A SHOT IN THE LIGHT

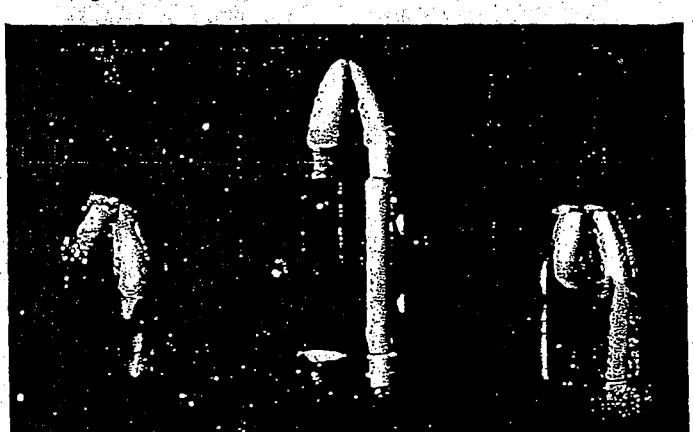
Precise bullet replicas take aim at crime-fighting standards

BY PETER WEISS

During the sniper shootings of 13 people in the Washington, D.C., area last October, police initially uncovered only a sparse trail of evidence—often just the bullet itself. As tension mounted over several weeks, newscasts repeatedly reported that examinations of bullet fragments were linking the shootings. That coverage brought the science and technology of bullet identification onto center stage. It also drew attention to a system still under development, in which images of bullets, bullet fragments, and bullet cases collected from crime scenes are matched against a database of previously recorded images.

Known as the National Integrated Ballistic Information Network (NIBIN), the system is already giving police a new way to ferret out links between crimes. Law enforcement officers have used the system many times to establish connections. However, officials won't say whether it served this purpose in the Washington sniper case.

Government and industry scientists are now working on ways to fine-tune this bullet-matching system. One critical component of this effort is the creation of unfired bullet replicas that look, even on a microscopic level, like they've been shot from a gun.



B. GARDNER/NIST

SLUG FEST — Engraved areas on an unfired standard bullet (right) duplicate to submicrometer accuracy the scratch patterns of six different bullets (one of them is at left) that were actually fired from guns. A brass prototype of a standard bullet (middle) didn't resemble real bullets closely enough to win acceptance by firearms examiners.

Such replica bullets are needed, their developers say, to ensure consistent performance and use of bullet-identification equipment across a national network. These bullets provide, in the parlance of analysts, a reference material akin to a standard weight that can be placed on any scale. Because the bullet replicas can be duplicated with extreme fidelity and distributed to bullet-matching analysts across the country, they'll offer a uniform standard against which the analysts can calibrate their equipment and their image-recording practices.

To check the uniformity of those replicas, their developers at the National Institute of Standard and Technology (NIST) in Gaithersburg, Md., have also devised a new way to compare bullet surfaces mathematically. This method may ultimately enable forensic scientists to numerically score the degree of similarity between two bullet samples—as is already done in comparisons of DNA samples—rather than rely solely on the judgment of experts.

BULLET MUG SHOTS When forensic scientists talk about bullets, they are referring to the metal slugs that zoom through gun barrels, not the gunpowder-packed cases that hold the projectiles before the shots are fired.

Bullets are intentionally made a bit too wide to fit easily through gun barrels. That way the hard barrel compresses the relatively soft metal of the bullet as the exploding gunpowder hurls the projectile down the barrel. The compression squashes the bullet slightly, enabling about a half-dozen spiral grooves cut along the barrel's inner wall to grab the bullet and make it spin. That spin stabilizes the bullet's imminent flight.

Between the spiral grooves are the so-called lands where the barrel is thickest. Those areas, which typically have unintentional microscopic scratches on them from their manufacture, squeeze the bullet the most and leave a signature of their scratches on its surface.

To check whether a bullet from a crime scene was fired from a specific gun, firearms examiners typically test-fire a bullet from the suspect gun and then compare the scratches on its land impressions to those on the crime-scene bullet. Bullet cases also get nicked and dinged by a gun, so examiners often scrutinize them, too.

The technology for making such comparisons hasn't changed much since the 1920s, when firearms examiners started using so-called comparison microscopes. Those devices optically present in one eyepiece side-by-side views of two different bullets, and an examiner judges their similarity for the court report.

However, in the past decade, technology developers have created automated bullet-matching workstations that meld traditional comparison microscopes with digital cameras, lasers, computers, huge databases, and image-analysis techniques. The result: an unprecedented tool for investigators that links crimes by automatically finding similarities among images of bullets or bullet cases from crime scenes or victims. However, courts don't accept as evidence the results of an automated search without verification by a firearms examiner looking at the actual bullets or cases with a comparison microscope.

