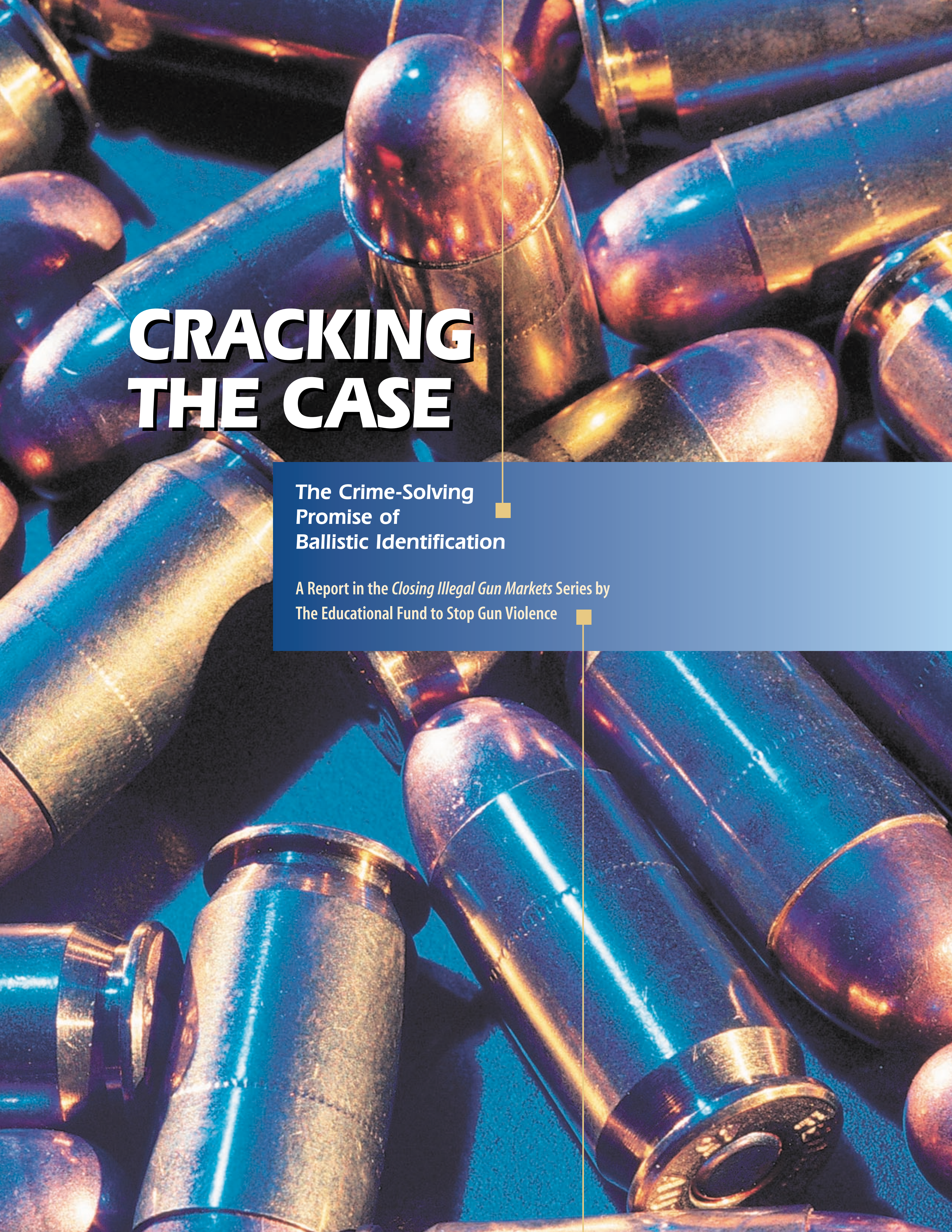

CRACKING THE CASE

The Crime-Solving Promise of Ballistic Identification

A Report in the *Closing Illegal Gun Markets* Series by The Educational Fund to Stop Gun Violence

Our Mission

The Educational Fund to Stop Gun Violence was founded in 1978 as an educational nonprofit dedicated to ending gun violence by fostering effective community and national action.

CRACKING THE CASE

The Crime-Solving Promise of Ballistic Identification

A Message from Joshua Horwitz

Executive Director of The Educational Fund to Stop Gun Violence

Law enforcement has used ballistic identification to solve the toughest of crimes. In 2002, ballistic identification was instrumental in helping Montgomery County Police Chief Charles Moose and a team of investigators track down the Washington DC-area snipers. But forward-thinking policymakers who understand both the current state of the art and the future of ballistic identification technology can make ballistics identification an even more powerful tool for law enforcement.

This report by The Educational Fund to Stop Gun Violence is designed to provide policymakers with the information they need to better arm law enforcement in the war on crime. Based on thoughtful analysis of extensive information from the leading ballistics technology experts, this report will inform policymakers, opinion leaders, advocates and the media about the promise of ballistic identification, now and in the future.

Even as this report goes to press, ballistic identification technology continues to evolve. At the training seminar put on by the Association of Firearm and Tool Mark Examiners in late May 2004, exciting new breakthroughs were announced. A powerful three-dimensional imaging system could be available later this year and improved analytical software will be released in 2005.

Finally, I want to acknowledge the Educational Fund staffers who worked on this study, especially Policy Director Eric Gorovitz for taking the lead in organizing, researching, and writing the report.

This work is dedicated to America's firearm and tool mark examiners, whose single-minded dedication to the pursuit of truth too often goes unrecognized.

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June 2004

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INTRODUCTION

In October 2002, the world watched helplessly as the Washington, D.C., area experienced a sudden rash of gun violence. Seven shootings, six of which were fatal, occurred in just two days in various D.C.-area suburbs. Investigators recovered bullets from some of the shootings and examined them under a microscope. Unique, microscopic markings indicated that the bullets had been fired from the same gun. A sniper was on the loose.

Montgomery County (MD) Police Chief Charles Moose speaks to the press during the October, 2002 sniper shootings.

As police searched for clues to the sniper's identity, terrified residents altered their daily routines, avoiding gas stations, shopping mall parking lots and other public places generally regarded as safe. Charles Moose, then Montgomery County, Md., police chief and leader of the investigation, made numerous public appeals for information, sometimes even speaking directly to the sniper. Responding to information from several eyewitnesses, police throughout the region stopped and searched hundreds of white vans, tying up traffic on the area's major highways. Professional and amateur profilers spun countless theories about the sniper's identity and motives. Yet the shootings continued and the death toll mounted.

By the time police arrested two suspects three weeks after the killing spree, 10 area citizens had been murdered. Three more had been wounded, including a 13-year-old boy shot outside of his school. The sniper investigation occupied the full attention of law enforcement agencies up and down the East Coast and cost taxpayers millions of dollars.

In retrospect, the microscopic markings on the bullets that police recovered early in the investigation provided strong evidence about the killers' identities. Those markings, and similar markings left on cartridge cases that were recovered later, constituted a unique "ballistic fingerprint" of the specific gun the snipers used. If police could have identified the make, model and serial number of the snipers' gun from its ballistic fingerprint, they could have used that information to access the existing crime gun trace system. That, in turn, would have led them directly to the Tacoma, Wash., gun store where the snipers had acquired the Bushmaster XM15 assault rifle they used to murder 10 people in the D.C. region while terrorizing millions more. Unfortunately, because there is no existing, comprehensive system linking ballistic fingerprints to the guns that produced them, the evidence police recovered so quickly could not help them identify the killers.

> ***Comprehensive ballistic identification allows police to trace a gun even before they recover that gun.***

"Ballistic identification" is the science of using a ballistic fingerprint to identify the specific firearm used in a shooting. A comprehensive ballistic identification system would connect a bullet or cartridge case recovered at a crime scene directly to the make, model and serial number of the gun from which that bullet or cartridge case was fired. In effect, comprehensive ballistic identification allows police to trace a gun even before they recover that gun. It is impossible to know whether ballistic identification of the snipers' gun would have stopped the attacks any sooner, but police would have considered it vital information during the investigation.

This Resource Guide explains the science behind ballistic identification, answers the most common questions about the status of the technology, details how federal and state law enforcement deploy the technology, and recommends how to best use current and emerging technologies to help law enforcement solve gun crimes.

The Resource Guide has four sections. Section I provides basic background information about the mechanics and terminology of ballistic identification. Section II describes the early history of ballistic identification and the technology in use today, and responds to some of the most common questions about existing systems. Section III introduces an emerging technology that will greatly enhance the power of ballistic identification. Section IV presents seven recommendations for promoting the ability of law enforcement to use ballistic identification to solve gun crimes.

