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Executive Technology Brief

Research: Applying It On the Front Lines

By Lois Pilant

Technology is one of the most important issues facing law enforcement today. How does an officer stop a fleeing felon if the city has prohibited pursuits? What are the alternatives to the use of deadly force? Is there a way the interminable wait for DNA test results can be reduced?

Ironically, as science goes galloping off into the future, law enforcement is often left in the dust. It's not that the technology isn't there. It is. It just hasn't been applied to law enforcement yet.

Money is the primary reason. Research and development is probably the most expensive work a government or private industry can undertake. It also is the riskiest and most time-consuming. Millions of dollars and years of effort can easily be invested in a product that might never make it out of the lab.

That's why law enforcement has depended on other sources, like the military, to supply technology that can be adapted to fit police needs. Did law enforcement invent the 37mm grenade launcher? Obviously not. But they certainly use it. Has law enforcement come up with gas and vapor bomblets that can clog the intake or melt the engine of a fleeing vehicle? No, but if they ever hit the market, the police probably will be the first to try them out.

Private industry has also offered its share of modern technology for law enforcement application. When the DuPont company began talking about a revolutionary

This is one in a series of reports designed to familiarize police executives with the technological advancements and resources available through the National Institute of Justice.

Points of view expressed in this publication are those of the authors and do not necessarily represent the official position or policies of the U.S. Department of Justice or of the International Association of Chiefs of Police.

The Assistant Attorney General, Office of Justice Programs, coordinates the activities of the following program offices and bureaus: National Institute of Justice, Bureau of Justice Statistics, Bureau of Justice Assistance, Office of Juvenile Justice and Delinquency Prevention and Office for Victims of Crime.

The International Association of Chiefs of Police, headquartered in Alexandria, Virginia, is the world's leading association of police executives. With more than 12,500 members from 73 nations, the IACP is committed to the betterment of the law enforcement profession.

SCIENCE AND TECHNOLOGY

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new product called Kevlar, it was a scientist at the National Institute of Justice (NIJ) who listened. The scientist reasoned that if this state-of-the-art fabric was as strong as steel and as light as nylon, then could it possibly protect police officers from gunfire? Five years later, 5,000 concealable ballistic vests were purchased by NIJ and given to police departments around the country. Soft body armor has been so successful at saving lives that today, wearing a vest is commonplace in most departments.

The NIJ, charged with the support of local and state law enforcement agencies, has in its 21-year history undertaken many projects that have led police into the use of new technology. NIJ is one of the smallest of the federal agencies, with a budget that, when compared to that of the behemoth Department of Defense, for example, seems minuscule. Still, it has tackled areas of research that no other agency or private company in the United States has touched.

Working with the NIJ, the Michigan State Police currently conducts annual tests on police vehicles. The report generated as a result of those tests is a primary determinant of the type of vehicle purchased by agencies throughout the country. The same is true for its testing of metal handcuffs, rifles and radios. Not only has the agency set the standard for scientific research in law enforcement, it has set product standards and guidelines that are part of procurement policies, as well as manufacturing criteria of products used in every area of the criminal justice profession.

Policing has evolved over the years, moving from a narrow definition of crime fighting, with a limited focus on community problems or the causes of crime, to a broader characterization that has the profession openly addressing societal issues and enlisting citizen help in solving crimes. The NIJ's response to such changes has been to move with the times. Offices were created that conduct field experimentation to find out if such concepts as sentencing guidelines and jury management really work. Another division routinely shows agencies how to turn research and policy into action.

But perhaps no area of the NIJ has received as much national attention or sparked as much enthusiasm among criminal justice practitioners as its technology initiatives that have recently been consolidated in the Science and Technology Division. This division administers grants that will ultimately put state-of-the-art technology into the hands of law enforcement.

Let's take a look at some of the areas in which NIJ has been involved.

DNA

The forensic science of DNA (deoxyribonucleic acid) testing is an outgrowth of its medical application, where it is used to analyze disease-causing genes, study inheritance patterns and detect alterations or changes. In the early days, DNA typing primarily was used for paternity testing, but by the late 1980s it was being used to convict defendants in criminal cases. Since then it has undergone more scrutiny than any other forensic science.