In the early 1990s, the FBI and the Bureau of Alcohol, Tobacco and Firearms (ATF) each began installing different commercial versions of such systems in their crime labs. They also started electronically linking these systems via high-speed networks to serve wider regions. Ultimately, the two agencies opted to unite their sys-

tems and equip all the labs with the same type of workstation, called the Integrated Ballistics Identification System (IBIS).

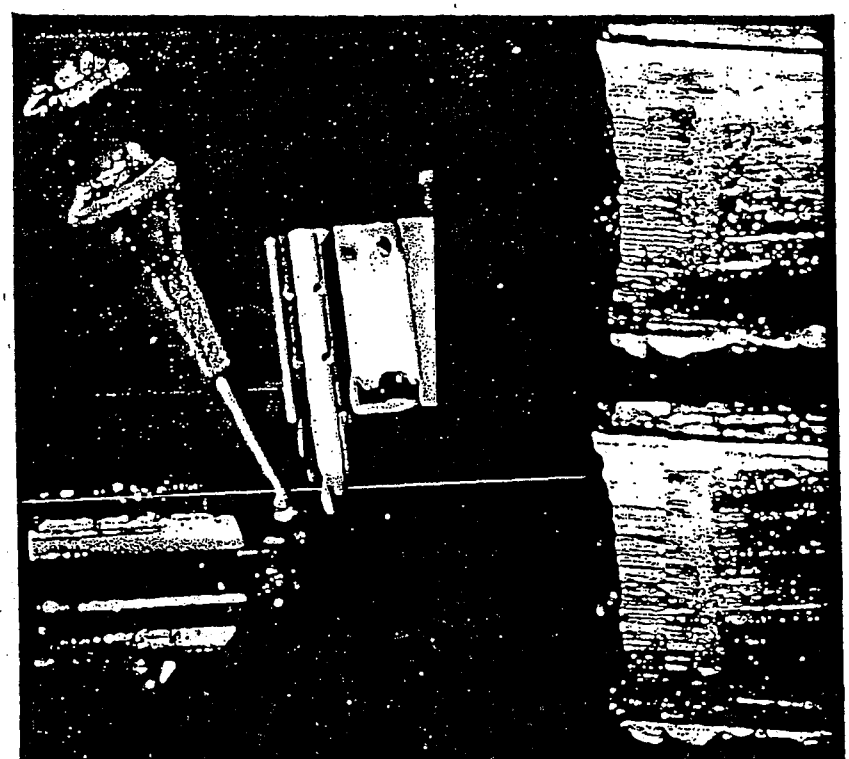
Last month, after a nearly 2-year push, computer specialists finished installing IBIS workstations into the last of the 233 U.S. crime labs slated to be on the national network, says Patricia Galupo, the network's director at ATF headquarters in Washington, D.C.

Labs in 28 other countries use the same type of workstations, says Richard T. Vaughn of Forensic Technology of Cote St. Luc, Quebec, the company that manufactures IBIS equipment. At least four other manufacturers, including one in the United States and three in Russia, also make automated bullet-identification systems.

Still to come for the U.S. network is full interconnection among its 16 multistate regions. Police in one region who want to check an image against the database of another region require the assistance of a technician at a computer center in Florida, Galupo says. That's the way such requests were also handled at the height of the Washington-area sniper investigation last October.

By April, high-speed data lines are slated to be in place between the regions, Galupo says. When the full network is running, the capability to conduct broader searchers will require only "an extra click or two of the mouse," she notes.

Even after April, however, police wanting multiregional or national searches will have to jump through extra hoops. That hierarchy is appropriate, Galupo argues, because the planners of the network considered multistate cases like the sniper shootings the exception rather than the rule. It would be cumbersome and slow to deal with a giant national database when most searches don't need it, she adds.



SCRATCHING THE SURFACE — To create a standard pattern, a diamond tip lubricated by drips of oil incises the surfaces of standard bullet blanks as they spin past (left). When viewed under a comparison microscope (right), scratches in the surfaces of commercial 9-millimeter bullets fired from the same pistol match (top), whereas scratches on bullets fired from different guns don't match (bottom). Each image shows a full land impression of each bullet, bordered by raised groove impressions at top and bottom.

FASTER THAN A SPEEDING BULLET This spread of bullet-matching muscle is supplying local investigators across the country with new leads in gun-linked crimes—often in cases that have long been in limbo.

The NIBIN Web site details many examples in which matches between bullets or cases pointed investigators toward links between previously unconnected crimes—even some that were years and long distances apart (*www.atf.treas.gov/nibin*). Many of these investigative breakthroughs also led to arrests and convictions.

Although it appears to work well, such bullet-comparison technology has its opponents. In particular, gun collectors and enthusiasts have argued that firearm signatures on bullets are too variable to be a reliable basis for linking the projectiles to specific weapons. Those critics have taken umbrage in particular at several state programs—none affiliated with NIBIN—that require registering, in a police-accessible database, microscope images of bullets shot from newly sold firearms.

