ANALYSIS OF ADVANCED FORENSIC SCIENCE CAPABILITIES

Law Enforcement Development Group

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Prepared for

NATIONAL INSTITUTE OF LAW ENFORCEMENT AND CRIMINAL JUSTICE
Law Enforcement Assistance Administration
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THE AEROSPACE CORPORATION

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ABSTRACT

This analysis addressed the technical feasibility and potential utility of advanced forensic science capabilities. The study focused on the potential of improved evidence individualization capabilities associated with solving the major crimes of murder, rape, burglary, assault, robbery, and larceny. This included methods to identify physical evidence such as fingerprints, hair, body fluids, paint, glass, soil, metal, fibers, and tool marks. A brief review of present and proposed individualization techniques highlights (1) the present lack of effective capabilities in this area, and (2) research programs and advanced technology which could permit this evidence to be precisely individualized on a routine basis by crime laboratories.

The potential utility of advanced forensic capabilities to increase conviction rates and reduce overall crime rates for the frequently committed crime of burglary was calculated. The calculations, based on models of the evidence utilization process and the criminal justice system, indicate that widespread adoption of many of the advanced systems could reduce burglary losses by billions of dollars over the next decade. A conclusion of the analysis is that savings for this major crime alone warrants further development of projected advanced capabilities into practical systems for widespread implementation. Legal and administrative implications of introducing advanced capabilities are also reviewed. A limited survey was also conducted of judges and prosecutors to determine relative preference for the various advanced forensic capabilities.

The results of this analysis can be used to determine priorities for forensic research programs as well as to guide police investigators and crime laboratory administrators in determining the potential benefits of advanced forensic methods.

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Dr. Joseph Peterson, formerly with the Institute and now on the staff of the John Jay College in New York, provided valuable comments and interpretation of data from previous studies.

SUMMARY

A. Background

The study described in this report was part of a comprehensive review of crime laboratories and forensic science operations sponsored by the Law Enforcement Assistance Administration (LEAA), National Institute of Law Enforcement and Criminal Justice. The Aerospace Corporation effort was directed toward assessing the potential utility of advanced forensic science capabilities in reducing crime. Other Institute-sponsored studies have focused on the operation and performance of current crime laboratory facilities and on the crime-reduction effectiveness of present forensic analysis capabilities.

The present analysis is an outgrowth of on-going work by the Institute to develop new and improved equipment systems for law enforcement applications. In support of this work, many new forensic science techniques have been proposed and some measure of their potential utility is required to determine which of them should be funded and developed by the government. In addition, some measure of utility would be helpful to crime laboratory administrators and police investigators in determining which of the new forensic systems presently emerging from research (whether government-sponsored or not) have the most potential to reduce crime and, therefore, need to be emphasized and given strong in-house support.

B. Approach

The study centered on the advanced forensic capabilities which are the most applicable to reducing the major crimes of murder, rape, burglary, robbery, assault, and larceny--the so-called Part I crimes defined in the FBI Uniform Crime Reports. The most important of these capabilities are those which can connect a suspect with a crime scene by verifying that physical material on his person is uniquely identical to that found at the crime scene. This process, known as evidence individualization, has been used to a limited extent for fingerprint evidence but virtually not at all for other types of crime scene evidence. The relatively few individualization procedures in use are so time consuming, complex, and costly that collection and analysis of crime scene evidence is not generally performed on a routine basis.

In view of these limitations, this analysis reviewed the technology and possible advances attainable through research and development for individualizing, on a routine basis, numerous physical materials associated with Part I crimes. Like fingerprints, other substances of human orgin, such as blood, hair, semen, saliva, urine, and skin, have characteristics which are unique to an individual or small groups of individuals. In addition, samples of materials of nonhuman origin, such as paint, glass, tool marks, soil, and fibers from clothing, have microscopic and molecular characteristics which offer the means to uniquely individualize these substances.