The reasons DNA typing has been subjected to such intense examination are numerous, not the least of which is that as evidence it can be extremely effective. With an incredible degree of accuracy, it can exclude or include a suspect and, therefore, ruin the case of the prosecution or the defense. It is also more damning because it is easily and readily extracted from blood and semen, common types of evidence found at crime scenes.

Because of its remarkable accuracy, admissibility has been challenged on such grounds as the lack of standards in testing protocol and computing match probabilities, as well as the validity of the science itself. To address those issues, the NIJ funded the National Institute of Standards and Technology (NIST) to develop standard nomenclature and performance standards for implementing DNA typing in crime labs. One of NIST's most recent advances was the development of a set of known DNA samples taken from human cells grown in the laboratory. This profile can be included in each DNA analysis to act as a control against procedural errors.

The NIJ, along with the FBI and other agencies, also funded a National Academy of Sciences study to establish the validity of DNA typing. In its recently released report, "DNA Technology in Forensic Science," the National Research Council strongly supported the validity of DNA testing. While the council suggested changes in certain areas, in general, it approved DNA typing as a legitimate tool for use in criminal and civil cases.

After years of challenges at all levels of the legal system, DNA profiling has come to be seen as an accepted part of the criminal justice system. There are, however, continuing concerns and controversies. One of the most recent is the question of whether there are differences in subpopulations. Is the DNA profile of a caucasian different from that of a black, Asian or Hispanic? Should data bases be established for each subpopulation, or could a DNA profile be subjected to a general data base when computing probability matches?

Some experts believe there are significant differences among subpopulations. Others say they haven't seen any valid evidence or scientific research to support such an assertion. Although studies are underway, the National Academy of Science has recommended that scientists proceed as if differences among subpopulations are not theory but fact, just to be on the safe side. The academy also recommended using a ceiling when computing probabilities. Regardless of the actual empirical distribution in a DNA profile, a probability of no less than one in 10 should be used.

One of the most exciting developments in DNA typing has been the discovery of a new technology that, based on preliminary research, will reduce the testing profile time by as much as 90 percent. Currently, the industry uses a complex process known as the "southern blot," or RFLP, a technology that involves cutting the DNA into pieces and separating the fragments with an electrical field. The fragments are labelled with a radioactive probe and ultimately compared to samples from the suspect. Not only is RFLP expensive and time-consuming, it demands highly trained personnel and must be performed sequentially at every location that is chosen for analysis. Although paternity testing generally

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uses only one location on the DNA chain, criminal cases typically use four or five.

A technique introduced in the last few years is the polymerase chain reaction (PCR). It is considerably less expensive, does not demand as highly trained personnel and can be performed simultaneously on several locations on the DNA chain. Because PCR allows millions of copies to be made, technicians no longer have to risk using all the evidence. Amplification, or copying, can use very small amounts; in some cases, if necessary, DNA can be taken from a single nucleated cell.

PCR does have at least one shortcoming—cleanliness in the lab is vital. Research and medical labs already have controls in place that alleviate the problem of errant, airborne particulate landing on and contaminating specimens. Crime labs, however, may have to make a substantial investment in similar controls.

PCR currently is used by a small number of labs and has been used in several court cases, but has not yet satisfied the reliability, accuracy, validity and acceptance tests to which RFLP was subjected. Although the FBI lab, most state and local crime labs, as well as commercial ones, still use RFLP and probably will for the next few years, it is expected that PCR eventually will supplant it.

NIJ has funded the Baylor College of Medicine in Houston to develop short tandem repeat (STR) segments that can be used in a rapid analysis of DNA in PCR, while the University of Texas Health Science Center, also in Houston, is studying improved methods for comparing DNA profiles from separate evidence sources and computing match probabilities. The NIST, in a program funded by the NIJ that set standards for numerous aspects of RFLP, is now looking at standards in the area of processes, procedures and materials for PCR.

The NIJ, interested in more than developing new technology, has expanded the possibilities in DNA analysis by funding research at the University of New Haven to study methods to extract DNA from the blood of skeletal remains. The agency also has continued to work with George Sensabaugh, one of the NIJ's original DNA grantees and a person hailed as one of the preeminent pioneers of DNA profiling. Sensabaugh, working at the University of California at Berkeley, currently is researching improved methods of obtaining DNA specimens, particularly those from unusual or difficult evidence sources.

