U.S. Department of Justice
Bureau of Justice Statistics

Automated Fingerprint Identification Systems: Technology and Policy Issues

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Automated Fingerprint Identification Systems: Technology and Policy Issues

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Preface

Automated Fingerprint Identification Systems (AFIS) technology has provided law enforcement with an invaluable tool for positive identification. AFIS allows law enforcement agencies to conduct comparisons of applicant and suspect prints with literally thousands or millions of file prints in a matter of minutes. This increased productivity is attended by increased accuracy rates and increased detection of alias usage. In latent fingerprint identification, where a crime scene yields no evidence other than the suspect's fingerprints, AFIS now can make computerized comparisons with file prints in minutes, providing a capability that would have taken hundreds of hours of manual searching and would have had little hope of success.

The Bureau of Justice Statistics believes that AFIS technology adds a significant capability to operational criminal justice information systems to generate the accurate and reliable data essential to the development of criminal justice research and statistics. This report describes the revolution AFIS technology is creating in both ten-print and latent fingerprint processing, the impact it is having on law enforcement capability, and its potential impact on information law and policy.

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Introduction

Automated Fingerprint Identification Systems (AFIS) technology is creating a revolutionary impact on law enforcement capability to apprehend offenders and solve crime. Its accuracy in searching and matching fingerprints is as high as 98 to 100 percent. In jurisdictions that have implemented AFIS, identification rates have increased dramatically. The sensational California "Night Stalker" case was broken by a latent print lifted from a stolen car. At the California Department of Justice, the print was entered into the state's new AFIS, and the hit on alleged serial killer Richard Ramirez was made in a matter of minutes. The first latent print run against San Francisco Police Department's AFIS data base had been the subject of thousands of hours of manual search methods over an eight-year period. The print belonged to the killer of Miriam Slamovich, a World War II concentration camp survivor, who was shot point blank in the face by an intruder in her home in 1978. Her assailant left a full, perfect print at the scene, but with no suspect and no other clues, there was little chance of making a match on existing file prints by conventional manual searching methods. Police detectives doggedly pursued the case, however, and when the AFIS system was implemented in 1985, it matched the print in six minutes. Slamovich's alleged killer was in custody the same day.

With the new generation of AFIS technology, law enforcement agencies around the country are breaking cases that previously would have gone unsolved. Law enforcement officials are saying that AFIS technology finally has brought the use of fingerprint evidence into the twentieth century and promises to spur clearance rates more than any other single law enforcement tool. AFIS may well have the greatest impact of any technological development on law enforcement effectiveness since the introduction of computers to widespread use in the criminal justice system in the 1960's.

The heart of AFIS technology is the ability of new computer equipment to scan and digitize fingerprints, to automatically create a spatial geometry or map of the unique ridge patterns of the prints, and to translate this spatial relationship into a binary code for the computer's searching algorithm. Making incredibly fine distinctions among literally thousands or millions of prints, an AFIS computer can compare a new fingerprint with massive collections of file prints in a matter of minutes and can make identifications that previously were possible only through a time-consuming and error-prone process of manual comparison. This report is intended to provide a brief introductory look at this new technology. It will explain in non-technical terms how AFIS technology works, the present status of AFIS implementation in the United States, and the impact the technology is having on law enforcement processes and other components of the criminal justice system. It also will identify a number of policy and legal issues related to the implementation and operation of this revolutionary new technology.

Traditional fingerprint methodology

To fully appreciate how the AFIS technology works and the impact it is having on fingerprint processing, it is necessary to understand how fingerprints are processed in the manual classification systems now in use in most law enforcement agencies and the role of fingerprint identification in the criminal justice process.

Manual classification systems

Based upon the unique and unchanging patterns of ridge detail on each individual's fingers, law enforcement agencies throughout the world have established fingerprint comparison as the universal method of verifying identification and ensuring the integrity of criminal record systems. To support the investigation and identification functions, criminal record repositories and identification bureaus in the United States have established files of fingerprints that are often massive. Generally, these files are of two types. The most extensive files are rolled inked impressions maintained on ten-print cards filed according to some classification system. Typically, these fingerprint cards are prepared at the time of an individual's arrest and are used to verify his identity and to determine whether he has a prior criminal record. Ten-print cards also are often submitted in connection with certain employment or licensing applications to determine whether the applicant has a criminal record that would legally bar him from being hired or obtaining the license.

The other general type of fingerprint records are so-called "latent" fingerprints developed as a result of criminal investigations. These prints generally are obtained at crime scenes or from documents or material related to the crimes. Latent fingerprints developed in this manner usually occur as isolated single finger impressions or as fragmentary parts of two or three adjacent fingers. They are often of poor quality.

It was apparent from the beginning of fingerprint retention that it would be necessary to devise a system that would not require incoming search prints to be compared with every fingerprint card already on file. Manual comparison and elimination of prints is a time-consuming and expensive process. As file sizes increase, such searches become more difficult until, at some point, a successful match becomes improbable, if not humanly impossible. From its inception until recent years, therefore, fingerprint identification methodology has been predicated upon the necessity of dividing file prints into classification categories based upon distinctive ridge patterns to eliminate the necessity of searching the entire file. (Exhibit 1, page 4, shows a standard FBI fingerprint card with both Henry and NCIC classifications.)

The first successful fingerprint classification system was developed at the turn of the century by Sir Edward Henry, an Englishman who served as Inspector General of Police in India and as Commissioner of London's Metropolitan Police. The Henry System, which, with improvements, remains the predominant classification system in use today, classified fingerprints by assigning each finger to one of two primary fingerprint pattern types—whorl or non-whorl. The fingerprints were represented as a unit rather than as individual fingers by assigning to each ten-print set an alphanumeric designation reflecting the pattern characteristics of all ten fingers. Thus, two pattern types times ten fingers yielded 2^{10} or 1,024 classification categories into which to subdivide fingerprints.

This was a manageable and workable system for file sizes then in use, despite the fact that the most common classification category was found to contain about 25 percent of all fingerprint records. However, considering that the FBI now maintains approximately 23 million criminal fingerprints and the state of California maintains approximately 7.5 million fingerprint cards in its state repository, it is obvious that the basic Henry System would not work for today's file sizes. As a result, the history of fingerprint technology development until very recently has been one of devising extended classification subcategories to enable the Henry System to accommodate increased numbers of prints. In recent years, the portion of fingerprints in the most common classification category has decreased from 25 percent to 6 percent. Nevertheless, 6 percent of the FBI's files is still a very large number to search. In addition, as increasing file sizes have necessitated more complex rules for subclassification, human judgment has come more into play, with the result that particular technicians might classify fingerprints differently. Misclassification, of course, results in the risk of missed identifications.

For latent print searching, the Henry System's inherent limitation is that it classifies the ten fingers as a unit rather than as separate fingerprints. A single latent print cannot be filed or searched as a unit. In manual classification systems, therefore, if the results of comparing latent prints with the prints of known suspects are negative, the latent impressions usually are filed for future reference in an "unsolved latent" file.

Manual fingerprint processing

As noted, fingerprint cards are submitted to identification bureaus or criminal record repositories primarily as a result of an arrest or a criminal investigation or in connection with applications for employment or licensing. These ten-print cards are searched against existing criminal fingerprint files to determine whether the individual has a prior criminal record. Whether the search is for criminal justice or noncriminal justice purposes, the process begins with a so-called "name search." The individual's name, date of birth, sex and other identifying information are taken from the incoming fingerprint card and searched against a master name index. In most of the states, this part of the search process is fully or at least partially automated. If a match or a close match is found in the name index, the file fingerprint cards associated with the match candidates (usually only one or two cards per search) are retrieved and are manually compared with the incoming search card by a fingerprint technician to verify positive identification. In the processing of criminal fingerprint cards, the great majority of successful matches, or "hits," are made in this relatively quick and inexpensive way—name search verified by manual fingerprint comparison. Statistical information developed recently by the state of California[1] indicated that approximately 47 percent of arrested persons are found to have prior criminal records through the process of identification by the name search and verification by fingerprint comparison.