The review of applicable technology indicates there are numerous potential advances attainable through research and development which could permit routine individualization of most of the physical evidence listed above. The analysis therefore addressed the question of which of the advance capabilities warrant allocation of research and development resources. This required the assessment of the potential utility and acceptability of the projected advanced techniques.

Quantitative calculations were made to estimate the impact of advanced capabilities on conviction rates and crime rates if they were developed and put into widespread use. A review of the legal and administrative restrictions to adopting new techniques was also made and a limited survey of judges and prosecutors was conducted to determine possible effects on the adjudication process of the increased use of physical evidence.

The quantitative calculations assessing the potential utility of advanced forensic capabilities are perhaps the most important and useful part of the analysis. In order to quantitatively calculate the potential impact of the application of advanced capabilities, detailed data were collected and the analysis was performed for one major crime, that of burglary. Burglary was selected for these calculations since it is a high incidence crime for which conviction rates are presently very low. It is also a major property loss crime for which relatively good statistics exist, so that calculations of the cost savings resulting from a reduction in crime can be made.

The calculations focused on nine major types of physical materials which can be assocated with the interaction of a burglar with the crime scene--fingerprints, blood, hair, paint, glass, soil, fibers from clothing, metal particles, and tool marks. The frequencies with which these various physical objects and impressions occur at burglary scenes were obtained. By using a simplified model of the evidence utilization process, the impact of the capabilities to individualize each of these materials on burglary conviction rates was calculated. The increased conviction rates were then translated into the corresponding decrease in burglary rates by using a model which described the flow of burglars into the courts and correctional system. The model also permitted comparisons to be made of the effectiveness of alternative methods (.i.e., other than increasing conviction rates through the use of various forensic capabilities) for reducing burglary; for example, through reducing recidivism or increasing sentence length. This allowed the effectiveness of advanced forensic capabilities to be weighed against alternative strategies for reducing crime.

The three measures of effectiveness used to quantitatively compare the various evidence individualization capabilities were (1) the increase in burglary conviction rate provided by each capability, (2) the reduction in the projected total burglaries in the U.S. over the next ten years due to the increased conviction rates, and (3) the dollar savings due to the burglaries prevented over the next decade. As described below three general cases associated with the use of the various evidence types were defined in order to calculate the three measures of effectiveness.

Case I represents the use of the personally unique characteristics of blood, hair, fingerprints, and other physiological materials in the same manner in which latent fingerprints are used to a limited degree today--namely, to permit implication of an otherwise unknown person through the automated or manual search of a previously developed data base which contains a set of these characteristics for some segment of the population (such as previously arrested or convicted felons, known criminals or everyone).

Case II represents the use of the same evidence types as Case I, but without a previously constructed data base. Without such a data base, successful use of the crime scene evidence requires that a suspect be taken into custody before his blood, hair, fingerprints or other personal characteristics can be compared to those found at the crime scene.

Case III represents the use of connective physical evidence which is transferred to the perpetrator from the crime scene environment (for example, glass fragments from a window broken to permit an illegal entry may lodge on the clothing of the perpetrator) or from the perpetrator to the crime scene environment (for example, fibers from the clothing of the perpetrator may dislodge and remain at the crime scene). Successful use of this evidence also requires that a suspect be taken into custody through other means and, obviously, that the physical material is found on his person, clothing or possessions.

Each of these three cases required substantial data and statistics to support the calculations. Results of this work are summarized in Table I below. The main report describes in detail the specific calculations and supporting data.

C. Conclusions

The figures in Table I indicate that certain evidence analysis capabilities could have a very significant impact on burglary rates and losses. These include a latent fingerprint analysis capability, a blood or hair analysis capability used with data files, and a tool mark analysis capability. If any one of these advanced capabilities were to be used throughout the country, savings from burglary losses over the next decade could exceed a billion dollars.