Forensics

The forensic sciences, while a vital component of law enforcement investigations, are not an old, established discipline. Popularized in the late 1800s by Arthur Conan Doyle's Sherlock Holmes stories, forensics has nevertheless taken its place as one of the most respected of police functions.

It is in this area, more so, perhaps, than any other, that science has focused its energies. New techniques, methods and technologies developed specifically for forensics are coming on line daily.

The NIJ's Science and Technology Division has been at the forefront of many of these new developments by administering grants that have not only put state-of-the-art technology into the hands of crime lab technicians, but helped increase the profession's credibility.

In the area of fingerprinting the NIJ is supporting the development of methods to condense the cyanoacrylate fuming, or "crazy glue," into a single-step process that will include a portable dye staining procedure. Such a tool will allow investigators to stain large areas at a crime scene, instead of cutting out pieces of objects and carting them to the crime lab for processing in a microwave oven. The process, developed by Alaska's Department of Public Safety, also will allow technicians to develop latent prints that might be destroyed by traditional methods or by lasers.

The NIJ also is funding research to find affordable, efficient and versatile reagents for use on latent fingerprints. A scientist at Texas Tech has been developing methods for reducing the background fluorescence that occurs when a laser is used on surfaces, with the result being that the print could be photographed. At the University of Pennsylvania, another study is focusing on developing new analog reagents and putting the results of these tests in a handbook to explain their use. These products will be a boon to departments that cannot afford expensive lasers.

Photography is one of the best ways a jury can get an accurate picture of evidence linking a suspect to a crime scene. But in many cases the photographs are blurred or out of focus. To tackle the task of photographic enhancement, the NIJ funded the University of Rochester to develop Restoretool, a product that digitizes a photograph and allows the technician to minutely correct grainy, blurred or poorly contrasted images by use of a computer program.

Another NIJ grant funded a project with Louisiana State University to develop photographic techniques to help investigators produce pictures of weapon indentations or injuries on human skin. Developed for use in child abuse cases, this form of photography uses a narrow band light source and can reproduce patterns on film that the human eye cannot see.

Toxicological specialists at the University of Washington, spurred by incidents of cyanide poisoning in over-the-counter medications, are studying ways to quickly detect two poisons, carbon monoxide and cyanide, in forensic specimens and in food and drugs. This technology also can be used in autopsies of people who died in suspicious fires or by carbon monoxide poisoning.

Those who work in the area of questioned documents have an array of techniques to determine the origin, date, fiber composition, trace elements, chemical elements, waxes, dyes and fillers of various types of papers. What has never been an exact science, however, is that of dating inks. One researcher at the University of Illinois at Chicago is studying the use of Supercritical Fluid Extraction, Gas Chromatography-Mass Spectrometry (GCMS), Fourier Transfer Infrared Spectrometry and High Pressure Liquid Chromatography (HPLC) to determine the molecular changes in ink over time.

Another technique that uses HPLC was developed by NIST and NIJ and is a fast, inexpensive way to tell if a suspect has fired a weapon. Micellar Electrokinetic Capillary Electrophoresis (MECE) has technicians using masking tape to lift gunshot residue from a suspect's hand. Those particles are dissolved in ethanol and, using HPLC, forced through a thin glass tube by an electrical field. NIJ has funded John Jay College to investigate methods using high-speed photographic equipment and fluorescence to identify patterns of gunshot residue on suspects and at the scene of a crime. The combination of MECE and high-speed photography will produce a gunshot residue map and a gunshot residue pattern.

Great strides have been made in the area of computer programs and forensics software. One that will be of tremendous benefit to law enforcement is a sourcebook of firearms information in the form of computer hypertext. This program lists almost every firearm, cartridge and bullet ever made, can be searched through a variety of categories and will show technicians and investigators how to prepare their information for court. One of the drawbacks of the program is that limited memory capacity has restricted the number of pictures that accompany weapon summaries. For this reason, the authors are studying the possibility of going to a CD-ROM format. A second NIJ grant has funded the development of three more computer sourcebooks on serology, fingerprints and trace evidence.