In addition to this Resource Guide, we have developed a model Ballistic Identification Law suitable for use at any level of government. We have also produced supporting materials that we hope will be helpful to advocates, policymakers, opinion leaders, the media and anyone else interested in ballistic identification. All of these materials are available on our Web site, ***www.efsgv.org.***

Finally, this Resource Guide was made possible by generous support from the Richard & Rhoda Goldman Fund. We also gratefully thank the following individuals and organizations for helping us to understand the history, technology and utility of ballistic identification: Jennifer Budden and Rahm Mahanand at the NIBIN Program at the federal Bureau of Alcohol, Tobacco, Firearms and Explosives; Pete Gagliardi, Cybele Daley and Michael McLean at Forensic Technology, Inc.; Todd Lizotte and Orest Ohar at ID Dynamics (formerly NanoVia, Inc.); Joseph Kopera at the Maryland State Police Crime Laboratory; Detective Mike Bonciemino at the New York Police Department; Doreen Hudson and Bill Moore at the Los Angeles Police Department Criminalistics Laboratory; John Rush at the California Criminalistics Institute of the California Department of Justice; and Lucien Haag of Forensic Science Services, Inc.

Section I
Ballistic Identification Basics

Ballistic 'Identification' or Ballistic 'Fingerprint'?

Every firearm leaves unique, reproducible markings on each bullet and cartridge case it fires. These markings function as a "ballistic fingerprint." Today, ballistic fingerprints are inadvertent but unavoidable byproducts of the way most guns are made. In the near future, however, identifying marks will be intentionally designed into each firearm. "Ballistic identification" is the use of a ballistic fingerprint, whether accidental or intentional, to identify the specific gun that fired a recovered bullet or cartridge case.

Understanding how ballistic identification works requires basic knowledge of what happens inside a gun when a cartridge is fired. That, in turn, requires knowledge of some basic terminology. This section defines essential terms and explains the processes that enable ballistic identification.

Firearm and Ammunition Basics

Ballistic fingerprints result from the interaction between fired ammunition, which has several components, and the interior of the gun, which has many parts. We begin by defining the components of ammunition and the relevant parts of a gun.

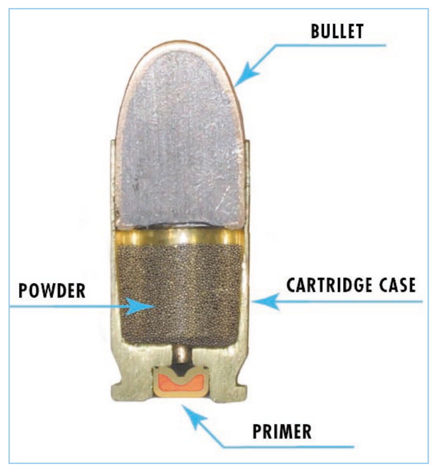


Figure 1-1: *Cutaway of complete cartridge showing the four components of ammunition.*

A **cartridge** or round of ammunition includes four components. The **primer** is a percussion-sensitive chemical mixture embedded in the base of the cartridge. The **powder** is a highly combustible compound that releases a tremendous amount of hot gas when burned. The powder sits inside the cartridge case, separated from the primer by a perforated barrier. The **bullet,** which sits directly over the powder, is the projectile that leaves the gun when the cartridge is fired. The **cartridge case,** usually made of brass, contains the bullet, powder and primer. *(Figure 1-1)*

A cartridge of ammunition fits into the **firing chamber** of a gun. This chamber is typically made of steel strong enough to withstand the extreme forces produced when the cartridge is discharged. The **barrel,** which is slightly smaller in diameter than the bullet and also made of very strong steel, begins at the front of the firing chamber. The barrel of a handgun or rifle contains grooves, called **rifling,** which spiral along the barrel's interior surface. The spaces between the grooves are called **lands.** Shotguns typically do not have rifled barrels. *(Figure 1-2)*

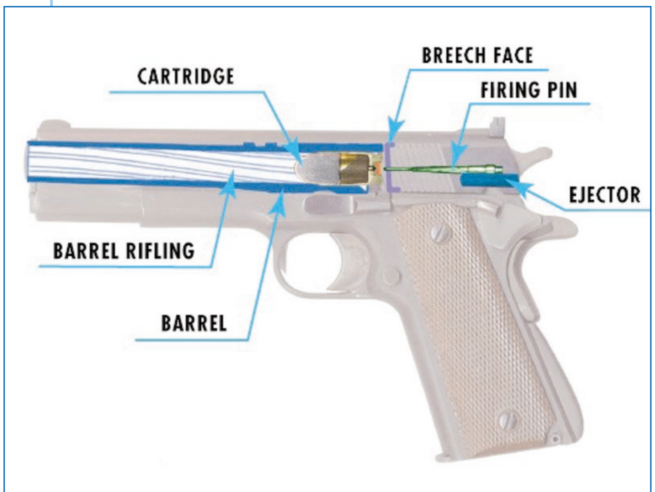


Figure 1-2: *Side view of a hand-gun with key internal components identified.*

The rear of the firing chamber is a flat surface called the **breech face.** A **firing pin** sits just behind the breech face. When the trigger is pulled, the firing pin moves forward through a hole in the breech face, striking the primer cap and causing the cartridge to discharge. After the cartridge discharges from a

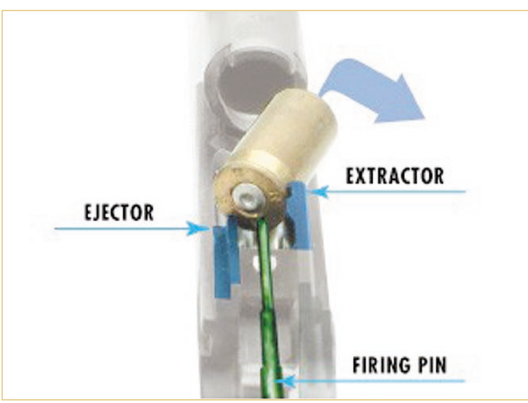


Figure 1-3: *Top view of a handgun with key components identified.*

semi-automatic firearm, the **extractor** pulls the just-fired cartridge case out of the firing chamber, and the **ejector** pushes the empty case out of the gun. In a revolver, the cartridge case remains in the firing chamber. *(Figure 1-3)*

What Happens When a Gun Is Fired?

The discharge of ammunition from a firearm involves a rapid series of mechanical interactions between the gun and the ammunition. These interactions occur under high pressure and with great force.

The series of interactions begins when the firing pin strikes the primer cap. The impact of the firing pin on the primer cap compresses the chemicals inside the cap, igniting the primer. The burning primer then ignites the powder inside the cartridge case. As the powder burns, it releases rapidly expanding gases in all directions.

These expanding gases propel the bullet out of the cartridge case and down the barrel. At the same time, the gases press the walls of the cartridge case against the interior of the firing chamber, and force the base of the cartridge case back against the breech face.

In a semi-automatic firearm, the rearward pressure of the cartridge case against the breech face causes the breech face, which is part of a moveable component called a **slide,** to begin moving backward. The empty cartridge case, held to the slide by the extractor, moves back with the slide until the cartridge case collides with the ejector. The impact of the moving cartridge case against the rigid ejector pushes the cartridge case out of the firearm through a hole in the slide (called a **port**).

Ballistic Fingerprints: Marks on Cartridge Cases and Bullets

Cartridge Case Fingerprints

A fired cartridge case bears several distinctive marks, caused by different components of the firearm. *(Figure 1-4)*

The most prominent mark, the **firing pin impression,** is created when the firing pin strikes the primer. To the naked eye, the firing pin impression looks like a small dimple in the primer cap (on center-fire ammunition) or the rim (on rim-fire ammunition). Under a microscope, however, the firing pin impression contains a unique imprint of the surface imperfections present on the tip of

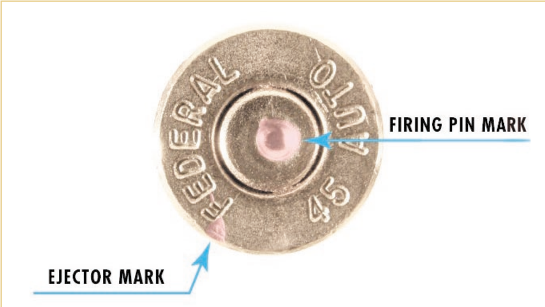


Figure 1-4: *Fired cartridge case with firing pin impression and ejector mark.*

every firing pin. Other features, like the size and shape of the impression, provide additional information.

Breech marks, which typically cannot be seen with the naked eye, result from the impact of the cartridge case against the breech face. The base of the cartridge case surrounding the primer cap is harder than the primer cap and often bears stamped characters identifying the manufacture and caliber of the ammunition. These characters can interfere with any breech marks that might be present. The clearest marks, therefore, appear on the surface of the primer cap, which is flat, relatively soft and typically free of other impressions (except for the readily identifiable firing pin impression).

Ejector marks result from the collision between the ejector and the cartridge case. Like firing pins, ejectors vary in position and shape, and have surface imperfections that leave unique features on a cartridge case.

Additional marks can sometimes be found on the walls of a cartridge case. These marks result from friction or impact between the cartridge case and the interior of the firing chamber or between the cartridge case and the extractor.