If the results of the name search on an arrest fingerprint card are negative, the fingerprints are classified by a trained technician and a "technical search" is performed to ensure that the individual has not escaped identification by using an alias or as a result of clerical error in conducting the name search. Manual technical searches are extremely time-consuming and expensive. Although the classification of the fingerprints limits the search to a portion of the entire file, it is still necessary to compare the search card with all of the file cards within that classification, plus additional cards on either side of the classification to compensate for possible classification errors in the search print or file prints, or both. In large files, this can entail a review of hundreds of file cards. But, for criminal prints, these searches may be quite productive. According to the California statistics noted above, 47 percent of arrestees are identified by name search. By conducting a technical search of the entire file, an additional eight percent of those arrested will be discovered to have criminal records, bringing the total to 55 percent.[2]

Noncriminal ("applicant") fingerprints submitted for employment and licensing purposes yield much different results. Statistics developed by the FBI[3] indicate that only about five percent of employment and licensing applicants are identified as having previous criminal records. An additional 1.5 percent of the applicants are identified through technical searches, bringing the total to 6.5 percent. This means that 95 percent of all applicant fingerprint cards must be classified and manually searched (i.e., those not identified by name search), and that the hit rate on them will only be one or two percent. It is hardly surprising, therefore, that most state record repositories process noncriminal justice cards by name search only, regarding technical searches as unjustifiable because of their high cost and low productivity.

As noted earlier, latent fingerprints cannot be classified and searched under the Henry System. Thus, latent prints usually are searched only against the file prints of known suspects and, if there is no match, the prints are placed in an unsolved latent file. If there is an extremely high priority on the case, the latent print may undergo a file search with little or nothing to limit the search. Such efforts are known as "cold searches" and the rare resultant hits are referred to as "cold makes."

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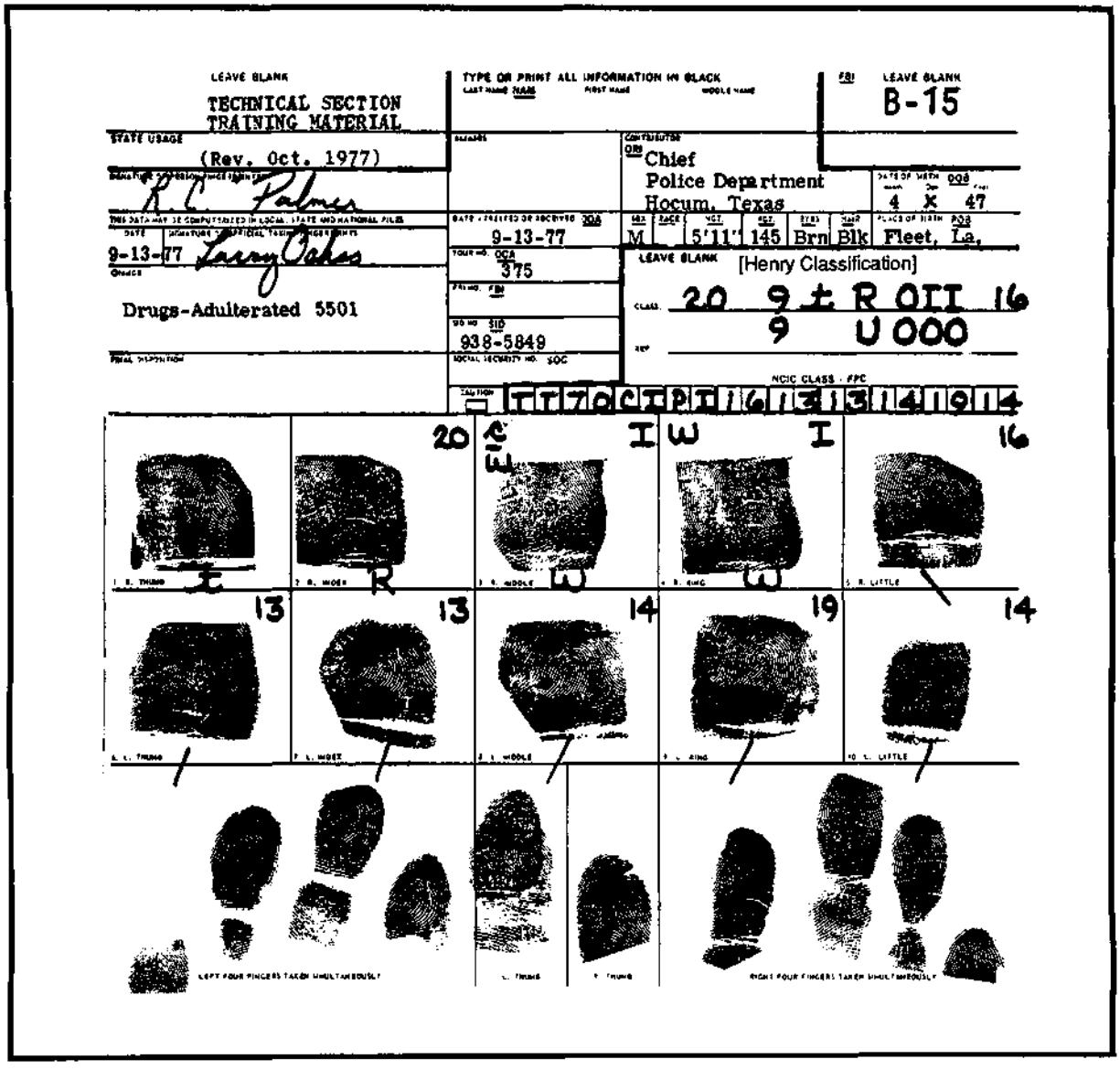
[1] *Tracking Juvenile Recidivists: Three Options for Creating Statewide, Longitudinal Records of Juvenile Offenders*, California Department of Justice, Bureau of Criminal Statistics and Special Services, August 1985, pp. 36-37.

[2] ibid, pp. 36-37.

[3] *A Study to Identify Criminal Justice Information Law, Policy and Management Practices Needed to Accommodate Access to and Use of III for Noncriminal Justice Purposes*, prepared for the FBI by SEARCH Group, Inc., September 1984, p. 58.

Exhibit 1
Fingerprint Card With Classifications



A typical fingerprint card with rolled inked impressions, along with an extended Henry Classification and NCIC Classification.

Source: Federal Bureau of Investigation

How AFIS technology works

Digital image processing

What has revolutionized fingerprint identification technology in the 1980's is the ability of newly-developed computer equipment to scan fingerprint impressions and automatically extract identifying characteristics in sufficient detail to enable the computer's searching and matching algorithms to distinguish a single fingerprint from thousands or even millions of file prints that have been similarly scanned and stored in digital form in the computer's memory. This concept of computerized digital image processing has eliminated the necessity for time-consuming and error-prone manual classification and comparison of fingerprints. It has greatly increased the speed and accuracy of ten-print processing and has made it possible to conduct cold searches on latent prints against very large fingerprint files. Thus, it has significantly improved the efficiency of the criminal identification process and has added an important new crime-solving capability to the law enforcement arsenal.

Fingerprint scanning

What is perhaps most extraordinary about these new systems is the sophistication and intricacy of the scanning and mapping algorithms, which convert the unique spatial relationship of a fingerprint's ridge endings and ridge bifurcations, called "minutiae points," and additional ridge direction and ridge contour information into a digitized representation of the fingerprint. In a ten-print to ten-print search on good quality rolled impressions, the computer plots the spatial relationship of 90 or more minutiae points for each finger, a number high enough to distinguish the uniqueness of that print from all others and to make it virtually certain that the computer will be successful in matching the candidate prints with the prints in the file. (Exhibit 2, page 8, shows the detection of minutiae data on a rolled print.)

Latent prints have less minutiae data for the scanners to map, but the systems are able to work with only a portion of the minutiae map and can score matches with an average of only 15 to 20 minutiae points. One law enforcement agency reported a hit on a fragmentary print which yielded only eight minutiae points.

In preparing fingerprints to be searched, the system allows the technician to enhance the prints, correcting for breaks in the skeletal pattern, cuts or breaks in the ridges caused by scars or burns. The system can even provide an evaluation of the quality of the print, disqualifying inferior prints. This print enhancement capability is especially important in searching latent prints, since it enables an experienced technician to fill in missing or blurred portions of print fragments to produce more useful images for the computer to work with. (Exhibit 3, page 9, shows the computer enhanced ridge tracing on a latent print.)

Computer searching

Equally sophisticated are the search algorithms used in the new AFIS systems to convert the minutiae data and ridge direction and contour data extracted by the scanner into a unique binary code that the computer can use in searching its files. The search algorithm determines the degree of correlation among the location, angle and relationship of the minutiae of the search print and the minutiae patterns of file prints. (Exhibit 4, page 10, shows the plotting or mapping of the relationship of minutiae.) The computer is not actually comparing fingerprint images in its search; it is conducting a mathematical search that will provide a candidate list of those binary codes in the file most similar to the binary code used in the search.

The mathematical search is carried out by an AFIS system component called a matcher, which can search a candidate print against the file prints at a rate of 500 to 600 prints per second. Matchers operate in parallel, each taking a portion of the data base. As file size increases, matchers may be added so that there need be no diminution of searching speed. Average searching time is, however, relative to a number of factors including the number of matchers employed, time spent in preparing and enhancing the prints, entering demographic data to limit the number of prints to be searched, and the time the candidate prints wait in the system's queue (temporary memory storage) prior to the search process. Search time for a ten-print search (rolled print to rolled print comparison) in a file of under 500,000 is a matter of minutes. For a latent search, the search time averages about one-half hour.

