spot or adaptive policing. Hot spot/adaptive policing typically uses crime data alone, mapped and timed for effective patrol deployment, but usually does not incorporate large, disparate dataset analysis and statistical modeling using external enabling factors and trigger events. Adaptive policing is, by definition, reactive to already identified crime patterns or trends already in play, whereas predictive policing incorporates forward-looking, proactive plans intended to prevent rather than react.

The capabilities made possible by COTS predictive analytics technology expand the possibilities of hot spot policing since it enables the ingestion of significantly more data from widely diverse sources, identifying patterns and making predictions that would most likely be undetectable using traditional methods. Predictive modeling software also enables risk assessment and the scoring of event likelihood in order to evaluate strategies in resource deployment and the potential for successful outcomes.

During the Predictive Policing Symposium, participants discussed many potential uses for predictive analytics. The list<sup>1</sup> contained over 40 possible uses within law enforcement alone. Here is a select subset of the list, in no particular order:

- \* Time and location of future incidence in a crime pattern or series
- ✤ Identification of individuals who are likely to reoffend
- Drug market displacement (i.e., where next open air drug market will pop up)
- Disorder and environmental variables
- Likely impact of specific operations
- Patrol staffing and resources allocation
- Early identifications of career criminals
- Identification and analysis of crime-prone events and locations
- Travel of serial offenders
- Predicting acts of terror
- Precursors and leading indicators to crime (including non-obvious predictors)
- Design of spaces, economic development, police/security resource allocation, infrastructure protection
- Risk for excessive use-of-force, discipline

<sup>&</sup>lt;sup>1</sup> <u>http://nij.gov/topics/law-enforcement/strategies/predictive-policing/symposium/pages/technical-breakout.aspx#usevalue</u>

Several of the use cases suggested in this list have already been evaluated with early success in limited scope tests of predictive analytics. In one southwestern U.S. police department, COTS predictive modeling software was used to ingest and correlate vast and disparate historical crime and incident data along with many years of weather data, city events, and other calendar and location data, paydays, and more. The model revealed non-obvious correlations between these events and identified potential enabling events and trigger factors that would be useful in predicting, or preventing, criminal activity. This model was then tested against itself to gauge its accuracy and was determined to be 75% accurate in predicting when and where specific crime types were likely to happen down to a patrol area and shift. Equally interesting was the success of this program in predicting where crime was not likely to happen to a 90% accuracy rate, which can be just as useful in deciding where scarce resources may not be needed.

A comprehensive predictive policing approach should combine multiple disparate data sources, predictive modeling, text analytics, visualization and reporting. This can result in improved execution efficiency, prevention, enforcement, investigations, resource planning, intelligence gathering, and case management.

Predictive Analytics



FIGURE 3: A VISUAL DEPICTION OF SEVERAL PREDICTIVE ANALYTIC USE CASES.

As depicted in the examples above, predictive analytics can build pattern-based models based on historical data from a variety of sources in order to reveal under what conditions a new event will result in a certain outcome. This allows the user to ask questions such as, "when these conditions are present again, what should we expect? If these are the characteristics of a new event (crime, etc.) then what is the likelihood that this event will have the same outcome?"

Such are the applications of predictive analytics that can not only improve the effectiveness of an agency's limited resources, but has the potential to reduce costs through improved efficiency as well.

#### RECOMMENDATIONS

In evaluating the potential for predictive analytics, consider the following:

- Does your agency have the capacity to dedicate resources for developing and maintaining an analytics-driven approach to public safety? Developing predictive models and deploying them to solve problems and deliver results requires training and a commitment to maintaining the focus on the initiative. Models are not static and continue to learn and deliver increasingly accurate predictions when more data is brought into them. The focus as well as the creativity of the analyst will play a role in the success of any predictive analytics-driven initiative.
- For agencies with limited resources, an analytics service approach may be adequate. Predictive analytics deployed in a cloud delivery model is available and may provide value with minimal staff resources. However, flexibility to determine data source inputs, test new models and algorithms, identify the *why* behind the *what, when and where* may be limited with a third-party service approach.
- When conducting an evaluation of predictive analytics software, consider the ability to extract data from a multitude of valuable sources. The most accurate and relevant predictions will result when a variety of information sources can be brought to bear. This includes unstructured text such as case narratives, documents, news feeds, and social media sites.
- When personal information is central to the predictive analysis use case, such as for investigations and crime solving or reducing likelihood of recidivism, resolving data from the various data sources into accurate identities is critical to the accuracy of the results. Consider predictive analytics software that accelerates the accuracy by which identity information is ingested in order to reduce duplicates and increase the accuracy of understanding the person.
- Agencies must make a concerted effort to socialize and direct adoption of methodologies and technologies such as predictive analytics in order to increase the probability of success.

#### CONCLUSION

There are simply so many potential opportunities that it makes sense to continue to push for broader adoption of predictive analytics in law enforcement and across all areas of criminal justice and public safety.

Of course, these efforts often come with a cost and with the economic conditions found throughout the U.S. and the impact it has had on federal, state, local, and tribal funding, acquiring and justifying funds for this purpose are challenging. That said, there are often ways to accomplish important tasks with some creativity. As we have learned, there are partnerships to be had with academia and other private sector entities and while some examples have been included within this document, they are but a few of the deployments that exist nationally. Many companies provide these capabilities and provide varied and innovative technologies and solutions that can support solving agency business challenges. Local law enforcement need not be left out of the conversation due to limited access to funds when it can find partnerships with universities and colleges with criminology research interests that have their own IT. Often, such organizations like the idea of partnering with the community in this way. It can be a win-win for a law enforcement agency and a university providing a needed service to the community while faculty and students get real world proofs of concept for research and an opening of doors to an even wider array of potential funding streams.

Then, there is the messaging aspect of predictive policing efforts. It is important that practitioners/operators and policy makers alike have an understanding of the power of predictive efforts in law enforcement, the successes already achieved, and the opportunities that lie ahead. This paper is one of the early steps in the process.

#### FOR FURTHER INFORMATION

 National Institute of Justice Predictive Policing Information -<u>http://www.nij.gov/topics/law-enforcement/strategies/predictive-policing/Pages/welcome.aspx</u>

#### ABOUT THE IJIS INSTITUTE

The IJIS Institute unites the private and public sectors to improve mission-critical information sharing and safeguarding for those who protect and serve our communities. The IJIS Institute provides training, technical assistance, national scope issue

management, and program management services to help government fully realize the power of information sharing.

Founded in 2001 as a 501(c)(3) nonprofit corporation with national headquarters on The George Washington University Virginia Science and Technology Campus in Ashburn, Virginia, the IJIS Institute has grown to nearly 400 member companies and individual associates from government, nonprofit, and educational institutions from across the United States.



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The IJIS Institute's Emerging Technologies Advisory Committee addresses new and emerging technologies in the justice and public safety domains. The Emerging Technologies Advisory Committee develops advisory materials and conducts briefings for industry and government on these key emerging technologies in support of national programs and increased adoption. The committee is corporation agnostic and strives to provide an industry view of these emerging technologies to help the practitioner community make more informed decisions.