Bullet Fingerprints

The diameter of a bullet is slightly larger than the interior diameter of a barrel designed for a bullet of that size. As a result, when a cartridge is fired, the bullet scrapes along the interior of the barrel. The lands, which occupy the space between the spiral rifling grooves, create gouges called **impressions** in the bullet, forcing the bullet to spin. These impressions reflect the number of lands and the direction in which they spiral. In addition, the land impressions contain microscopic scratches, called **striations,** caused by imperfections on the surface of the lands. *(Figures 1-5 and 1-6)*

Figure 1-5: *Fired bullet showing land impressions.*

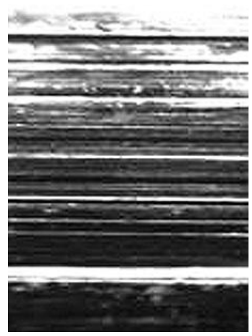


Figure 1-6: *Magnified striations in land impressions of a fired bullet.*

Forensic examiners use the number and direction, and sometimes the shape, of land impressions to make initial determinations about the type of gun used to fire the bullet. One gun design, for example, may have six lands spiraling to the left, while another has eight lands spiraling to the right. However, these characteristics, which are visible to the naked eye, cannot alone identify a specific gun because every gun with the same basic design will produce the same pattern.

The microscopic striations, on the other hand, are unique. The surface imperfections that create the striations result from machining the barrel. The tools used to machine the barrel wear slightly with each use and may even be sharpened, cleaned or replaced during the manufacture of a series of barrels. Consequently, each barrel bears distinct imperfections, some of which leave marks on every bullet that travels through the barrel. Striations remain identifiable even after many rounds are fired through the barrel.

To most of us, the ballistic fingerprint on a bullet or cartridge case looks like a set of indecipherable nicks and dings. To a trained forensic examiner, however, the ballistic fingerprint is an important piece of evidence that can often help solve a crime.

Forensic Use of Ballistic Fingerprints

Early History of Ballistic Identification

The forensic potential of marks on bullets and cartridge cases became recognized during the latter half of the 19th century, and by the 1920s, such evidence was appearing in criminal trials around the country.[1] In these early cases, available technology was limited to magnifying glasses, rudimentary cameras and monocular microscopes. Even with these primitive tools, however, enterprising investigators were able to confirm or eliminate matches in several significant cases. Forensic innovator Calvin Goddard offered ballistic identification evidence in 1921 to help secure convictions of accused murderers Nicola Sacco and Bartolomeo Vanzetti. In 1929, using a comparison microscope adapted for the purpose by his partner, Phillip Gravelle,

Figure 1-7: *Re-enactment of the 1929 St. Valentine's Day Massacre in Chicago, IL.*

Goddard used similar techniques to absolve the Chicago Police Department of participation in the St. Valentine's Day Massacre. *(Figure 1-7)*

Since then, ballistic identification has benefited from a long series of structural, scientific and technological advances. Law enforcement agencies around the country (and the world) have established science-based crime labs, researchers have learned much more about how to match bullets and cartridge cases to the guns used to fire them, and comparison microscopes have become more sophisticated. By the end of the 1980s, ballistic identification was an established subspecialty of forensic science. Despite this evolution, however, the basic tools and techniques have remained unchanged in their essential details.

Ballistic Identification Fundamentals

When both a firearm and a bullet or cartridge case are recovered during an investigation, a specially trained forensic expert called a tool mark examiner can compare the ballistic fingerprint of the recovered bullet or cartridge case with the ballistic fingerprint of a second bullet or cartridge case test-fired from the recovered firearm. If the ballistic fingerprint on the test-fired bullet or cartridge case matches the ballistic fingerprint on the recovered bullet or cartridge case, investigators know that the recovered bullet or cartridge case was also fired from the recovered gun. A confirmed link between a specific firearm and a bullet or cartridge case recovered from a crime scene constitutes a valuable lead, because investigators may be able to connect the firearm to a person, who may then become either a suspect or a source of information helpful to the investigation.

If investigators do not know the identity of the owner or possessor of the recovered firearm, they may be able to learn it by tracing the weapon. To trace a firearm, investigators submit the make, model and serial number of the recovered firearm to the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATFE), the federal agency with primary responsibility for regulating the gun industry and enforcing our national gun laws. All manufacturers, distributors, and licensed dealers are required by federal law to maintain records of the acquisition and disposition of each firearm they make, purchase or sell. Because federal law prohibits BATFE from maintaining any centralized database of these records, BATFE must contact the manufacturer of the recovered firearm, and the manufacturer must check its records to determine who purchased the firearm. BATFE then continues down the chain of distribution, requesting information from each distributor or dealer who bought the firearm. Eventually, BATFE identifies the retail dealer who first sold the firearm to a consumer, and whose records should identify that buyer. Although the first retail purchaser may not necessarily be involved in the shooting, this information allows investigators to contact a person who at some time possessed a firearm that was involved in a crime. Firearm tracing is an extremely valuable tool for law enforcement agencies investigating gun crime.[2]

Another well-established use of ballistic fingerprints arises when investigators recover one or more bullets or cartridge cases, but no firearm. In these cases, the ballistic fingerprint allows forensic examiners to connect shootings that might otherwise appear unrelated. For example, examiners can compare cartridge cases recovered from two different crime scenes to determine whether the same firearm was involved in both shootings. Examiners achieve these results by comparing ballistic fingerprints under a comparison microscope, which enables side-by-side examination of two specimens. Investigators working on the D.C.-area sniper shootings in 2002, and the more recent highway sniper shootings in Ohio, used this technique to link the shootings in each case.

Despite the long-standing effectiveness of these techniques, two significant limitations have prevented law enforcement agencies from making the best use of the information ballistic fingerprints provide. First, many gun crimes that could be linked through ballistic fingerprints remain unidentified because of the high volume of gun-related cases most urban law enforcement agencies face. With hundreds or thousands of shootings to investigate each year, forensic examiners cannot possibly compare the ballistic fingerprints from each potentially connected pair of open cases.

One major obstacle to the routine use of ballistic fingerprint comparisons is the cumbersome nature of manual recordkeeping systems. The Miami-Dade Crime Laboratory in Florida, for example, developed in the 1950s an elaborate system of Rolodex cards, with the help of a specialist who had recently retired from Goddard's crime lab in Chicago. The system required the examiner to fill out a file card for each cartridge case, describing the cartridge case and manually noting the location and characteristics of each mark. *(Figure 1-8)* To use the file in a subsequent investigation, the examiner had to flip through thousands of cards on huge Rolodex drums looking for a possible match.[3] Although this system could and did help investigators solve crimes, it was difficult and time-consuming to use.

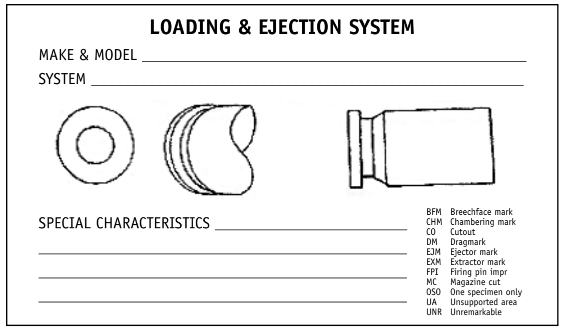


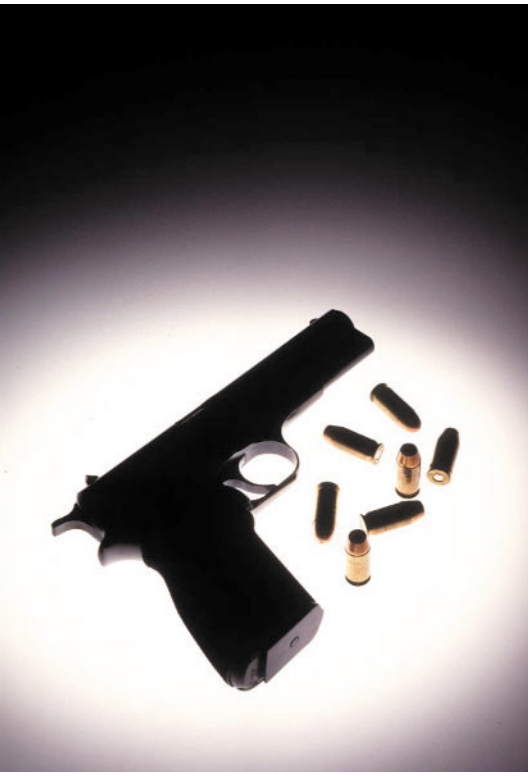
Figure 1-8: *Manual ballistic fingerprint file card. (Adapted from Kennington, R.,* ***The Matrix: 9mm Parabellum: An Empirical Study of Type Determination,*** *1992).*

Additionally, investigators cannot determine, from the ballistic fingerprint alone, precisely which firearm was used to discharge the bullet or cartridge case. Investigators often have no leads other than a recovered bullet or cartridge case, and without a way to link ballistic fingerprints to the guns that produce them, investigators cannot initiate a trace and cannot identify a potential suspect. This problem was especially visible early in the investigation of the D.C.-area sniper shootings when, despite linking the shootings through ballistic fingerprints, authorities could not identify the precise gun the shooter was using. Had they been able to do so, a routine trace would have led them directly to the Washington state gun dealer from whom John Muhammad acquired the Bushmaster XM15 assault rifle that he and Lee Boyd Malvo used in the shootings.