During the search for a mathematical match, the computer uses a scoring system that assigns points to each of the criteria used in the match. The technician sets a threshold score above which he has assurance that a match has produced a hit. At the conclusion of the search, the system reads out the candidate list, the number of which is defined by the technician as a search parameter. Based on parameters set in the scoring system, the score of the candidate in the number one position, if high enough, indicates that the match is probably a hit. If the score is low, it means that the system has chosen the selected number of candidates most similar to the search print, but there

is little probability of a hit. The optimal functioning of an AFIS would produce a hit on the candidate in the number one position every time and the score would be high enough to leave no doubt. (Exhibit 5, page 11, shows a computerized comparison of the minutiae of a latent search print with the file print, along with fingerprint classification and search candidate scores.) For the 10-print search, fingerprint experts are reporting that in approximately 98 percent of the prints that are matched, the candidate's score met the threshold and was in the large number one position.[4] This level of accuracy, which is made possible by the number of minutiae available from rolled prints, eliminates the necessity of comparing the search prints with the file prints of the other candidates on the list. If all of the candidates fall below the threshold score, then there is a high probability that the candidate's prints are not in the system. Nevertheless, some AFIS systems have policies calling for review of some of the candidate prints in such cases as an added precaution against missed identifications. For example, California Department of Justice's California Identification System (Cal-ID) policy requires comparison of the search prints with the file prints of the candidate in the number one position if there is a sizable differential between the scores of the number one and two positions. For latent searches, where there are fewer minutiae to work with, comparisons may be made on as many as three to five candidates. Again, as a policy matter, Cal-ID checks only the number one candidate for verification in property crimes, but checks up to three candidates for person crimes. Cal-ID's policies governing the verification process are the result of careful study and testing of its AFIS performance relative to candidate position and hit frequency. Such policy determinations, in general, factor technical performance, cost, time, and the priority given to particular kinds of crimes.

Finally, it is important to note that an AFIS makes no final decisions on identity. While the score may virtually guarantee a hit, only the trained eye of the fingerprint technician will make the final verification. The use of the fingerprint as evidence in court requires the fingerprint technician to prove, by a comparison of measurements and points of minutiae on the latent and file prints, that the prints match. For verification, an AFIS assists but does not replace the fingerprint expert.

Image retrieval

The latest technological development in AFIS is image storage and retrieval. It is essentially a by-product of the initial conversion process by which the search print is read into the system in digital form. New image storage and retrieval technology allows the digitized fingerprint images used to plot the minutiae to be stored on an optical disk and retrieved at a later time for comparing candidate lists with the search prints. It allows the digitized search prints and the retrieved image of the candidate file prints to appear side by side on the operator's screen for comparison. This gives the technician the distinct advantage of not having to leave the terminal to retrieve the prints. Without image storage and retrieval, the process entails going to the hard-copy file of rolled prints to collect the prints of candidates to be compared with the search prints. As a less costly alternative to image retrieval, some law enforcement agencies use microfilm and microfiche readers to speed the verification process.

Sharing of AFIS data

A question frequently asked is whether AFIS computers can communicate with AFIS computers in other jurisdictions. The answer is that if they are from the same vendor, that vendor has the technical capability to allow the two systems to share data. If the AFIS computers are not from the same vendor, then the answer is no, the computers cannot "talk" to each other directly because the algorithms and communications protocols are different. The technology is incompatible simply because the computers of the various vendors were designed differently. Thus, one AFIS computer cannot search the files of another AFIS computer of a different manufacturer.

Rather than seeking compatibility among AFIS computers of different vendors, AFIS technology is moving toward the development of a national standard for the interchange of fingerprint data and images. Since an AFIS computer works by having an input device read and digitize a rolled fingerprint image, what the computer needs from another jurisdiction is digitized fingerprint image data and personal identification information, or demographics, to limit the search. Simply stated, an AFIS computer just needs good fingerprint images that it can read on its own terms. On August 25, 1986, the American National Standards Institute accepted the standard entitled

[4]Proceedings of a SEARCH National Conference on Automated Identification Systems. Sacramento: SEARCH Group, Inc. (forthcoming). The conference was conducted in Kansas City, Missouri, February 26-28, 1986, and included managers of operational Automated Fingerprint Identification Systems, who were in general agreement on performance capabilities of new AFIS technology.

"Data Format for the Interchange of Fingerprint Information" (NBS/ICST-1-1986), which was developed by the Institute for Computer Sciences and Technology of the National Bureau of Standards (NBS). Most observers believe that this NBS standard for electronically transferring fingerprint images will pave the way for the sharing of fingerprint data among law enforcement agencies in a form that can be utilized by all AFIS systems.

Another method for sharing data is facsimile technology. Facsimile-reproduced fingerprints represent a low-cost method of transmitting fingerprint images from remote sites to the AFIS computer. The critical questions are whether the facsimile prints are of sufficient quality to use as substitutes for the inked impressions in the AFIS, and whether there will be a degradation in the scores produced in the search. Thus far, the testing of facsimile image transfer and use in AFIS systems has shown that good quality facsimile copies of good quality inked prints can meet search accuracy requirements.

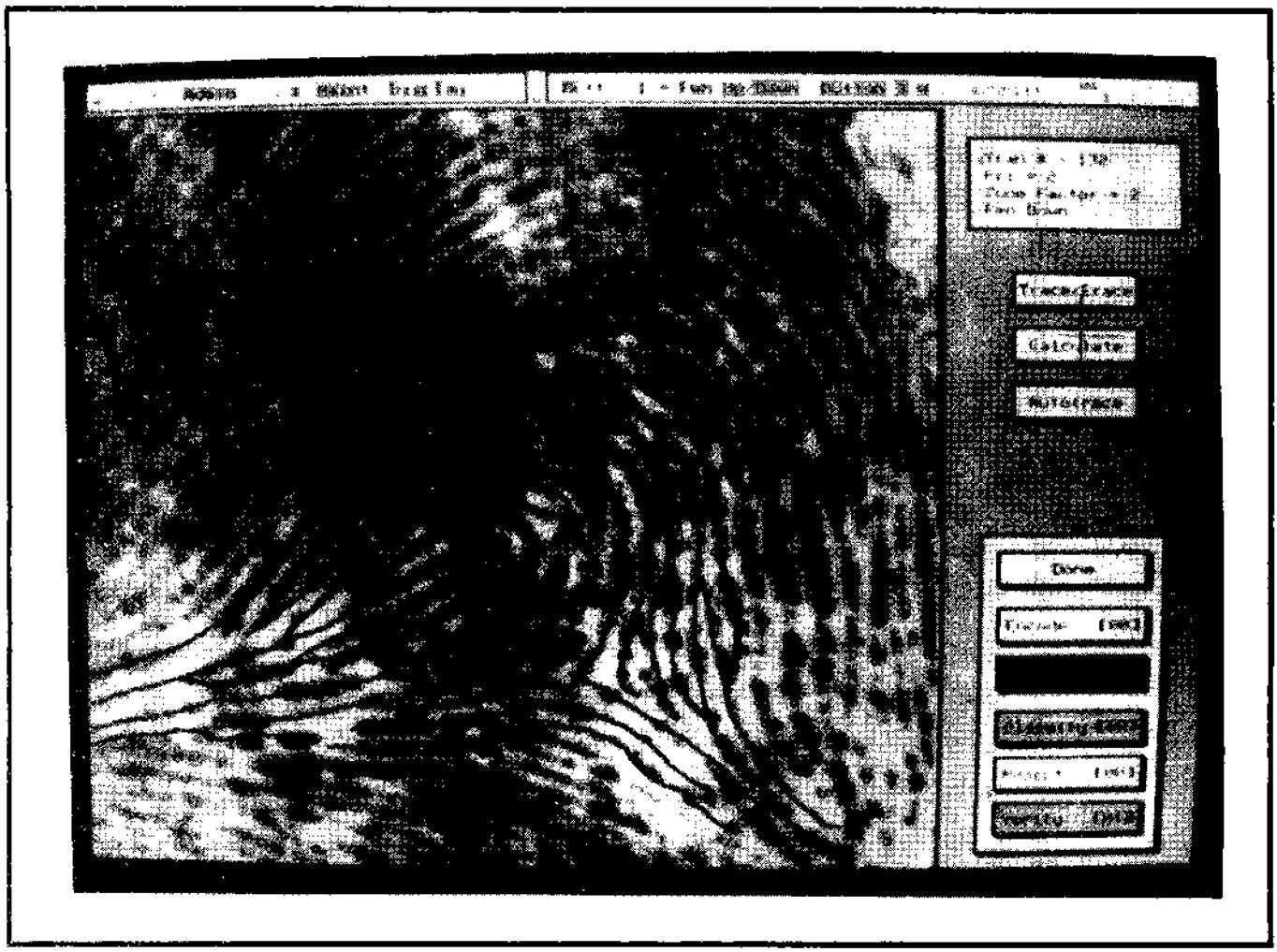
The future for sharing fingerprint data among law enforcement agencies looks very good. Capabilities at present are limited, but the experiments in image transmission standards and facsimile transmission of prints promise that the technology is not far from becoming an operational reality.