Full use of fingerprint evidence alone is projected to reduce burglary losses by almost $8 billion over the next decade. This type of advanced

Table I. Impact of Advanced Evidence Analysis Systems On Future Burglary Rates and Losses (for Ten-Year Period)

Case	Evidence Type	Conviction Rate per 100 Burglaries (Current = 6.6) (Rate)	(% Increase)	Percentage Burglary Reduction	Dollar Loss Prevented ($ Billion)
I	Fingerprints	17.9	171	48	7.9
	Blood	8.2	24	11	1.8
	Hair	7.9	20	9	1.5
	All Three[a]	20.3	208	53	8.7
II	Fingerprints	7.1	7.7	4.0	0.6
	Blood	6.7	1.1	0.6	0.08
	Hair	6.7	0.9	0.5	0.07
	All Three[a]	7.2	9.5	5.0	0.7
III	Paint	6.8	3.6	1.8	0.3
	Glass	6.9	4.2	2.1	0.3
	Fibers	6.8	2.4	1.2	0.2
	Soil	6.7	1.1	0.6	0.08
	Metal	6.7	0.9	0.5	0.07
	Tool Marks	7.7	17.0	8.0	1.3
	All Six[a]	8.2	24.0	11.0	1.8

[a]The totals shown are not simply the sum calculated for each evidence type. There is an overlap in effectiveness when multiple types of evidence are used because only one crime may be solved.

system would more than pay for itself since preliminary estimates of the additional costs to collect fingerprint evidence and operate advanced filing and searching systems in the 50 states are at a maximum approximately only one-fourth of the projected savings from the reduced burglary loss.

Perhaps of greater significance is the fact that even improved capabilities for individualization that yield relatively small increases in conviction rates have meaningful impacts on burglary losses. For example, the capabilities to individualize soil and metals (Case III) or hair or blood, as used in Case II without a data base, would increase the conviction rate over its current value by fewer than one person per 1000 burglaries. Even so, use of these capabilities could reduce the nation's expected burglary losses over the next decade by almost 100 million dollars.

The large effect that a relatively small increase in the number of persons convicted per burglary has on the burglary rate arises principally from the fact that the offense is characterized by several crimes per criminal per year. The conviction and subsequent incarceration of the average perpetrator prevents several burglaries from occurring during his confinement, and many more if the correctional process results in his rehabilitation.

The leverage of increased convictions resulting from the use of advanced forensic capabilities is so substantial that the crime reduction benefits observed for the use of all three of the Case I types of evidence cannot be matched by a hypothetically perfect correctional system which results in a zero recidivism rate or a merciless adjudication system which gives lifetime sentences to convicted burglars. Similarly, the less effective Case II and

Case III applications yield burglary reduction benefits which are equal in magnitude to that of either a severalfold decrease in the recidivism rate or a severalfold increase in the confinement period for convicted burglars.

Most of the major crimes are like burglary in that several offenses per offender are normally committed. These include robbery, auto theft, larceny and perhaps rape.* Because of the repeat nature of these crimes it can be inferred (although the calculations were not performed because of the additional data required) that the phenomenon seen for burglary also occurs for these crimes, i.e., that relatively small increases in the number of offenders who are identified and convicted yield significant decreases in the rates of these crimes.

Obviously, the physiological substances, such as blood, hair or fingerprints, must be legally obtained from suspects (Cases I and II) and the search of a suspect's body, clothing or personal possessions with a thoroughness sufficient to identify the (often minute) physical materials also found at the crime scene must also be legal. An analysis of the court rulings concerning conditions of the admissibility of evidence led to the conclusion that there were no major constitutional obstacles in obtaining these various evidence types on a routine basis.

The availability of an advanced technique will not ensure its widespread adoption. The characteristics these systems should possess if they are to be adopted on a widespread basis were generalized from the past history of

*Murder is the one major crime which is normally not in this category; fortunately, this Part I crime has the highest clearance and conviction rates.

crime laboratory acceptance or rejection of new techniques and from surveys of crime laboratories. It was observed that the likelihood of the widespread acceptance of new or improved forensic science capabilities by the laboratories will be enhanced if research can provide capabilities which (1) can be purchased within their typical resources, (2) do not require highly specialized skills for conducting and interpreting the analysis, and (3) are nondestructive.