Fortunately, modern technology has provided powerful solutions to both of these problems. The next two sections discuss these solutions and their potential to help law enforcement solve gun crimes faster and more efficiently.

Section II

Today's Ballistic Identification Technology



Through most of the 20th century, ballistic identification was an established investigative tool relying on relatively primitive technology: microscopes, cameras, file cards and a great deal of patience. Only in the last decade has ballistic identification become a high-tech discipline. This section describes the current status of ballistic identification technology.

The Emergence of Computerized Databases

In the 1990s, computers joined comparison microscopes as essential tools of forensic examination. With advances in digital imaging technology and data storage capacity, forensic examiners envisioned a centralized database of images of bullets and cartridge cases that could be compared against a bullet or cartridge case recovered from a crime scene. By the mid-1990s, two such systems emerged.[4]

The first system, developed by the Federal Bureau of Investigation (FBI), was called "Drugfire." Drugfire used imaging software to capture, catalog and compare digital images of cartridge cases (bullets were added later). An examiner would capture an image of a recovered bullet or cartridge and compare it with similar images from the database. Drugfire enabled the examiner to see many images of potential matches on one screen, greatly speeding up the process. However, Drugfire did not rank the images by how close a match they were, leaving that determination entirely to the examiner. More than 170 law enforcement agencies nationwide participated in the Drugfire program.[5]

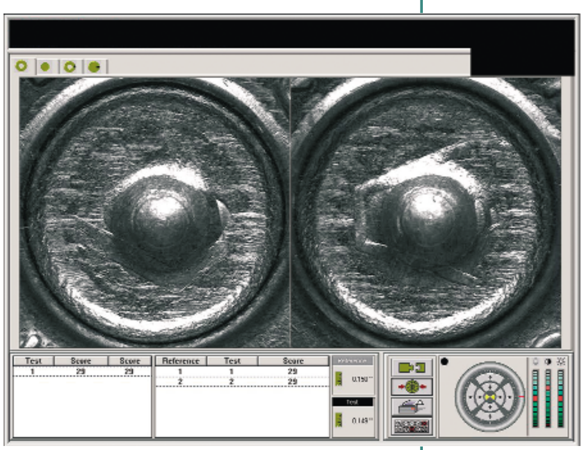


Figure 2-1: *Images of two firing pin impressions presented for comparison by IBIS. (Forensic Technology, Inc.)*

The second system, developed by the Bureau of Alcohol, Tobacco and Firearms (ATF), was originally called "Ceasefire." Like Drugfire, Ceasefire used imaging software to capture images of the markings on bullets and included a sophisticated comparison algorithm that automatically identified likely matches. Rather than requiring the examiner to sift through dozens or hundreds of images, the computer presented the examiner with a ranked list of the most likely matches. When the ATF expanded Ceasefire to include cartridge cases, it renamed the program the Integrated Ballistics Identification System (IBIS). *(Figure 2-1)*

In 1997, the ATF and the FBI agreed to try to combine Drugfire and IBIS to reduce the cost and inefficiency of maintaining both systems. However, technical obstacles prevented integrating the systems, sparking a pitched battle for supremacy. Adherents of the FBI's Drugfire system preferred its imaging technology and the degree of control they retained, while supporters of ATF's IBIS system praised its automation and speed.

After several years of wrangling, a compromise emerged. The new system would adopt IBIS's imaging technology and comparison algorithms while relying on the FBI's telecommunications network. Although a few devotees continued to use Drugfire on their own, IBIS became the standard centralized system. The National Integrated Ballistic Information Network (NIBIN) was born.

IBIS and NIBIN

NIBIN's central component is a large database of digital images of cartridge cases and bullets recovered in criminal investigations. Currently, 194 state and local law enforcement agencies are connected to NIBIN through 228 terminals.[6]

Figure 2-2: *An IBIS data acquisition station. (Forensic Technology, Inc.)*

The IBIS Technology

Using a microscope attached to a computer, a trained IBIS technician selects appropriate areas of a recovered bullet or cartridge case for the system to capture.[7] *(Figure 2-2)* The IBIS software then captures images of those areas and creates a file containing the images and other demographic information about the evidence (such as caliber, manufacturer, recovery location, etc.). IBIS uses a fixed, ring-shaped light to illuminate the evidence from all directions, rather than an "oblique" light, which illuminates from one side. The ring light improves the comparability of images by eliminating variations in light placement, but may, in some cases, reduce the clarity of some of the marks. Recent versions of the IBIS equipment allow technicians to capture side-lit images as well, but the computer does not conduct comparisons on these images. Examiners can use the side-lit image, however, to help confirm or reject a potential match.

Figure 2-3: *Fired bullets mushroomed by impact; note the visible land impressions at the base of each bullet.*

For a recovered bullet, IBIS scans and evaluates the land impressions at the very base of the bullet, where the impressions are most likely to remain useable after impact. *(Figure 2-3)* For a cartridge case, IBIS can scan and analyze, at the option of the technician, the firing pin impression, the breech face striations on the primer cap and/or any ejector marks. An experienced technician can enter a cartridge case into IBIS in just a couple of minutes; bullets can take a few minutes longer.

IBIS then compares the new image with those already in the database. To improve efficiency, the operator can limit the search to images with appropriate demographic characteristics. IBIS applies a complex algorithm to each image, which takes just a few minutes, and returns a ranked list of images that might be a match. Ideally, the highest-ranked potential match will be a true match, but examiners typically expect to review at least the top 10 potential matches.

Finally, a trained forensic examiner compares the new image with those returned by

IBIS to see if any are sufficiently similar to justify direct comparison of the bullets or cartridge cases. If the examiner confirms a likely match, investigators must then acquire the original bullet or cartridge case from which the matching image was made. This way, the examiner can compare the actual physical evidence under a microscope. In other words, IBIS does not establish a "hit" on its own; only a forensic examiner can determine the existence of an actual match using the physical evidence itself, rather than the digital images *(Figure 2-4)*.

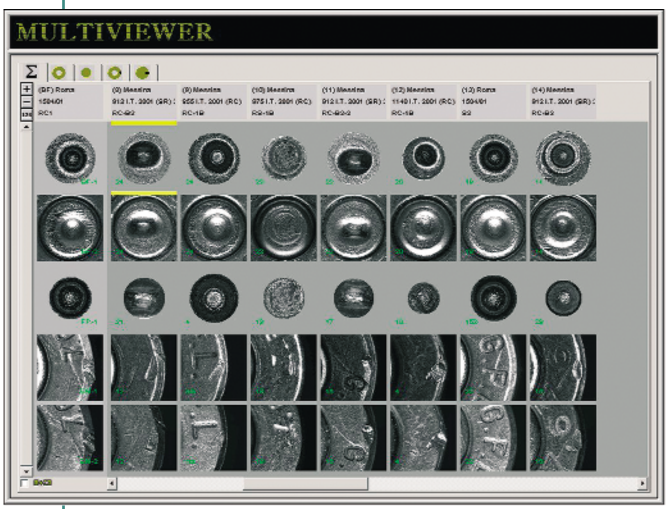


Figure 2-4: *IBIS presents possible matches for review by an examiner. (Forensic Technology, Inc.)*

The primary benefit of IBIS is that the system quickly narrows the field of potential matches and identifies a manageable number of candidates for an examiner to review. Compared to the manual systems upon which ballistic identification relied for the last 70 years, IBIS works miracles.

NIBIN: A Valuable Law Enforcement Tool

NIBIN applies IBIS to a nationwide network of computers, linked to several regional servers. BATFE provides the participating agency with an IBIS terminal, which costs hundreds of thousands of dollars, and connects the equipment to the servers on which the database resides. BATFE, through a contract with the company that makes the system, Forensic Technology, Inc. (FTI), also maintains the servers and the network, provides technical support to participating agencies, and pays for training of local agency personnel in the use of IBIS. Training occurs at FTI's facilities in Largo, Fla., and takes about a week.

Each local agency provides its own staff to enter images of recovered bullets or cartridge cases from crime scenes and to evaluate potential matches. The technician scans the evidence to create images, and submits them to the NIBIN database over the network. The system adds the images to the database and compares them to previously entered images.