Exhibit 2
Minutiae Detection

Minutiae detection shown by white markings (shown in color on computer screen) at ridge endings and bifurcations.

Source: North American MORPHO Systems, Inc.

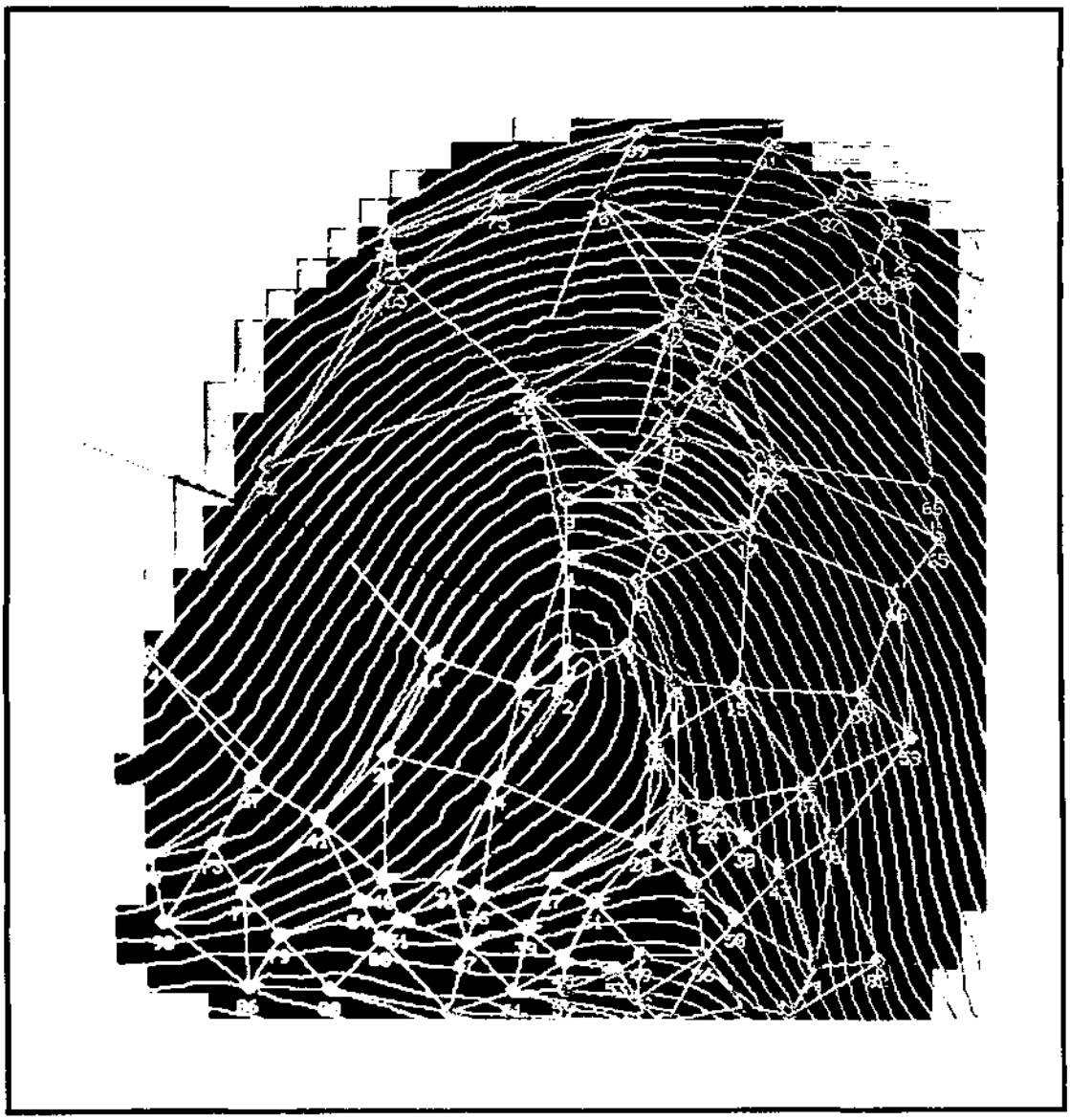
Exhibit 3
Enhanced Ridge Tracing



Computerized enhancement of ridges shown as black line tracings (shown in color on computer screen).

Source: Identification Security Systems, Inc.

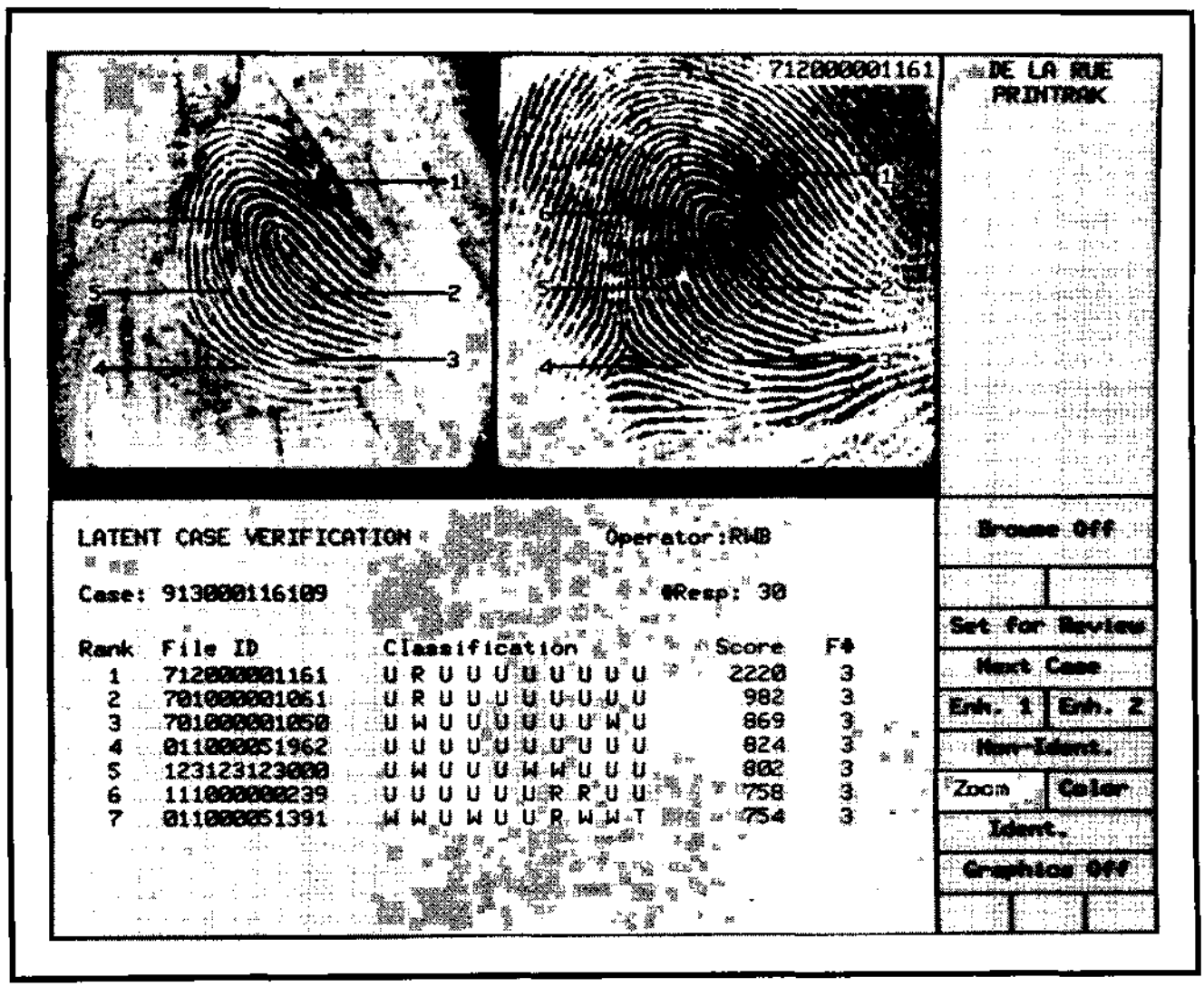
Exhibit 4
Minutiae Patterns



Minutiae positions, directions, and relationships shown as unique pattern (shown in color on computer screen).