One of the greatest criticisms of crime labs in recent years has been the fact that lab personnel are not certified. In some states, evidence has been impeached and verdicts overturned because crime labs lack testing and equipment standards and their personnel are not licensed. In the past, there was no licensing or certifying agency, or any structure or organization set up to test personnel. The NIJ recently provided the seed money to the American Board of Criminalistics, a new organization with strong support from the American Academy of Forensic Sciences, to develop a national certification program for crime lab technicians. Testing will cover forensic biology—including DNA—drug identification, fire debris analysis and trace evidence.

Less-Than-Lethal Devices or Tools

Perhaps the most exciting development funded by the NIJ has been the search for alternatives to deadly force. Commonly known as less-than-lethal (LTL) tools, these technologies were not necessarily intended for law enforcement's purpose. They come from the military and private industry, and include everything from the high tech, like devices that protect strategic defense systems, to the mundane, like range finders in cameras.

Before choosing which technologies to study, the NIJ hosted user workshops to get input from military, law enforcement, corrections and academic sources. Scientists then sifted through hundreds of possibilities—law enforcement's wish

list. Some were outlandish, little more than a hopeful gleam in someone's eye. But others were legitimate ideas using technology that had the makings of safe and viable less-than-lethal tools.

The NIJ, working in conjunction with scientists at Department of Energy (DOE) labs around the country, currently is studying the feasibility of several of these possibilities. Although some are still at the pipe-dream level, others are further along in development.

Foam restraining systems, for example, are used as a part of the protective hierarchy of security that surrounds defense weapons systems. In one application, a rapid-drying, non-toxic foam is sprayed on a person to completely and immediately stop his movements. It also can be used to block access to certain areas—like the bathroom—during drug raids. A second type of foam acts like contact cement, in that the person sticks to whatever he touches. Initial field tests of both systems will be done by the American Correctional Association (ACA) in the Florida Department of Corrections, and by the National Sheriffs Association (NSA) in member jails.

Bright white and pulsed light also are LTL possibilities that need little modification to fit law enforcement needs. Scientists are studying two uses of brilliant white light: to distract and disorient a person or a group, authorities would unexpectedly shine a continuous light so bright the subject could not see behind it; or use a single flash of light that would cause temporary blindness.

Pulsed light would come in the form of lasers that would be alternately and rapidly focused on a violent suspect. Because the eye has a different focal point for different colors and cannot move quickly between those points, pulsed light can disorient as successfully as a continuous source of brilliant white light. The ACA and the NSA also will be conducting field evaluations on light systems.

Using technology from a variety of sources, the NIJ is addressing law enforcement and corrections needs during civil disturbances, riots and violent demonstrations. Impact projectiles—rubber bullets, wooden balls, plastic darts, bean bags—fired from a grenade launcher are typically used to quell such disturbances, particularly in prison systems. One of the problems is that if authorities are too close to the crowd, a projectile could be fatal. If they are too far away, the projectile is useless. Distance is normally determined by the officer firing the weapon. To alleviate the possibility of human error, the NIJ is studying the use of velocity range finders that would automatically focus on a target, calculate the range and adjust the velocity of the launcher. Such a tool would eliminate the risk of injury and ensure its effectiveness.

One of the concerns frequently expressed by police during NIJ's preliminary user workshops was a need to keep suspects from abusing officers while being transported in the back of a patrol car. The most likely solution was to use airbags like those used in passenger cars. Ideally, an officer would flip a switch and incapacitate the suspect by inflating the airbag. Researchers currently are looking for the most economical and feasible solution. Cost to reset an automobile airbag runs about $2,000 and must be done by the manufacturer or an authorized dealer. Police need something cheaper and simpler, something that is reliable and that the officer can simply stuff back into a canister for reuse.