The results of this analysis indicate that advanced forensic science capabilities, if fully exploited, have a significant potential for reducing major crimes and that this potential is likely to be as significant in terms of reducing crime as that of other suggested improvements in or changes to the operations of police, courts or corrections systems. This analysis indicates that further research and development, along with well supported field evaluation, is particularly warranted for those systems which improve fingerprint, blood, hair, and tool mark individualization capabilities.

CHAPTER I. INTRODUCTION

A. Purpose

The study described in this report is one of three concurrent studies sponsored by the National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration (LEAA), to increase the effectiveness of criminalistics operations. The two other studies, by Planning Research Corporation[1] and Calspan Corporation,[2] addressed the internal efficiencies and overall effectiveness of the crime laboratory as currently configured. In this report, the potential of advanced forensic capabilities to reduce crime is analyzed. Results of this analysis can be used to provide planning guidance and program rationale for the research and development of advanced forensic capabilities, and also serve as guidelines for police investigators in determining the relative importance of new forensic capabilities supporting their operations.

B. Scope

The two basic uses of the crime laboratory are (1) the determination of whether or not a crime was committed, and (2) the identification or connection of a suspect with a particular crime. The first use, which encompasses much of the crime laboratory's present workload, deals primarily with drugs, alcohol, arson, and forensic pathology. These will not be covered in this study since with the exception of forensic pathology, the determination of whether or not a crime has been committed primarily concerns the crimes of narcotics possession, arson, drunkness, etc--the so-called Part II crimes as defined in the FBI Uniform Crime Reports. The second use is associated with the Part I felony crimes of murder, rape, burglary, assault, robbery and larceny. By direction of the Institute, only the second use of the crime laboratory is covered in this report since prime emphasis was placed on examining the potential utility of advanced forensic analysis capabilities to solve Part I crimes.

The perpetrator of a crime, through interaction with the crime scene environment, frequently transfers physical material from his person or possession to the crime scene (or vice-versa). In crimes such as burglary and larceny, this material often provides the only link from the perpetrator to the crime scene, since usually there are no eyewitnesses or unique motives or informants.

For this link to be useful in the control of crime, the crime laboratory should be able to verify that the physical material found on a suspect is identical to or virtually identical to that found at the crime scene and that a chance similarity would be extremely unlikely. This analytical process, called evidence individualization, is well known for the case of fingerprint evidence. However, as will be discussed in Chapter II, crime laboratories currently have very limited capability to positively individualize many of the types of evidence found at the crime scene. In addition, because present individualization procedures are so time consuming, complex, and costly, the collection and analysis of such evidence is not generally performed.

As a consequence, this study will (1) review the potential technical advances in evidence individualization, attainable through research and development, and (2) assess the potential utility of the routine application of these advanced techniques. The potential utility was assessed by quantitative calculations of projected reductions in the level and cost of crime, a review of the legal and administrative restrictions to adopting new techniques, and a survey of judges and prosecutors as to the possible effects the increase in use of physical evidence may have on the adjudication process.

For simplicity in presenting the methods of analysis and results of this study, the types of evidence treated and the method of their use by investigators have been organized into two primary evidence types and two methods of use. This leads to three basic types of cases associated with using crime scene evidence to locate and identify the perpetrators of major crimes. These cases are defined in Table 1 and described below.

Table 1. Evidence Types and Their Use

Case	Crime Scene Evidence Types	Use of Evidence
I	Personally related evidence: fingerprints, blood, hair, semen, saliva, urine, fingernails, skin, voice, etc.	Implicate person if (1) that person's fingerprints, blood, hair or other characteristics are in a previously established data file, and (2) those characteristics are similar or identical to those associated with the crime.
II	Personally related evidence: fingerprints, blood, hair, semen, saliva, urine, fingernails, skin, voice, etc. (same evidence types as Case I)	Implicate person if (1) that person is brought into custody through other investigative efforts, and (2) his fingerprints, blood, hair or other personal characteristics are similar or identical to those associated with the crime.
III	Nonpersonally related evidence: Paint, glass, fibers, soil, wood, bullet, metal, tool marks, and other physical materials and impressions	Implicate person if (1) that person is brought into custody through other investigative efforts, and (2) physical materials identical to those found at the crime scene are also present on that person, his clothing or his possessions.