Source: NEC Information Systems, Inc.

Exhibit 5
Latent Fingerprint Comparison



Computerized comparison of the minutiae of a digitized latent fingerprint (left) with a digitized file print (right). Lower portion of screen shows candidate list, classification and scoring system.

Source: De La Rue Printrak Inc.

Impact on law enforcement capability

What kind of impact will the new AFIS technology have on the functions of law enforcement? First and foremost, it seems certain that the technology will significantly increase the *efficiency* of the ten-print search and the *effectiveness* of the latent search, with attendant cost and manpower savings and greatly increased crime-solving potential.

Ten-print processing

The ten-print to ten-print search—the comparison of newly-rolled prints with rolled file prints—is the bread and butter of both criminal and noncriminal identification. As noted earlier, virtually all identification bureaus and criminal record repositories begin the processing of fingerprint cards by conducting a search of their master name indexes. This will continue to be the prevailing practice in agencies with AFIS systems. Nationally, some 50 to 55 percent of name searches result in identifications. With manual systems, some agencies stop here; if no hit is produced, they do not conduct a technical fingerprint search because such searches consume too much manpower. The majority of agencies, however, conduct a manual technical fingerprint search when there is no hit on the name search. Manually classifying and comparing fingerprints requires a significant investment of time and people. With an AFIS, those remaining 45 to 50 percent of incoming fingerprint cards that do not produce a hit on the name search can undergo a fast, efficient and accurate technical fingerprint search.

Available information suggests that manual fingerprint searches on a national basis achieve an accuracy rate ranging from 60 to 74 percent.[5] (Accuracy in fingerprint terminology is a measure of the ability of the system to locate a print that is in the data base. Failure to locate a print in the file can be attributable to a variety of factors, including errors in data entry, classification, filing, and comparison, as well as errors in the search algorithm and scoring system. Accuracy rate is different than hit rate, which measures the percentage of candidate prints that are matched with file prints.) At the upper boundary, a 74 percent manual accuracy rate is an impressive figure in one sense, given the vast numbers of fingerprint records in criminal history files; but it still means that one in four potential fingerprint identifications is missed. The AFIS technology has changed these numbers dramatically. In agencies that have implemented AFIS systems, the accuracy rate of ten-print fingerprint searches has improved to an estimated 98 percent, and 99 percent in systems with a million records or less.[6] In the first few months of operation, the AFIS system in Baltimore, Maryland identified 525 arrestees using aliases. The San Francisco Police Department estimates that as many as 17 percent of arrestees lie about their names and other identifying information, but still are identified by the Department's AFIS system.

It is not surprising that the increased speed and accuracy of AFIS equipment produces greatly increased efficiency in state-level ten-print functions that must accommodate large volumes of searches against massive files. California officials have reported that the California Department of Justice's CAL-ID statewide AFIS system in its early stages of operation has achieved a productivity increase of 300 to 400 percent in the processing of ten-print cards. The system is now processing 1,000 to 1,400 fingerprint cards a day using 12 people. In a manual mode, that level of production would require an estimated 46 to 50 people. CAL-ID officials project an eventual savings of 50 percent reduction in the costs of ten-print processing, which is on the order of $2 million annually.[7]

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[5] See Terry Lindh and Stephen Ferris. *Fingerprint Identification Systems* (Paper prepared for presentation at the Automated Fingerprint Identification Seminar, University of Tennessee Space Institute, April 15-17, 1985), p. 28. In a national survey Lindh and Ferris found a 60-65 percent manual accuracy rate. Inspector Ken Moses, Crime Scene Investigation Unit, San Francisco Police Department, conducted a national survey in 1979 and found a 74 percent manual accuracy rate. Experts agree that the range in percentage is largely attributable to the degree of thoroughness of the actual comparisons of the suspect print with the file prints.

[6] *Proceedings of a SEARCH National Conference on Automated Fingerprint Identification Systems, op. cit.* For example, Peggy A. James, Latent Print Examiner, Houston Police Department, reported that in its six years of operation, Houston's AFIS has missed 750 10-print records known to be in a data base, a figure representing one-half of one percent of the 151, 237 records in the data base.

[7] California Identification System CAL-ID Project, Project No. 2100-23, Feasibility Study Report Update, October 15, 1984, California Department of Justice; page 4.

Latent print processing

The latent to ten-print search, which runs a crime scene print against files of criminal and noncriminal ten-print cards, is the crime-solving function of identification bureaus. As stated earlier, manual searches of latent prints are exceedingly time-consuming and costly and yield little results even when there are suspects and other information to limit the number of comparisons that must be made. Although an estimated 35 percent of crime scenes yield usable latent prints, very few identifications have resulted from manual searching methods. A study of four major metropolitan police departments conducted by the Rand Corporation found that the hit rate for manual latent searches ranged from four to nine percent.[8] Moreover, most agencies will only conduct manual latent searching when there are suspects or other information to limit the search. "Cold makes," which are based on the latent print alone, are rarely undertaken.

The speed and accuracy of the AFIS technology, however, makes it possible to search a single latent print against the individual fingers of thousands or even millions of file prints in a matter of minutes. Not surprisingly, the impact of the technology on latent print processing has been phenomenal. In its first two phases of development, CAL-ID entered 420,000 fingerprint cards into the file that is used for latent searching. The file includes persons born in 1950 or later who have been convicted of a felony, a group that is estimated to represent only 34 percent of the AFIS data base but 47 percent of daily AFIS activity.[9] When the file is fully implemented, the latent file will contain 1.5 million records of individuals with felony convictions born 1940 and after. CAL-ID is now experiencing a hit rate of 15 percent on latent searches and officials project an increase in the hit rate to 18 percent. In its first year of operation, the San Francisco Police Department's AFIS system conducted 5,514 latent print searches and made 1,001 identifications, a hit rate of 18 percent. San Francisco cleared 816 of those cases, including 52 homicides, compared to 58 cases cleared the previous year on the basis of latent print identifications.

In Houston, 4,645 latent searches have resulted in a hit rate of 13 percent, clearing over 600 cases that officials say could not have been solved any other way. One hit cleared 30 cases in five counties. In Prince George's County, Maryland, an AFIS computer shared by six city and county police departments made 150 hits in its first nine months of operation, including one hit that cleared some 40 burglaries.

Law enforcement officials believe that the AFIS systems not only are helping to solve crimes that otherwise would not have been solved, but are putting chronic offenders in jail and halting repeat offenses. By the end of fiscal year 1985, San Francisco had convicted and sentenced over 900 burglars identified by its AFIS, which has been credited as a contributing factor in the city's 26 percent drop in burglaries.

Fingerprint lifting techniques

The identification of latent prints by an AFIS begins at the crime scene where the fingerprints must be detected and developed. When a finger touches an object, it leaves a residue of water, oils, salt, amino acids, and other chemicals. When detected, the crime scene print will show the ridge patterns and minutiae needed to make comparisons with file prints. Historically, however, finding and raising crime scene prints have met with limited success. Too often the prints were not immediately visible, or were of poor quality, or could not be made visible on certain surfaces. The traditional method of carbon dusting powder required relatively fresh prints on certain surfaces and with ample amounts of residue. Powder works well on glass and hard surfaces, but not on paper, fabric or other porous surfaces that absorb the moisture and salts left by the fingers. Before the advent of today's AFIS technology, those hard to find and develop crime scene prints met with little success in manual identification.

Today, a revolution is taking place in the technology of detecting and lifting crime scene prints. The principal new techniques involve the use of chemicals and lasers. One of the first chemicals that was enlisted to assist the dusting method was ninhydrin, an oxidizing agent that colors or stains the amino acids and makes visible the ridge patterns. Ninhydrin works effectively on surfaces such as paper. Research is being conducted to use chemicals that will restore amino acids to faint prints that have lost their moisture, thereby making them visible and usable.

[8] P. Greenwood, J.M. Chaiken, J. Petersilia. *The Criminal Investigative Process*. New York: D.C. Heath and Company, 1977; pp. 162-165. Of the four cities examined in the study, three had approximately the same percentage rate of identifications from latent prints: Miami, Florida had 9.0 percent; Richmond, California had 9.9 percent; and Los Angeles, California had 9.1 percent. Washington, D.C. had 4.3 percent.

[9] ibid, pp. 5-6.