NIBIN has been extremely valuable for law enforcement agencies that use it regularly. The database contains hundreds of thousands of images, and has received tens of thousands of queries.[8] In response to these queries, IBIS has helped investigators link thousands of sets of cases that otherwise would have remained unconnected, and possibly unsolved. In one instance, IBIS linked 13 shootings to a single 9-mm handgun.[9]

Consider these four examples:

- **An early adopter of the system, the New York Police Department, has submitted nearly 70,000 cartridge cases and more than 30,000 bullets to NIBIN, and has had more than 1,100 confirmed "hits." The detective in charge of the program adds his own training to FTI's and follows a rigid entry protocol that, he contends, increases the chances of finding a match.[10]**

- **One recent sutdy found that the use of NIBIN greatly increased the productivity of the Boston Police Department's Ballistics Unit, raising six-fold the Unit's monthly number of ballistic matches and greatly increasing the cost effectiveness of the Unit's gun crime investigations.[11]**

- **The Los Angeles Police Department implemented its "Walk-In Wednesday" program in 2003 to encourage the submission of firearms evidence into NIBIN. The new program has generated a dramatic shift in how detectives use NIBIN in their investigations, and the LAPD has found that frequent and early use of NIBIN generates more leads faster, and helps detectives direct their investigations more productively.[12]**

- **The Oakland, Calif., Police Department responded to a dramatic rise in gun violence during the late 1990s in part by entering into a unique arrangement with the local BATFE office. Under this arrangement, BATFE provides salary support for a retired BATFE technician to enter Oakland's backlogged evidence into NIBIN and to follow up on the results. This arrangement has enabled officials in Oakland, which lacked the resources to support a trained technician, to tackle its large backlog and to make numerous connections among cases that otherwise would have gone undetected.[13]**

Each example demonstrates the law enforcement value of NIBIN when local agencies use the system routinely. NIBIN's ability to link cases is unparalleled, but many law enforcement agencies—including some that are part of the network—cannot realize the system's full potential because of inadequate funding or cultural resistance to embracing the technology.

In addition, some law enforcement agencies have failed to recognize that everyone loses potential leads when recovered evidence is not entered. If an investigator does not enter a recovered cartridge case into the system, a future investigator of another crime committed with the same gun will not discover a link between the two crimes. In addition, investigators of the first crime will not learn that the weapon has been recovered in a later crime, and may miss an opportunity to close their case.

NIBIN has repeatedly proven its value as a law enforcement tool. That value would be even greater, however, if every law enforcement agency had the resources and inclination to fully use the system.

Even at its fullest potential, however, NIBIN has one fundamental limitation as a tool for ballistic identification: it only contains images of ballistic fingerprints from crime scenes. As a result, NIBIN cannot lead investigators directly to the specific firearm that produced a recovered ballistic fingerprint unless the weapon is eventually recovered. Two states have attempted to overcome this limitation by implementing a new application of the IBIS technology: a reference database of the ballistic fingerprints of new handguns.

IBIS and Reference Databases for New Handguns

Maryland and New York have recently established their own databases, also using IBIS equipment and software, to capture images of cartridge cases fired from new handguns before their first retail sale. In theory, such a database would contain a complete file of images from every new handgun sold in the state. If one of those handguns is later used in a crime, IBIS could match the ballistic fingerprint recovered from a crime scene with the previously entered reference image that was produced by the same gun. Unlike NIBIN, which can only make a match after a handgun has been used in at least two crimes, these "reference" databases can generate a lead the first time a handgun is used in a crime. Investigators can trace the handgun as soon as they identify a match in the database, even if they have not recovered the handgun.

The systems in the two states are similar. In both states, the reference databases include images of cartridge cases fired from handguns. Neither of the state databases contains images of bullets, which are recovered less often than cartridge cases and take longer to enter. Nor do the state databases contain images of cartridge cases fired from rifles or shotguns, because the vast majority of gun crimes are committed with handguns. These limitations reduce data entry and maintenance costs. However, these restrictions also prevent the systems from achieving their full crime-solving potential. Recognizing the crime-solving value of IBIS, policy makers in both states have proposed expanding their systems to include images captured from long guns.

Each state requires gun manufacturers to include at least one test-fired cartridge case (Maryland requires two) with each handgun sold in that state. Each state also requires manufacturers to package and label the cases according to strict guidelines to ensure the proper identification of the handgun from which the cases were fired. However, because manufacturers often sell their products through distributors and cannot always tell which handguns will be sold in Maryland or New York, most gun manufacturers include test-fired cartridge cases with all of the handguns they ship, regardless of the destination. Some manufacturers, however, have not exercised sufficient care in following the law, resulting in cartridges cases being shipped with guns that did not fire them.[14]

When a dealer in Maryland or New York sells a new handgun, the dealer forwards the cartridge case(s) to the state police. The state police employ trained technicians who enter the cartridge case(s) into the reference database using dedicated IBIS terminals. Each state also provides a procedure for capturing cartridge cases prior to delivery to the buyer if, for any reason, a dealer receives a new handgun without the required cartridges.[15]

Maryland's reference database, called Maryland IBIS, was created in 2000 by the Responsible Gun Safety Act. All entries are submitted to MD-IBIS at the Maryland State Police Crime Lab in Pikesville, a suburb of Baltimore. According to a report issued by the Maryland State Police in September 2003, the system "provides a powerful weapon in law enforcement's arsenal against crime." To date, the State Police have entered ballistic images of more than 40,000 cartridge cases. Unfortunately, local agencies have queried the system fewer than 200 times, producing just six hits.

New York calls its reference database the Combined Ballistic Identification System, or CoBIS. Created in 2001, CoBIS is similar to the Maryland system. However, the New York State Police have created six regional centers around the state to enter images into the database. Charles Simon of the New York State Division of Criminal Justice Services, which implements the program, repeatedly declined our requests for information about the current status of CoBIS, responding that, "while we would be happy to discuss CoBIS with you in the future, we are unable to do so at this time due to ongoing projects which have not yet been formally announced." According to the California Department of Justice, however, CoBIS entered roughly 21,000 images during 2002, but by March 2003 had not yet produced a hit.[16]

CRITICISMS AND RESPONSES

In both Maryland and New York, critics have charged that the new databases are ineffective and costly. A close examination of how the programs were designed and implemented, however, suggests that their effectiveness and efficiency could greatly increase with a few relatively minor changes.

CRITICISM: Reference databases invade gun owner privacy.

The National Rifle Association has falsely claimed, in opposing reference databases, that "for lawful gun owners, this scheme is national gun registration."[17]

RESPONSE: Reference databases contain no information about gun owners.

Reference databases contain digital images of ballistic fingerprints, along with information identifying the gun that produced each image. That data includes the make, model and serial number of the gun, but no information about the purchaser. Police investigating a gun crime can use the identifying information from the database to initiate a gun trace, as if they had recovered the gun, using existing records already maintained under current law. Reference databases contain no information about gun owners or gun buyers, and cannot function as a registration system.

CRITICISM: Reference databases have not produced results.

The charge that the reference databases have been ineffective stems in part from the fact that neither has produced many "hits." The Maryland system has made just six matches, and the New York system has yet to produce any.

RESPONSE 1: Few queries lead to few hits.

Law enforcement agencies in both states have made few queries of the reference databases. As of the end of March 2004, all of Maryland's law enforcement agencies had submitted a mere 177 queries to MD-IBIS, yielding six hits. Considering that the Baltimore Police Department alone investigates hundreds of shootings involving thousands of pieces of evidence every year, the small number of queries suggests that Maryland's law enforcement agencies are not using the system to its full potential. Similarly, New York City, which uses NIBIN so effectively, does not routinely query CoBIS. Experience with NIBIN has repeatedly demonstrated that increased use yields better results.

RESPONSE 2: Reference databases are too young to produce many hits.

Reference databases, which have only existed for a few years, contain images taken from brand new handguns—and few of these have had time to show up in crimes. Most crime guns are at least three to five years old, so the guns that have been entered into the state databases should just now begin to show up in crimes. As time goes on and more guns that have been entered are used in crimes, the hit rate should improve.

RESPONSE 3: Interstate trafficking undermines enforcement.

Each state database only contains ballistic fingerprints of handguns sold in that state, so crime guns that come from out of state will not show up at all.[18] Maryland State Police worry some manufacturers may even be evading the imaging requirement by funneling new handguns into Maryland through retail dealers in other states, so that the guns are technically "used" by the time they enter Maryland's stream of commerce. Because Maryland exempts used guns from the imaging requirement, guns distributed in this fashion are excluded from the database. Expanding the system to other states and centralizing the databases so that an agency can query more than one state at a time would greatly improve the likelihood of finding a match. BATFE has all of the necessary equipment and expertise, and could efficiently host a central new-gun database accessible in every state.

CRITICISM: The IBIS technology cannot handle a reference database.

A feasibility study conducted by the California Department of Justice raised concerns about whether an IBIS database of new handgun images could ever work.[19] *The California report focused on the fact that cartridge cases fired from different guns of the same model are more likely to have common features, making them harder to distinguish. These shared features, called* ***class characteristics,*** *can narrow the focus of an investigation to a particular manufacturer, but they could also overwhelm the ability of the IBIS algorithm to distinguish among casings fired from different guns made by that manufacturer.*

Because all of the cartridge cases in NIBIN were collected from crime scenes, the complete database contains ballistic fingerprints produced by a huge variety of guns, with relatively few samples of any specific model. The new databases, on the other hand, could potentially contain hundreds or thousands of entries of a single model, because they capture all new guns prior to sale. The California study raised the question of whether the IBIS algorithms are sufficiently discriminating to distinguish among a large number of entries that share class characteristics.

RESPONSE: Effectiveness does not require perfection.

The California study found that by including both firing pin and breech face impressions in the correlation, IBIS correctly identified the match 48 percent of the time. In another 12 percent of the trials, IBIS included the known match among the 10 most likely candidates, meaning that the examiner could find the match after reviewing 10 or fewer images. Of course, examiners could expand their review to include more than the top 10 candidates if a given investigation warranted the additional time. Although this performance is not perfect, it greatly improves on the existing manual system and quickly focuses examiners' attention on likely matches. When other leads are not available, the ability to focus an investigation on just a few known guns is a tremendous asset.