Case I represents the use of the personally unique characteristics of fingerprints, blood, hair, and other physiological material. This evidence would be used in the same manner in which latent fingerprints are used to a limited degree today, that is, to identify an otherwise unknown person through an automated or manual search of a previously developed data base. This file would contain a set of these characteristics for some segment of the population (previously arrested or convicted felons, known criminals, etc.) or perhaps the entire population, if that were technically and legally feasible.

Case II represents the use of the same evidence as in Case I but without an existing data base. Without such a file, the successful use of crime scene evidence requires that a suspect be taken into custody before his fingerprints, blood, hair or other personal characteristics can be compared to those found at the crime scene.

For Case III there is also no data file, but there is evidence consisting of physical material transferred to the perpetrator from the crime scene environment (for example, glass fragments from a window broken to gain illegal entry lodged on his clothing) or from the perpetrator to the crime scene environment (for example, dislodged clothing fibers). Like Case II, successful use of Case III evidence requires that a suspect first be taken into custody, and that physical materials present at the crime scene be transferred to or from him and remain on his person, clothing or possessions. Calculation of the potential utility of Case III evidence (which is not personally related) requires additional analysis to establish the probability that the various types of evidence will be found on the suspect after he is arrested.

C. Organization

This report is organized into four chapters and six appendices. Following this Introduction, Chapter II reviews (1) the frequency with which potential physical evidence occurs at crime scenes, and (2) the frequency with which it is currently used in the investigation of crimes. It discusses the technological deficiencies and other factors that contribute to the apparently significant underuse of physical evidence by the criminal justice system today. Capabilities for analyzing and individualizing physical evidence which may be possible as a result of research and development of advanced technologies are briefly reviewed.

Chapter III presents quantitative estimates of the possible increase in conviction rates if these advanced techniques for individualizing evidence were available. Calculations are also presented which estimate the impact of such techniques on the rate of crime in order to better define their effectiveness and to permit their comparison to other alternatives for the control of crime.

Chapter IV addresses the impact that the legal factors involved in the collection of evidence and the admission of the analysis of that evidence in court might have on the potential of these advanced techniques. It also contains a brief analysis of the characteristics such advanced capabilities should possess if they are to be adopted to any significant degree by the nation's crime laboratories.

The six appendices contain backup material and detailed references. They describe the methods used to make the quantitative calculations of potential utility, provide additional material related to the legal acceptability discussion, and summarize the questionnaire and tabulated results of the survey of judges and prosecutors.

CHAPTER II. PRESENT AND POTENTIAL FORENSIC SCIENCE CAPABILITIES

A. The Present Use of Physical Evidence

Currently, the crime laboratory plays only a minor role in the investigation and adjudication of most Part I crimes. As listed in Table 2, various studies have established that the scientific examination of physical evidence is performed in only about 2% to 10% of all felony crimes.[3-8] Furthermore, approximately 70% of the workload consists of the analysis of drug and alcohol evidence. Analysis of this evidence is not normally related to solving Part I crimes.[8]

The recent study (1972) by Parker and Peterson[7] is the most authoritative examination of the very limited degree to which physical evidence is