One of the most recent and effective chemicals enlisted in fingerprint detection is cyanoacrylate, which is common household super glue. In its gaseous state, super glue's vapor attaches itself to fingerprint chemicals, turns them white, and hardens them. It works well on fabric and plastic, which are materials that render dusting powder ineffective. Until recently, cyanoacrylate took too long to harden, sometimes up to thirty days. Now there are hardening catalysts, such as sodium hydroxide, that reduce the developing process to 15 to 20 minutes. Super glue can be used at the crime scene if the evidence can be enclosed in a chamber filled with the glue's vapor. The Orange County Sheriff's and Coroner's Office uses common PCV pipe and and plastic sheeting to erect enclosures around large items such as automobiles, as it did in the case of the alleged California "Night Stalker." When the plastic is sealed, the super glue vapor is injected and prints develop on the outside of the automobile. Super glue was also instrumental in developing a print on a pillow case in a rape case.

Lasers are detecting fingerprints on surfaces on which dusting or chemicals have proven ineffective. An intense flood of green laser light can detect florescence in the chemicals found in fingerprint residue, even in very small quantities. Riboflavin, along with other chemicals in fingerprint residue, emits electromagnetic radiation that glows in laser light. An object flooded with the green light from argonion lasers will allow technicians wearing orange goggles to see fingerprints not visible to the naked eye. When prints are faint or blurred by other background materials, florescence can be induced by florescent powders and stains, thereby restoring the florescence needed to develop the print. The FBI employed a laser to detect a fingerprint of a Nazi war criminal on a postcard; the print was 40 years old. Lasers are used mostly in the laboratory because of their size, although smaller, more portable units currently are being tested at crime scenes.

The fingerprint lifting techniques of dusting powders, chemicals and lasers are complimentary, and are routinely used in combinations, since one will detect prints where another cannot. They are used in sequence, as well. For example, traditional carbon dusting would be ineffective once an object had been subjected to super glue. In the case of the California "Night Stalker," success was achieved using both traditional methods and newer methods utilizing chemicals and lasers.

Photographic and telecommunications technologies are also being used to lift and transmit prints to the AFIS. The Orange County Sheriff's and Coroner's Office is experimenting with a remote television camera linked to telecommunications lines that could allow an electronically captured print to be transmitted directly from the crime scene to Cal-ID. Orange County's director of forensic sciences foresees the day in the near future when a crime scene print sent to Cal-ID for instant processing will allow an all-points-bulletin to be issued on a suspect in a matter of minutes.

The advent of AFIS technology and improved fingerprint detection and developing techniques have brought new life to crime scene units. As mentioned earlier, a latent print with no other identifying information had very little chance of being matched by manual comparison. One crime scene investigator in the San Francisco Police Department estimated that a manual search of the 300,000 fingerprint cards would take 33 years working eight hours a day, seven days a week. Similarly, a recent hit made in minutes on Cal-ID's AFIS would have taken 67 years of manual searching. The crime scene units now know that if they can get the print, they have a very good chance of identification. The new technologies for lifting prints enhance that identification potential.

AFIS implementation

Considering the demonstrated effectiveness of the AFIS technology, it is not surprising that implementation of AFIS systems in law enforcement agencies throughout the country is progressing rapidly. Due to the high cost of the systems, however, it is also not surprising that implementation has been confined to the federal level (the FBI), state identification bureaus and large cities and metropolitan areas. At the federal and state levels, acquisition and operation of AFIS equipment can be justified primarily by increased efficiency in processing the large numbers of ten-print cards, criminal and noncriminal, that are submitted by law enforcement agencies throughout the state. At the city and county level, on the other hand, AFIS systems are justified primarily because of the crime-solving potential of the latent print processing capability.

The FBI system

The FBI's AFIS system was developed as part of a long-term program begun in the early 1970's to automate the functions of the Identification Division, which houses the FBI's criminal and noncriminal fingerprint files and criminal history records for federal and state offenders. The Identification Division conducts criminal history record searches for federal and non-federal law enforcement agencies throughout the country and for federal and state noncriminal justice agencies that are authorized by federal or state law to request criminal history searches in connection with employment, licensing or other official functions. Currently, the Identification Division conducts approximately 14,000 searches for criminal justice purposes and 13,000 searches for noncriminal justice purposes each day.

The automated file used for ten-print searching contains approximately 18 million fingerprint records of offenders born in 1929 or later. Currently, the Identification Division processes about 264,000 automated technical fingerprint searches per month and is experiencing a hit rate on criminal fingerprint cards of 8.6 percent. FBI officials have stated that the accuracy level of the system is better than 99 percent.

The FBI is currently in the process of developing and testing an automated system for searching latent fingerprints. An automated image retrieval system is also under development. These systems are expected to be operational by the end of this decade.

State-level systems

At the time this report was prepared, 18 states had installed or were in the process of acquiring or installing AFIS systems in their state identification bureaus. Of these, the systems in Alaska, California and Minnesota are operational and Colorado, Indiana, Illinois and Massachusetts have purchased systems and are in the process of installing them. Virginia and Tennessee have selected vendors and expect system installation to begin very soon. Six other states, Delaware, Florida, Georgia, Kentucky, North Carolina and Washington, have begun the procurement process and Arizona, Pennsylvania and New York plan to begin the procurement process within the next few months. All of these states expect to have their systems in operation by the end of 1987. In addition, three states, Maryland, Michigan and Wisconsin, are considering the implementation of AFIS systems within the next few years. State officials in Idaho, Montana, Utah and Wyoming are exploring the possibility of implementing a regional system to be shared by those four states. Massachusetts officials are discussing arrangements for sharing the system now being installed with surrounding New England states.

The California system, known as CAL-ID, which is operational but not yet fully implemented statewide, deserves special mention, since, when it is fully implemented in mid-1987, it will be among the most advanced fingerprint identification systems. In addition to the central site at the California Department of Justice's facility in Sacramento, CAL-ID will feature a statewide automated identification network that will provide law enforcement agencies throughout California with remote terminal access for performing computerized fingerprint searches and for retrieving fingerprint images for screen display or hard-copy printout.

The central facility includes the capability of conducting automated searches of the master name index as well as automated ten-print and latent print searches. The remote network will enable sheriffs and police departments anywhere in the state to perform ten-print searches on persons in custody and will enable larger jurisdictions to input fingerprint minutiae data to conduct remote cold searches on latent prints from crime scenes. Smaller local jurisdictions will be able to receive fingerprint images to verify name search identifications and for comparison with the fingerprints of known criminal suspects, but they will not be able to input fingerprint minutiae data to conduct cold searches on latent prints. California also will establish a number of "Full Use Access Agencies" in up to six large population areas of the state. In addition to access to the central state data bases, these agencies will have their own automated identification data bases containing fingerprints of

persons with criminal or applicant records in their geographical areas. They will also be able to support local networks to permit other law enforcement agencies in their areas to access their data bases as well as the state data bases.

As mentioned earlier, California has already realized significant productivity increases and cost savings associated with the processing of ten-print cards. In addition, officials estimate that the remote access network will make it possible for local agencies to conduct over 50,000 latent searches each year, resulting in the identification of some 7,500 suspects. It is anticipated that these searches will save law enforcement agencies some 600,000 investigative hours now needed to develop suspect lists, resulting in manpower savings of $9,000,000 annually.[10]

City and county systems

The demonstrated capability of AFIS systems to solve crimes and facilitate the arrest and conviction of criminals who probably would not be apprehended in any other way has been a powerful incentive for city and county officials to implement the technology. Although the high cost of the equipment puts it out of the reach of most small agencies, many large city and county police departments have implemented systems and many others plan to acquire AFIS capability either independently or as part of the statewide systems now being implemented. At the time this report was prepared, AFIS systems were operational in Baltimore, Maryland; the District of Columbia; Houston; Kansas City, Missouri; Miami; San Jose and San Francisco. In addition, regional or cooperative systems shared by several law enforcement agencies in large metropolitan areas were operational in Fairfax, Virginia; Nassau County, New York; Prince George's and Montgomery Counties, Maryland; St. Louis (REGIS); and Virginia Beach—Hampton Roads, Virginia. Systems are presently being installed in Chicago, Las Vegas, and Pierce County (Tacoma), Washington; and officials in Austin, Denver, Jacksonville (Florida) and King County (Seattle), Washington are in some stage of the process of acquiring AFIS systems.

As mentioned in the previous section, city and county law enforcement agencies throughout California will have remote terminal access to the CAL-ID system and as many as six large cities or population centers will be provided with their own automated fingerprint data bases for both ten-print and latent print searches. It is likely that other states will also provide at least some local agencies with remote terminal access. Indeed, many local agencies throughout the country that expect eventually to have AFIS systems or at least access to a state system have delayed planning and acquisition activities of their own until it is clear what their state identification bureaus intend to do.