Another concern expressed by police was that of officer and citizen safety during high-speed vehicle pursuits—several cities have banned the practice following serious or fatal accidents. The most popular solution was to find a way to stop fleeing vehicles remotely and safely. Military and private industry have a number of technologies that are currently being studied by NIJ and DOE scientists and researchers. One solution involves exploding bomblets in front of a fleeing vehicle. One type would release a gas that would inhibit combustion and cause the car to shut down. Another would contain acetylene to enhance combustion and cause an engine meltdown. Yet another bomblet might be filled with tiny styrofoam particles that could clog the engine intakes.

But there are other possibilities: Fogs that coat the windshield and inhibit driver visibility; microwave systems that impair vehicle electronics; and electromagnetics to fool a vehicle computer into shutting down the engine. Scientists currently are looking at the various technologies with several criteria in mind. The optimal solution must be safe, reliable, portable, reasonably priced and deployable by any trained officer.

In the last few years, a great deal of research has gone into what many believed would be the perfect less-than-lethal device—a chemical incapacitant. Criteria for such a tool was that it had to have a rapid onset and the ability to be administered remotely and easily (in a dart, for example). And because even the most lethal of weapons, a firearm, at times does not stop an assailant, a chemical incapacitant had to perform when the handgun could not or was inappropriate.

The drug that held the most promise was alfentenil, a potent synthetic narcotic most often used in hospitals as an anesthetic. The drawback was that while alfentenil successfully depressed the central nervous system, it also depressed respiration. Scientists currently are studying administering an antidote at the same time the alfentenil is injected. Such an antidote would not affect the action of the drug, but would inhibit its action on respiration. Scientists also are studying dose safety margins, which ensure that the dose administered is as safe and effective for a child as it is for an adult.

In related research is an effort to find a delivery system for administering a chemical incapacitant. One idea currently being studied is to redesign the police baton so that it doubles as a chemical dart delivery system. While some say it would reduce the baton's power, others maintain that it will add to the arsenal of police tools without adding more paraphernalia to carry on the duty belt.

While scientists study the less-than-lethal possibilities with the primary focus on borrowing military technology, they also are looking at LTL devices manufactured by private industry. Liability and operational issues are under study, as are the various scenarios in which these weapons would be used.

Although it may be several years before any advanced type of LTL tool is developed, NIJ scientists hope that one

of the first benefits of their research will be the start of a working relationship between science and criminal justice. Police and corrections officials will be encouraged to learn the intricacies of research by visiting area laboratories, while scientists go on "ride-alongs" or participate in police operations to learn the real needs of the criminal justice profession.

Hair Analysis

Hair analysis is the newest in the area of drug detection sciences. And even though it is in its infant stages and years away from use in the workplace, researchers expect that one day it will be one of the most accurate and reliable tools for use as a control mechanism by parole and probation officers.

Scientists currently are involved in three areas of research: analysis procedures, comparing hair analysis to urine testing and determining a user's habits through hair analysis.

The advantages to this type of testing are that it may allow for more precise information about times of ingestion and could show drug use over a longer period of time than urinalysis can. For example, because hair grows about one-half inch per month, researchers hope to determine when a drug was used by calculating its location along the hair shaft.

What research has not determined is how the drug gets into the hair. According to the National Institute on Drug Abuse (NIDA), the institution studying hair analysis, there are four possibilities. Drugs may be captured within the protein matrix of the hair follicle during the metabolic process; they may bind to the pigments that determine hair color; they may enter the hair through glands that secrete sebum, the waxy substance that makes hair oily; or they may penetrate the hair shaft as the body eliminates them through sweating.

The NIJ has worked with NIDA to support research that would answer these questions. And while there are still more areas that need to be explored, researchers hope hair analysis eventually will surpass urinalysis as a drug detection tool in accuracy and in detecting long-term patterns of drug use.

The Future

The NIJ, as a division of the Department of Justice, has been charged with the support of local and state law enforcement. Toward that end, it is funding a variety of research that includes everything from body armor to chemical incapacitants, and is addressing such issues as setting standards for law enforcement equipment to finding new ways to control violent suspects.

By its very nature, research is expensive, risky, time consuming and often frustrating. Regardless of how difficult, meeting the needs of the criminal justice profession continues to be the NIJ's primary goal. As research continues, the institute will keep law enforcement and corrections professionals updated on its effort to get the most technologically advanced equipment into the hands of those who need it most.

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