CRITICISM: Correlations are slow in reference databases.

The California study concluded that a reference database in that state would grow to 670,000 images within five years. At this size, the study stated, it could take about an hour to correlate a single cartridge case.

RESPONSE: Better late than never.

The California study included a test of the impact of increasing database size on correlation times, using databases containing hundreds of images. The study found, as a result of this test, that "correlation times are not a significant issue for a large database."[20] In other words, IBIS performed the test correlations quickly even as the size of the database grew.

Even if it does take an hour to perform a correlation when the database gets very large, in the absence of other leads, that is not a long wait. When the D.C.-area sniper was on the loose, hundreds of law enforcement officers spent thousands of hours searching for any clue, at tremendous public expense. A database capable of returning a potential lead in just an hour would have been a welcome addition to that investigation.

Finally, the main limiting factor for correlation times is the processing speed of the computer conducting the correlation. IBIS's ability to compare images using large databases has increased dramatically since the system was introduced, and will continue to improve as computer processing speeds grow even faster. When the California study tests were performed in 2001, top-end processors had a clock speed just a small fraction of that available today.

CRITICISM: Reference databases are expensive.

Maryland spent $1.8 million acquiring the hardware necessary for MD-IBIS, while New York spent even more. Estimates for California, which has a much bigger firearms market than Maryland or New York, were astronomical. These costs make it difficult for states to embrace new gun databases, even if the law enforcement benefits are clear.

RESPONSE: Most of these costs are avoidable.

By far, the largest contributor to the high costs of the Maryland and New York databases was the price of new IBIS terminals. Of course, both states already had numerous IBIS terminals in place, as part of NIBIN.[21] However, according to BATFE, federal law restricts the use of NIBIN's terminals to the capture of images of bullets and cartridge cases recovered in connection with a crime. As BATFE interprets the law, agencies cannot use their NIBIN terminals to enter data into a reference database because the reference databases contain the serial numbers of handguns.[22] Even more significantly, agencies investigating crimes cannot even use their NIBIN terminals to query the reference databases.

The Maryland State Police Crime Lab, where MD-IBIS resides, provides the clearest and most absurd example of the problems created by BATFE's rule. A technician uses the lab's NIBIN terminal to create a ballistic image and to query the central BATFE database. To query MD-IBIS, the technician must walk a few feet into an adjacent room to another, virtually identical terminal purchased separately by the state for hundreds of thousands of dollars, and spend several more minutes scanning the same evidence again. Although the two scanned images should be virtually identical (assuming the technician conducts the scans properly), the technician may not use the first image to access the state reference database because the image was created on a NIBIN terminal a few feet away.

The high cost of the Maryland and New York systems can be virtually eliminated simply by authorizing the use of NIBIN terminals for both entering images into the reference databases and submitting images from recovered bullets and cartridge cases.

The New York Police Department, which is in the unique position of owning its own NIBIN terminal, has entered into a memorandum of understanding with BATFE allowing NYPD to query the state system, so long as the New York State Police, not the NYPD, review the results. That part of the CoBIS program, however, has not yet begun.[23]

CRITICISM: Tampering and wear-and-tear defeat IBIS.

Critics argue that criminals can easily defeat the IBIS technology by altering the firing pin or the breech face. Indeed, for a time the National Rifle Association posted on its Web site a video showing criminals how to use common household tools to change a firearm's ballistic fingerprint. Further, critics allege that repeated use alone can cause sufficient alteration to make IBIS ineffective.

RESPONSE 1: Tampering is uncommon and unreliable.

Criminals can alter the firing pin or breech face of a firearm, but that does not mean that IBIS will fail to make a match. BATFE, commenting on the California study mentioned above, pointed out that only two known instances of attempted alteration exist among the many thousands of images in the NIBIN database, and that in one of those, IBIS successfully made a match despite the alteration.[24] IBIS's technology examines many, many data points, so a match is possible if even a portion of the original ballistic fingerprint remains intact.

Equally important, criminals are not known for their advanced planning skills. Fingerprints are easy to defeat, simply by wearing gloves, but that does not mean that police no longer dust crime scenes looking for prints. Most criminals do not wear gloves; similarly most will not alter their firearms.

RESPONSE 2: Ballistic fingerprints are extremely durable.

Forensic examiners know that ballistic fingerprints are extremely durable. Although small changes occur each time a gun is fired, the ballistic fingerprint as a whole remains largely intact after hundreds, or even thousands, of discharges.

After years of incremental change, ballistic identification technology has advanced by leaps and bounds in the last decade. The IBIS technology has proven its value as a law enforcement tool, and similar technology can be adapted rapidly to establish a comprehensive ballistic identification system capable of identifying the specific gun used in a crime.

The next section discusses the future of ballistic identification.

Section III

The Next Generation: Microstamping

NIBIN and the state databases depend upon the transfer of accidental markings from the interior of a firearm to the bullets and cartridge cases discharged from that firearm. The next generation of ballistic identification technology replaces those accidental markings with microscopic codes intentionally inserted into the firing chamber. This shift to intentional design means that the manufacturer can control what the identifying marks look like and where they are located. In addition, by duplicating these marks in various surfaces, manufacturers can assist law enforcement by making it even harder for criminals to defeat ballistic identification by tampering with the firearm.

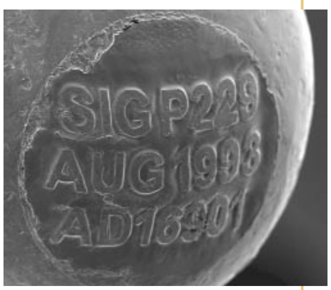
Microstamping Technology

The basic technology of microstamping involves the use of powerful lasers to make extremely precise, microscopic engravings.[25] By channeling a laser through a series of mirrors and lenses, engineers can create a powerful beam that is a fraction of the width of a human hair. If the beam also passes through a stencil-like template before being reduced by the lenses, the beam can cut the image of the template into the target surface. This technology has been used to produce the tiny nozzles in ink-jet printers and to mark microchips to prevent counterfeiting.

A small company in New Hampshire called NanoVia, which developed this technology for the computer industry, began experimenting with using similar technology to etch a mark on the tip of a firing pin in the early 1990s. *(Figure 3-1)* When NanoVia's engineers put that firing pin into a pistol, fired a cartridge and examined the cartridge case under a microscope, they found that the mark was readily visible inside the firing pin impression on the cartridge case. Later tests determined that the mark remained clearly visible after many rounds were fired. *(Figure 3-2)*

NanoVia's engineers found that they could put more than 20 alphanumeric characters onto the tip of a firing pin. This development raised the intriguing possibility that a marked firing pin could label every cartridge with the make, model and serial number of the gun that fired it.

On the other hand, firing pins can be filed down or replaced, potentially undermining the effectiveness of such a system. Although most criminals are unlikely to take such measures, NanoVia went back to the drawing board, and two additional innovations emerged.



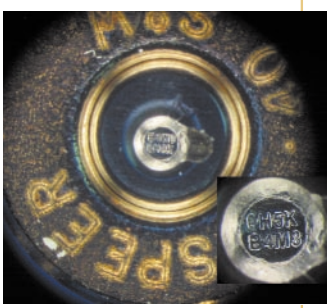


Figure 3-1 (Top): *Tip of a firing pin marked with a microstamp.*

Figure 3-2 (Bottom): *Firing pin impression left by microstamped firing pin on a fired cartridge case.*

(ID Dynamics, LLC [NanoVia Ballistic Program Acquisition])

First, the engineers designed a redundant series of tamper-resistant markings. They developed a coding system, analogous to a bar code, comprising a series of dots that encircle the area of the firing pin containing the alphanumeric code. This duplication allows the recovery of the code even if the alphanumeric figures are filed off. A third level of repetition, even farther back on the pin, could be added as well, and testing indicates that all three versions of the code transfer reliably to the cartridge case. If one tried to remove all three codes, the firing pin would become too short to function.

Second, the engineers confronted the problem posed by the rare, enterprising criminal who replaces the firing pin rather than altering it. Firing pins are small and inexpensive, and can be replaced without much difficulty. The breech face, however, cannot be replaced without replacing the entire slide. NanoVia's engineers etched the code into the breech face, and found that it transfers clearly to a discharged cartridge. They could also protect against attempted alterations by placing the code in multiple locations on the breech face. *(Figure 3-3)* In addition, NanoVia tried putting the code on the walls of the firing chamber to see if it would transfer to the side of the cartridge case. At the time of this writing, that approach shows promise but has not yet produced a clear, consistent mark on the cartridge case.

Figure 3-3: *Breech face marked with redundant microstamps. (ID Dynamics, LLC [NanoVia Ballistic Program Acquisition])*

Early critics of microstamping expressed concerns that the markings would not be sufficiently durable under the high stresses that occur inside a firearm. One widely respected forensic scientist, Lucien Haag, was so skeptical about the durability of microstamps that he decided to conduct his own tests. Haag acquired marked firing pins from NanoVia and tested them using guns that he thought were most likely to challenge the technology. His results indicate that marked firing pins continue to leave clear impressions on cartridges even after hundreds of rounds, and even in guns that operate under extremely high pressure.[26] In short, microstamping appears to have a promising future as a law enforcement tool.