Operational system features

Although, as mentioned above, state-level systems tend to emphasize the ten-print function and local systems tend to emphasize the latent print processing capability, all of the systems installed thus far and all of those now being implemented have both ten-print and latent print processing capability. All of the sites routinely search incoming ten-print cards against the stored files of ten-print cards—that is, standard arrest and applicant processing. Interestingly, the accuracy of the technology is such that the ten-print to ten-print search can be conducted on only one or two fingers and the system will find the matching fingerprints in excess of 98 percent of the time. Since file storage space is expensive and file conversion—entering the existing file of ten-print cards into the system—is both time-consuming and expensive, virtually all of the sites have elected to enter only a finger or thumb from each hand into the file to be used for ten-print searching. Virtually all sites also have elected to utilize a year-of-birth cutoff date for converting existing fingerprint files. Commonly, only prints of persons born in 1940 or later are entered. This results in considerable cost savings while sacrificing little in the effectiveness of the system, since many experts estimate that 90 percent or more of criminal activity is committed by persons 40 years old or younger. Florida's AFIS system will utilize a "day one" approach, entering records into the system based on new arrests, because its present fingerprint files are stored on microfilm and are not suitable for conversion.

All of the sites also search incoming latent prints against a file of ten-prints—conventional crime scene processing. Here, again, some of the sites have elected to enter only selected parts of their existing ten-print files into the data base to be used for latent searching. California's phased system implementation began by entering only convicted felons born in 1960 or later. Interestingly, if the accused "Night Stalker" killer/rapist had been born only a few months earlier, his fingerprints would not have been in the AFIS data base when his latent print was lifted from

[10] ibid, p. 14.

a stolen car. However, he would have been identified in the next phase of implementation which entered persons with felony convictions with birthdates 1950 and after. Most of the state AFIS systems are utilizing some combination of age and prior criminal activity to limit the number of fingerprints entered into the file to be used for latent searching. California has also elected to enter only eight fingers from each fingerprint card, omitting the little fingers because hits on them are so rare.

Although most of the systems now in operation do not include image storage and retrieval capability, since the technology is very new and was not available when some of the systems were installed, virtually all of those now being implemented include this capability as an integral part of the system despite its high cost. As pointed out earlier, this capability permits the images of the search print and candidate file prints to appear side by side on the operator's screen, making it unnecessary for the technician to leave the terminal to retrieve candidate prints from hard-copy files. It also makes it possible to provide remote access to the system and remote transmission of digital fingerprint information.

The technology makes it possible to search new latent prints against the unsolved latent file, but few of the sites are doing this. Although the capability of identifying patterns of related crimes can be useful occasionally, most agencies have not been able to justify the costs of this capability with the limited benefits derived from it.

Policy and legal issues

As is the case with the introduction of any new and revolutionary technology, the implementation of AFIS technology will raise new policy issues and force the re-examination of existing policy decisions. AFIS applications may also raise legal issues. The following discussion identifies some of the policy and legal issues that may arise and require the attention of policymakers in the planning and operation of AFIS systems.

Organizational impact

Implementation of AFIS technology may cause a shift in relationships between state and local law enforcement agencies and even between divisions of particular agencies. Implementation of statewide AFIS systems may tend to increase the reliance by local agencies on the services of the state bureaus of identification and further the trend away from the maintenance of fingerprint files and criminal history files at the local level. On the other hand, implementation of AFIS systems at the city or county level may tend to reverse this trend, particularly where the state does not implement a state-level system. The advent of AFIS may also cause a re-examination of the organizational structure supporting fingerprint processing, particularly at the state level. While ten-print processing and latent print processing may be performed by the same agency at the city level, these two functions traditionally have been separate at the state level. The ten-print function is usually performed by a bureau of criminal identification (often attached to the criminal records repository), while the latent print function usually is assigned to an office associated with the crime laboratory. All AFIS systems installed so far, and probably all that will be installed, include both ten-print and latent processing capability. In most of the states that have implemented AFIS systems the systems have been housed in the bureaus of identification. This trend is likely to continue and may result in the gradual absorption of the latent print function by the criminal identification bureaus.

Impact on identification bureau workloads

AFIS technology undoubtedly will have a significant impact on the ability of the state criminal record bureaus to handle the increasing criminal and noncriminal workloads that in recent years appeared to be becoming unmanageable in many states. These workloads have increased to the point that many states have become unable to perform technical fingerprint searches in all criminal cases and only a few states are able to do fingerprint searches for noncriminal applications for employment and licensing purposes. The AFIS technology should result in significant improvements in the efficiency and accuracy of the criminal fingerprint function, reducing or even eliminating the number of offenders who avoid association with their past criminal records by using aliases. With respect to noncriminal applications, the increased efficiency of AFIS technology should permit state repositories to adopt policies requiring fingerprint searches and positive identification in all cases in which records are released for noncriminal justice purposes.

In the past, the inability of the state repositories to perform fingerprint searches for employment and licensing applications and the risk associated with releasing records for such purposes based solely on name searches have caused many state criminal justice officials to resist proposed new laws and policies authorizing criminal record searches for additional employment and licensing purposes. With the implementation of AFIS systems, this resistance may lessen. Indeed, state policymakers may even encourage the trend toward wider availability of criminal records for noncriminal justice purposes, viewing the income from fees charged for processing such applications as an important source of funds to support the implementation and operation of the AFIS systems. California anticipates that funds derived from a surcharge added to the fee for processing employment and licensing applications will cover the costs of operating CAL-ID.

Fingerprinting of juveniles

The implementation of AFIS technology may trigger a re-examination of state laws and local policies concerning the fingerprinting of juveniles and the uses that may be made of juvenile fingerprints. At present many state laws prohibit or restrict the fingerprinting of juveniles and impose restrictions on the use and disposition of those prints that are taken. Typically, these laws provide that juveniles may not be fingerprinted unless they are to be prosecuted as adults or they have committed designated offenses that would be

felonies if they were adults. Commonly the laws provide that fingerprints of juveniles may not be comingled with adult fingerprint files and may not be placed in state central repositories or sent to any federal fingerprint repository. Some states require that juvenile fingerprints must be returned or destroyed if the juvenile is not adjudicated delinquent and most states provide that juvenile records, including fingerprints, must be destroyed when the juvenile reaches adulthood or at some designated point thereafter, at least if he has established a clean record period beforehand.[11]

As pointed out earlier in this report, it has been estimated that fingerprints are left at the scenes of more than a third of all crimes, particularly property crimes. New fingerprint-lifting technology makes it possible to obtain usable prints in many of these cases and the new AFIS technology makes it possible to search these latent prints against existing files of fingerprints and identify offenders even when no other evidence is available to compile a list of suspects. Since statistics indicate that many, perhaps most, property crimes are committed by juveniles, it is apparent that the unavailability of juvenile fingerprints or the inability to search crime scene latent prints against existing juvenile fingerprint files will mean that the full crime-solving potential of the AFIS technology cannot be realized. This consideration may result in a re-evaluation of existing policies related to the fingerprinting of juveniles. Minnesota's system now includes juvenile prints and a sampling of juvenile prints in St. Paul, Minnesota's data base indicated that although juvenile prints constituted only about 3.5 percent of the AFIS data base, they accounted for 53 percent of all latent hits, most of which were related to property crimes.[12]

Retention and subsequent use of applicant fingerprints

The AFIS technology has also made it feasible and productive to search noncriminal fingerprints accompanying applications for employment or licensing against files of unsolved latent prints and to search new latent prints against existing files of applicant fingerprints. This practice may raise legal issues in some jurisdictions, since courts may conclude that the fingerprint subject's rights are violated when fingerprints submitted for a specific purpose—a noncriminal search—are retained and used subsequently for other purposes. Indeed, at least one court has reached that conclusion. In that case, decided in 1978 by a New York state court,[13] the court ruled that a state law requiring the fingerprinting of potential grand jurors is not constitutionally objectionable, but that retaining the prints once the initial qualifications decision is made would violate the fingerprint subject's privacy rights. Other courts have reached contrary conclusions, however. A California state court and a federal district court in Louisiana have upheld the constitutionality of local ordinances requiring workers in certain occupations to register with the local police and be fingerprinted for the purpose of assisting the police in controlling crime problems thought to be associated with transients employed in these occupations. In the California case,[14] decided in 1970, the registrant was already a suspect in a rape case in which latent prints had been obtained from the crime scene. The fingerprints obtained when he subsequently registered in order to be employed locally as a bartender were matched with the latent prints and he was arrested and charged with the rape and a related sexual offense. The court rejected his challenge of the use of the fingerprints in his prosecution, concluding

[11] *Criminal Justice Information Policy: Privacy and Juvenile Justice Records*, U.S. Department of Justice, Bureau of Justice Statistics, Washington, D.C., 1982, pp. 32-34.