In defense of the technology, ATF firearms examiner Martin G. Ols of the bureau's national laboratory in Rockville, Md., notes that many studies have demonstrated that bullet markings are unique to each gun. He also acknowledges that those markings do vary slightly as a gun is fired repeatedly. Because of that and the ongoing expansion of data sharing, the need for consistency checks and standards has become critical. "We want to make sure we get everything as uniform as we possibly can," he says.

At the urging of Ols and other ATF forensic scientists, therefore, a team of NIST researchers has designed "standard bullets." These resemble bullets randomly scratched as they were fired. This provides forensics scientists with precisely fabricated measuring sticks for testing the performance of bullet-comparison workstations, says NIST mechanical engineer Jun-Feng Song. He, physicist Theodore V. Vorburger, and their NIST colleagues are also developing methods for making realistic replicas of different bullet cases.

To acquire genuine scratch patterns to put on their standard bullets, the NIST team collected six bullets from the ATF and FBI. Each bullet had been fired from a different gun. Next, the researchers measured profiles of the bullets' surface ridges and grooves to accuracies of 20 nanometers in depth and a few micrometers across the surface. Then, working with Ols, the NIST researchers chose one land impression from each of the bullets to be reproduced on their bullet replica. Their goal was a single, versatile standard bullet with signatures from a half-dozen firearms.

To produce standard bullets, the NIST team first machined pieces of a copper alloy into bullet shapes. Metallurgists then electroplated those pieces with a millimeter-thick layer of pure copper. That created a surface with a microstructure both fine and uniform enough to accept the minuscule details needed to faithfully render a firearm's signature on a bullet.

Next, the NIST team cut the selected scratch patterns into the copper surfaces using a type of computer-controlled machine tool that was invented during the Cold War to hone superprecise nuclear-warhead parts.

Engraving the finely detailed bullet marks is slow work. A single impression requires 19 rounds of cutting, Song says. During each of those rounds, the diamond tip carves away no more than 10 micrometers of metal. To pattern 20 bullet replicas took about a month, but it was worth the wait, he says. Preliminary measurements show that the NIST standard bullets match each other to sub-

micrometer precision. Such reproducibility is a hallmark of a high-quality standard reference item.

Those painstaking efforts have caught the attention of forensic scientists on the other side of the Atlantic Ocean. Last fall, European firearms specialists invited Song and Vorburger to discuss the standard bullets and their uses at a forensic science meeting in Bratislava, Slovak Republic.

The new standard bullets are "the only means for a proper quality control of an automated [bullet-comparison] system" and should be delivered with those systems, comments Bert van Leuven of the Netherlands Forensic Institute in Rijswijk, who extended the invitation to the NIST researchers.

In Florida, a not-for-profit, nongovernmental organization that assists crime labs plans to convene a panel of ballistics experts early this year to study the NIST bullets, says David M. Epstein of the National Forensic Science Technology Center in Largo. If the panel approves the standard bullets, the center may buy many of them from NIST and—much like a lending library—make those reference materials available to labs as needed for quality control. He says the bullets are expected to cost about $2,000 each.

To test standard bullets' uniformity, the NIST team also devised a computer program that mathematically compares bullets' surface profiles and generates a number to indicate how well the profiles match. Song says that the NIST researchers wrote their own bullet-comparison program rather than use IBIS scores because the workstation manufacturer keeps its image-analysis algorithm secret. From IBIS scores alone, the NIST team would not have known exactly how the bullets were being compared, he notes.

The new way to numerically compare bullet profiles could have other implications, some members of the NIST team speculate. Hard numbers play well in court. For instance, when prosecutors present DNA evidence that links a suspect to body fluids found at a crime scene, they can cite statistics indicating how close the genetic match is. In contrast, a firearms examiner can offer only his or her expert opinion that a pair of bullets do or don't match.

A public-domain algorithm like that of NIST, which yields an independently verifiable number for how well two bullets match, might provide firearms examiners with an unprecedented opportunity to harden their testimonies, suggests NIST forensic scientist Susan M. Ballou.

Regardless of whether this happens, standard bullets are poised to play an important, behind-the-scenes role in making automated bullet identification a more effective crime-fighting tool. ■

Name: Date:

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By Peter Weiss

Answer the following questions WITH COMPLETE SENTENCES.

1. How many people were shot in the sniper shootings mentioned in this article? Where did it take place? What month and year did it take place?

2. What evidence was linking the shootings?

3. What is the National Integrated Ballistic Information Network?

4. What is the critical component that will fine tune the NIBIN?

5. How is the National Institute of Standard and Technology helping improve bullistics?

6. What is meant by the word "bullets"?

7. How do you check whether a bullet from a crime scene was fired from a specific gun?

8. What are Integrated Ballistics Identification Systems?

9. What are the opponents saying?

10. What does Martin G. Ols state in the article?

11. How do the NIST team acquire genuine scratch patterns o their standard bullets?