Implementation of Microstamping

The implementation of microstamping requires the direct participation of firearms manufacturers, because they must build the microstamp, ideally on both firing pins and firing chambers, into firearm production. The technology for achieving both is available today, but it must be adapted for use in firearm manufacturing.

Additional research and testing will identify the optimal characteristics (such as the size and shape of the code characters) and placement of microstamps in the firing chamber and on the firing pin. Some of this development is under way at a company called ID Dynamics, which acquired the technology from NanoVia in 2003. The fundamental technology is sound, however, and should be ready for the market within two years.

The incorporation of microstamping also enables gun manufacturers to help law enforcement in other ways. For example, microstamping invites the adoption of a standardized Firearm Identification Number (FIN) system that could ultimately replace the current, inadequate serial number system.[27] Like the Vehicle Identification Number (VIN) used for motor vehicles, the FIN could communicate valuable information about the firearm, such as the make, model, date of manufacture, etc. With a standardized coding system, all of this information could be included in the microstamp, allowing law enforcement to extract detailed information about the gun directly from a recovered cartridge case.

Section IV
RECOMMENDATIONS

Ballistic identification is a valuable law enforcement tool that has not yet received the support it deserves. The leading technology available today, the IBIS system, works well when it is properly used. The emerging technology, microstamping, requires some additional investment in development, but will, within a few years, greatly expand the power of ballistic identification. While the new technology continues to be developed, law enforcement should use the existing technology to the fullest extent possible. Even after microstamping becomes standard, reference databases built around IBIS will continue to be valuable because of the large number of guns that will be manufactured and sold between now and then.

The following recommendations are designed to guide policy makers in establishing ballistic identification systems that will efficiently aid law enforcement now and in the future.

Recommendation 1

Every law enforcement agency should have access to NIBIN and the resources necessary for full implementation of ballisitic identification.

Law enforcement agencies that use NIBIN regularly derive tremendous benefits and efficiencies from the system. However, some agencies do not participate in the system at all, while others fail to realize its full crime solving potential. Additional resources would provide local law enforcement with the support necessary for trained staff to enter and review evidence on the most up-to-date systems.

Recommendation 2

Every state, or the federal government, should establish a reference database of ballistic fingerprints for new guns.

America's robust illegal gun market ignores state borders. Even worse, Maryland's experience suggests that some manufacturers may be intentionally funneling guns through dealers in Pennsylvania in order to evade Maryland's reference database. Such activity would not be possible if Pennsylvania had its own database. The more states that establish such systems, the harder it will be for traffickers to evade detection. Even better, a single federal system would ensure that every firearm that enters the market would be included in a database, and would encourage widespread use by law enforcement agencies nationwide.

Recommendation 3

BATFE should host the reference databases and provide access to them through NIBIN terminals.

The greatest obstacle to efficiently using reference databases is BATFE's refusal to allow NIBIN terminals to be used to capture and enter images or to submit queries. This rule forces law enforcement agencies to spend scarce resources to buy duplicative equipment, and requires repetitive data entry that inhibits regular use. In addition, because the state reference databases are entirely separate, law enforcement agencies in one state cannot access the databases in another state. If all of the state databases were maintained on the NIBIN servers, but kept separate from NIBIN's crime-gun database, law enforcement agencies could query multiple states if needed. Finally, centralized hosting on the NIBIN system efficiently uses a compatible network that is already in place, greatly reducing the cost of establishing reference databases for new guns.

Recommendation 4

New ballistic identification policies should encourage the rapid development of microstamping, while continuing to support IBIS-based databases.

Although the IBIS technology works well, microstamping provides an opportunity for greatly easing law enforcement's task in solving gun crimes. The gun industry, which has long professed a desire for improved enforcement, has a central role to play in giving law enforcement necessary tools. Microstamping is the most direct way that the gun industry can help, because the technology allows the manufacturer to insert unique, identifying information directly into the firing chamber of each firearm. However, even if development advances as quickly as it should, the first microstamped firearms will probably not show up at crime scenes for another eight to10 years. In the interim, we should assist law enforcement by supporting IBIS-based databases.

Recommendation 5

Federal funding should be made available to support the development of microstamping.

The federal government, through the National Institute of Justice or another appropriate agency, should provide funding to ensure completion of the last stages of development of microstamping technology. A federal/private partnership is the best way to ensure that this technology promptly becomes available to assist law enforcement in solving gun crimes. If funding is left entirely to the market or to the gun industry, the technology will likely take much longer than it should to reach implementation, resulting in a longer-than-necessary delay in the availability of microstamping as a law enforcement tool.

Recommendation 6

The implementation of microstamping should include the establishment of a standardized serial number system for firearms.

Firearm serial numbers today provide very little information about the gun. Guns made by different manufacturers may even have the same serial numbers. Car makers, however, have used an informative, standardized numbering system for decades. Since 1980, cars and car parts have been labeled with a Vehicle Identification Number (VIN). Much more than a simple serial number, the VIN contains detailed information about the car, identifying the country and year of manufacture, the manufacturer, model and serial number, and some information about equipment included on the vehicle. The VIN on a mangled truck axle led investigators in the 1995 Oklahoma City bombing to bomber Timothy McVeigh. Microstamping enables the establishment of a standardized Firearm Identification Number system that will provide a great deal more information to law enforcement than a serial number alone.

Recommendation 7

The costs of creating ballistic identification systems should be borne by the gun industry and their customers, not by the general public.

The gun industry is in the best position to efficiently incorporate ballistic identification. By building ballistic identification into the manufacturing process, whether through digital imaging or microstamping, gun companies can spread these costs over their entire product lines. On a per-unit basis, these costs would be minimal, especially as compared with the large public expense incurred in the establishment of the Maryland and New York systems. More importantly, shifting these costs to the industry affords gun manufacturers the opportunity to deliver on their claimed commitment to crime prevention and enforcement.

Ballistic Identification Glossary

Ballistic fingerprint: A set of unique, reproducible markings left on each fired bullet and cartridge case by the firearm from which the bullet or cartridge case was fired.

Ballistic identification: The use of a ballistic fingerprint to identify the specific, individual firearm used to fire a given bullet or cartridge case.

Barrel: The tube on a firearm through which a bullet is propelled when a cartridge is fired.

Breech face: The flat, vertical surface that forms the rear of the firing chamber of a firearm.

Breech mark: A microscopic mark left on the base of a fired cartridge case by the surface of the breech face. Breech marks are most readily visible on the surface of the primer.

Bullet: The component of a cartridge, usually made of lead, that exits the firearm through the barrel when the cartridge is fired. Some lead bullets are "jacketed" with a layer of copper alloy or other metal.

Cartridge: A unit of firearm ammunition containing four components: primer, powder, bullet and cartridge case.

Cartridge case: The component of firearm ammunition, usually made of brass, that holds the primer, powder and bullet.

Crime gun database: A database, such as that established by the NIBIN program, containing ballistic fingerprints of firearms recovered in criminal investigations. (See *reference database*)

Drugfire: A ballistic identification system developed by the Federal Bureau of Investigation in the 1990s. Drugfire was replaced by IBIS when NIBIN was created.

Ejector: On a semi-automatic firearm, a stationary metal bar or block that forces a fired cartridge case to eject from the firearm.

Ejector mark: An impression, usually visible to the naked eye, left on the base of a fired cartridge case by the collision between the cartridge case and the ejector. Microscopic details of an ejector mark are part of a firearm's ballistic fingerprint.

Extractor: On a semi-automatic firearm, a small hook embedded in the slide that hooks under the rim of a cartridge in the firing chamber and pulls the discharged cartridge case out of the firing chamber.

Firing chamber: The portion of a firearm, located at the back end of the barrel, that contains a cartridge for firing.

Firing pin: A narrow rod which, when released by pulling the trigger, springs forward and strikes the primer of a chambered cartridge, causing the cartridge to discharge.

Firing pin impression: An impression, visible to the naked eye, left on the primer of a fired cartridge by the firing pin. Microscopic details of a firing pin impression are part of a firearm's ballistic fingerprint.

FTI: Forensic Technology, Inc., the company that manufactures the IBIS system.

Groove: A spiraling channel cut into the interior surface of the barrel of a firearm and designed to cause a bullet to spin as it leaves the barrel.

Hit: A match, confirmed by a trained forensic examiner, between the ballistic fingerprint on a recovered cartridge case or bullet and a previously-captured ballistic fingerprint.

IBIS: A computerized digital imaging system that captures and compares digital photographs of fired bullets and cartridge cases. IBIS stands for "integrated ballistic identification system."

ID Dynamics: The company that acquired NanoVia's microstamping technology in 2003.

Land: The raised surface between two grooves on the interior of a rifled barrel.

Land impression: An impression in the side of a bullet made by a land on the interior of the rifled barrel through which the bullet was discharged.