[12] Source: Sergeant Joseph Corcoran, St. Paul, Minnesota Police Department, *Summary of the First Hundred Latent Hits in the Maffin System*, St. Paul, Minnesota Police Department.

[13] Goodman v. Liebovitz, 410 N.Y.S. 2d 502, 96 Misc. 2d 1059 (S.Ct., N.Y. County 1978) affirmed 423 N.Y.S. 2d 488, 73 App. Div. 2d 855 (App. Div. 1980).

[14] People v. Stuller, 10 Cal. App. 3d 582; 89 Cal. Rptr. 158 (1970).

that the ordinance was a valid exercise of the municipality's police power and that the fingerprints were constitutionally obtained. That being the case, the court held, there were no legal restrictions concerning subsequent use of the fingerprints. In the Louisiana case, decided in 1979, the federal district court upheld the constitutionality of a similar worker registration ordinance, rejecting claims that it violated the privacy rights of the registrants.[15]

It may well be that this issue will be the subject of additional court scrutiny. As the implementation and operation of AFIS systems continue, suits may be brought challenging the retention of applicant fingerprints and their use for any purpose other than the pre-employment background searches for which they were obtained. In the cases that have considered this issue and related issues, the courts have been generally in agreement that retention and subsequent use of applicant fingerprints for criminal justice purposes does not abridge constitutional protections against compelled self-incrimination or unreasonable searches and seizures. However, as indicated by the cases discussed above, courts have disagreed on the issue of whether such retention and use violate the constitutional protection against invasion of privacy. It may be that as the usefulness of the AFIS technology as a crime-solving tool is demonstrated, the courts will conclude that the public policy interest in realizing the full potential of this new technology outweighs the privacy interests of the fingerprint subjects. For the present, however, it probably is prudent to regard the issue as not yet resolved. As a precaution, law enforcement agencies might consider requiring licensing and employment applicants to sign a release consenting to the use of their fingerprints for AFIS searches against latent files and the retention of the prints for subsequent criminal justice searches.

[15] Service Machine & Shipbuilding Corp. v. Edwards, 466 F. Supp. 1200 (W.D. La. 1979).

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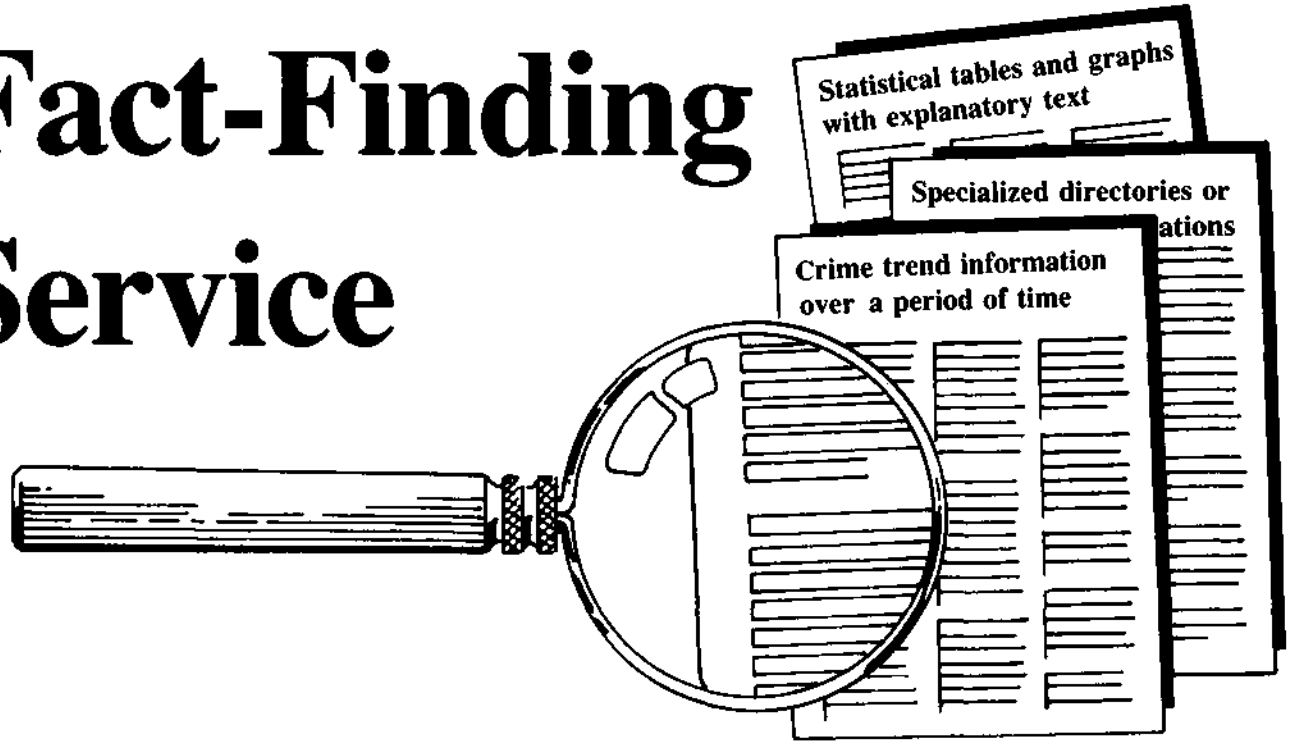

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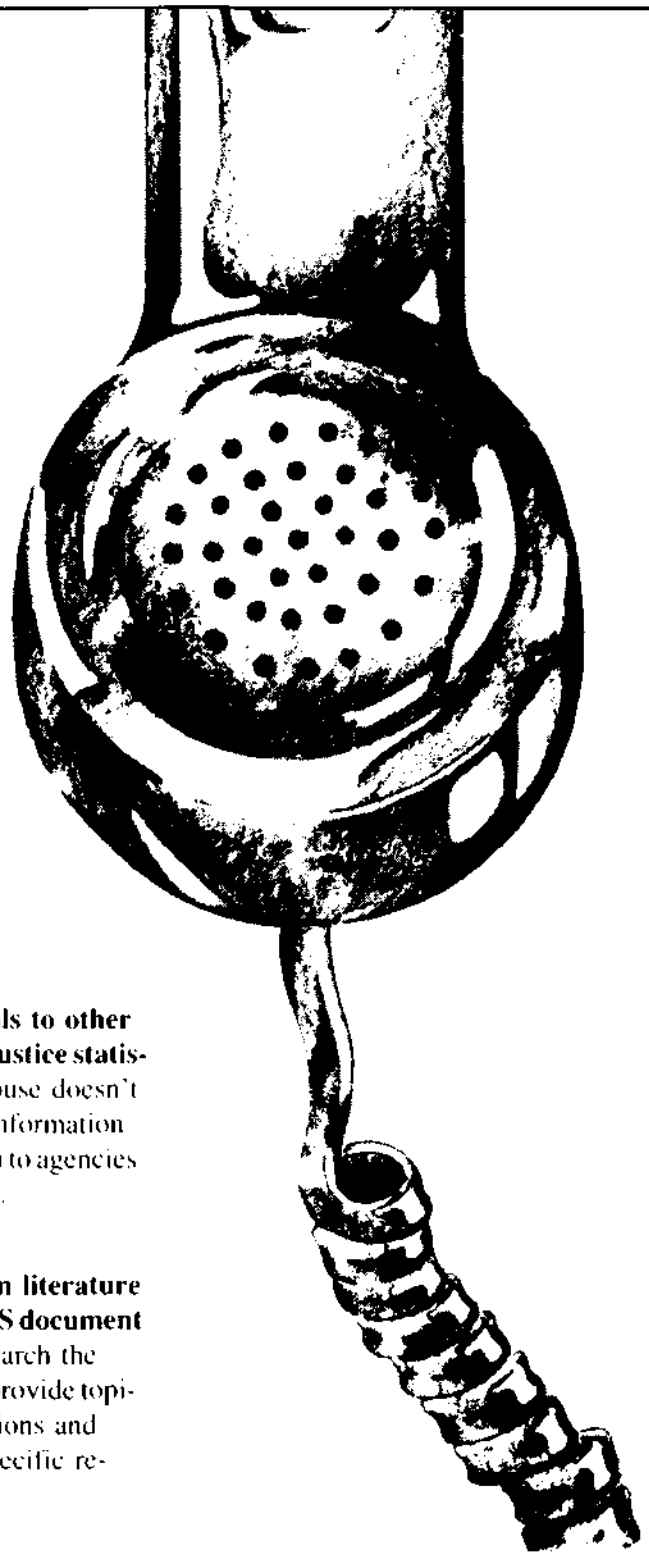

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