Magazine: A spring-loaded ammunition storage and feeding device that attaches to a firearm. A magazine can be detachable or fixed (i.e., non-detachable).

Microstamp: A microscopic array of characters etched into the interior surfaces of a firearm during manufacturing, which transfers the characters to a cartridge case when the cartridge is discharged.

NanoVia: The company that developed microstamping. (See *ID Dynamics*)

NIBIN: National Integrated Ballistic Information Network, operated by the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATFE) and the Federal Bureau of Investigation (FBI). NIBIN uses the IBIS system to capture and compare ballistic fingerprints from cartridge cases and bullets recovered at crime scenes.

Port: An opening in the slide of a semi-automatic firearm through which a discharged cartridge case is ejected.

Powder: The component of firearm ammunition that ignites and burns when a cartridge is fired, releasing a tremendous amount of rapidly expanding gas that propels the bullet along the barrel.

Primer: A percussion-sensitive chemical mixture contained in the base of a cartridge. The primer explodes when struck by the firing pin, igniting the powder.

Reference database: A database containing ballistic fingerprints of new firearms, along with the make, model and serial numbers of those firearms. (See *crime gun database*)

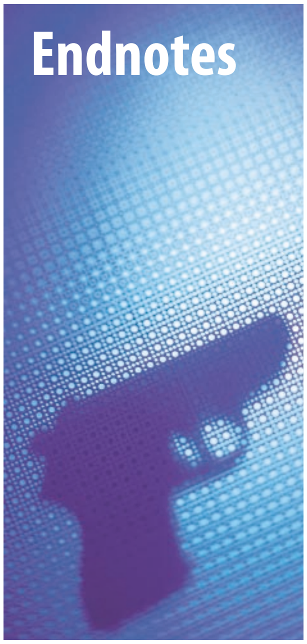
Rifling: A spiraling pattern of grooves on the interior surface of the barrel of most firearms, designed to cause the bullet to spin as it moves down the barrel.

Slide: On a semi-automatic firearm, a moving component that encases the barrel and the firing chamber. When a cartridge is discharged, the slide moves toward the rear of the firearm, pulling the fired cartridge case out of the firing chamber (see *extractor*) and driving it against the ejector. The slide then moves forward, forcing a new cartridge from the magazine into the firing chamber.

Striation: A microscopic scratch left on the surface of a bullet by the lands of the rifled barrel of a firearm.

Tracing: An investigative technique using existing records to identify the first retail purchaser of a firearm that was recovered in connection with a criminal investigation.

Endnotes



[1] For a more detailed summary of the history of ballistic identification, see Hamby, JH & Thorpe, JW, “The History of Firearm and Toolmark Identification,” 31 AFTE J. (1999).

[2] In fiscal 2003 alone, BATFE’s National Tracing Center, located in Falling Water, W.Va., processed over 280,000 crime gun trace requests. (ATF Snapshot 2004, accessed on the World Wide Web at ***http://www.atf.gov/about/2004snap.pdf*** on May 5, 2004). A new law, adopted by the Unites States Congress without a hearing in February, 2004, prohibits BATFE from releasing to “any person or entity” any information regarding trace requests. Accordingly, detailed information about the results of these hundreds of thousands of investigations, even in aggregrate, is extremely difficult to obtain.

[3] Kennington, RH, “The Matrix: 9mm Parabellum—An Empirical Study of Type Determination” (1992).

[4] “National Integrated Ballistics Information Network (NIBIN) for Law Enforcement,” Congressional Research Service Report for Congress, July 3, 2001 (Order code RL31040).

[5] Ibid.

[6] Personal communication, Cybele Daley, Executive Director, Government Affairs, Forensic Technology, Inc., April 17, 2004.

[7] The following discussion draws heavily on information we received during a visit to the Largo, FL, training center of Forensic Technology, Inc., on December 2, 2003, and in subsequent conversations. We thank Forensic Technology, Inc., for allowing us to visit their facility and for educating us about how IBIS works.

[8] BATFE declined to provide more precise data, referring to new legal prohibitions resulting from the January, 2004 enactment of Public Law 108-199. Provisions of that law, collectively referred to as the “Tiahrt amendments” in honor of the Kansas Republican who proposed them, prohibit BATFE from disclosing to the public “the contents or any portion thereof of any information required to be kept by [federal firearms] licensees.” P.L. 108-199. That information includes, among other things, the identity of gun purchasers and the serial numbers of the guns they purchase. Although statistical information about NIBIN is clearly not subject to this prohibition, BATFE has adopted a policy of treating every request for information with extreme caution, to ensure that no information that is covered by the Tiahrt amendments is disclosed to the public. Accordingly, BATFE can take weeks or months to respond to even the most routine questions that seek only information that BATFE is clearly permitted to release.

[9] Michigan State Police, News Release, January 22, 2004.

[10] Telephone Interview with Detective Mike Bonciemino, NYPD, January 9, 2004.

[11] Braga, A, and Pierce, G., “Linking Crime Guns: The Impact of Ballistics Imaging Technology on the Productivity of the Boston Police Department’s Ballistics Unit,” 49 J. Forensic Sci. No. 4, Paper ID JFS2003205, available online at www.astm.org (July, 2004).

[12] Telephone Interviews with Doreen Hudson (February 2, 2004) and Bill Moore (March 12, 2004), LAPD Scientific Investigation Division.

[13] Personal communication, Oakland Police Chief Richard Word, June 25, 2003.

[14] The Maryland State Police found, for example, that cartridge cases submitted by Glock, one of the largest manufacturers of handguns sold in America, was shipping handguns with cartridge cases that had not been fired by the handgun with which they were shipped. Maryland State Police Forensic Sciences Division, "Maryland-IBIS (Integrated Ballistics Identification System)," September, 2003. A study by an examiner in Arizona also found that: 1) 11 of 15 Glocks examined for the study were shipped with cartridge cases that had not been fired from the gun with which they were shipped; and 2) six of the 15 Glocks were shipped with two cartridge cases that had been fired from two different guns. Tew, Jon D., "Incorrect Manufacturer-Supplied Test Fire Cartridge Cases," 35 Assoc. Firearms Toolmark Exam. J. 195 (Spring, 2003).

[15] For example, an out-of-state firearm distributor may remove the cartridge cases prior to delivering the firearm to the New York dealer.

[16] California Department of Justice, "Feasibility of a California Ballistics Identification System," January, 2003.

[17] "Joint Statement [of National Rifle Association and NRA-Institute for Legislative Action] on Ballistic 'Fingerprinting,'" October 17, 2002, accessed on the World Wide Web at ***http://www.nraila.org/News/Read/Releases.aspx?ID=2053*** on May 5, 2004.

[18] Trace data reported by the Bureau of Alcohol, Tobacco and Firearms (which became BATFE in 2003) indicates that 38 percent of crime guns recovered in Baltimore and traced to a licensed gun dealer in 2000 came from outside of Maryland. When the crime was committed by a person aged 18–24, the percentage of crime guns traced to out-of-state dealers jumps to 45 percent. Bureau of Alcohol, Tobacco and Firearms, "Crime Gun Trace Reports, 2000—Baltimore, MD," pp. 15–16 (July, 2002). In New York City, this problem is even more severe. A whopping 85 percent of all traced crime guns in New York City in 2000 came from out of state, with a handful of southern states providing most of the supply. For gun crimes involving young people aged 18–24, out-of-state sources provided 93% of the crime guns. Bureau of Alcohol, Tobacco and Firearms, "Crime Gun Trace Reports, 2000—New York, NY," pp. 15–16 (July, 2002).

[19] California Department of Justice, "Feasibility of a California Ballistics Identification System," January, 2003.

[20] Ibid., Attachment A, p. 8-5.

[21] There are currently five terminals in Maryland and eight in New York. Cybele Daley (FTI), personal communication, April 27, 2004.

[22] BATFE claims that the inclusion of serial numbers in reference databases runs afoul of a prohibition on the expenditure of BATFE's funds "in connection with consolidating or centralizing, within the Department of Justice, the records, or any portion thereof, of acquisition and disposition of firearms maintained by Federal firearms licensees." P.L. 108-199. Because licensed dealers maintain records that include the serial numbers of firearms, BATFE views reference databases as "consolidating or centralizing" a "portion" of the records maintained by licensees.

[23] Telephone interview with Detective Mike Bonciemino, NYPD, January 9, 2004.

[24] California Department of Justice, "Feasibility of a California Ballistics Identification System," January, 2003, Attachment B, pp. 14–15.

[25] The following discussion draws heavily on information we received during a visit to the New Hampshire facilities of NanoVia on December 3, 2003, and in subsequent conversations. We thank NanoVia for allowing us to visit their facilities and for educating us about microstamping.

[26] Telephone interview with Lucien Haag, February 5, 2004.

[27] Currently, firearm serial numbers are not standardized. Consequently, firearms from different manufacturers can have the same serial number, and authorities cannot tell much about the gun from the serial number alone. In addition, roughly 10 percent of crime gun trace requests fail because of problems with the serial number submitted by the requesting agency. A standardized serial number would reduce these errors.

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