Table 2. Use of Physical Evidence

Authors	Sample	Percentage of Crimes in Which Evidence in Used
Gardner[3]	Nationwide	5
Parker[4]	Nationwide	2
Rosenthal[5]	Erie, Niagara, and Wyoming Counties of New York	1-6
Zuniga[6]	Juveniles	3
Parker & Peterson[7]	Berkeley and Nationwide	2
Parker & Gurgin[8]	Santa Clara County	10

exploited in the major property and violent crimes. In this study, three criminalists accompanied police to over 700 crime scenes in Berkeley, California during a three-month period. The criminalists tabulated physical objects and impressions found in entrances, exits, pathways, and foci of the crimes which, in their judgment, might have evidentiary value. A total of 23 categories of physical objects were considered: tool marks, fingerprints, organic substances, glass, tracks, paint, clothing, wood, dust, cigarettes, paper, soils, fibers, tools, grease, construction materials, documents, containers, metal, hair, blood, inorganic substances, and miscellaneous. Results of this study are summarized in Table 3.

As can be seen from Table 3, potential evidence of one or more types was found to occur in approximately 87% of the crime scenes examined (the median value was three types of evidence at each scene). Despite the apparent availability of evidentiary materials, a follow-up of these cases revealed that physical evidence of some type was submitted by investigators to a crime laboratory for analysis in only about 0.5% of these particular cases.

It is obvious, then, that there is a great disparity between the availability and the use of physical evidence in Part I crimes, and that law enforcement agencies presently make relatively little use of potential physical evidence for suspect development or for prosecution. In addition, a limited survey* of judges and prosecutors conducted for this analysis indicated that there is no observable trend towards the increased use of physical evidence, in spite of the recent limitations the Supreme Court has placed on obtaining

*See Appendix F.

Table 3. The Availability of Physical Evidence and Its Current Use

Offense	Number of Cases Examined	Cases with Potential Physical Evidence		Cases with Evidence Submitted to Crime Laboratories	
		Number	Percent	Number	Percent
Burglary	547	484	88	0	0
Auto Theft	85	80	94	0	0
Larceny	45	33	73	0	0
Robbery	26	21	81	1	4
Rape	6	6	100	0	0
Assault/ Battery	6	5	83	1	20
Murder	5	5	100	2	40
Total (Average)	720	634	(87)	4	(0.5)

and using other traditional types of evidence such as confessions[9] and eyewitness testimony.[10]

B. Factors Underlying the Disparity Between the Availability and Use of Physical Evidence

There are several reasons for the disparity between the apparent availability of physical evidence in Part I crimes and its use in the arrest-and-prosecution process. One is the large volume of drug and drunk driving cases in which laboratory analyses are required by statute.* The nation's crime laboratories are so overburdened with such cases that available manpower and time do not permit analysis of all available evidence. For example, Joseph[11] stated that "nearly every laboratory in the United States and Canada is overcrowded, understaffed, underpaid, underequipped, and overworked." Consequently, much of the physical evidence that could be collected cannot be analyzed and, as a result, in most cases it is not even collected and submitted for analysis.

Another reason for this disparity consists of administrative obstacles studied and reported by Peterson,[12] who observed that the police often consider the collection and examination of physical evidence to be less important than their other responsibilities. Hence there are relatively few systematic procedures for its recovery in routine cases, and assignment of resources and manpower for these purposes is generally minimal.

The lack of techniques and equipment to efficiently and effectively analyze physical evidence is also a reason for its little use and this lack is the basis for this study. Before describing the nature of these deficiencies and the potential that technology holds for alleviating them, it is worth noting that improved forensic technology cannot, in itself, overcome the administrative problems of crime laboratory use discussed previously. However, it can reasonably be expected that any demonstrated technical improvements would

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*As stated previously, more than 70% of crime laboratory work is devoted to drug and blood alcohol analyses.[8]

lead to the reallocation of law enforcement resources necessary for their adoption on a widespread basis.

C. Potential Improvements in Forensic Science Capabilities

1. General background. The ideal forensic individualization process would verify that either a suspect's personal characteristics or the characteristics of materials found on him are identical to those of the physical evidence found at the crime scene. In addition, it would be desirable to perform such individualization rapidly and inexpensively by using equipment that can be purchased and operated with the resources available to the local crime laboratory.* However, as discussed below, criminalists are able to analyze and individualize most physical evidence to only a very limited degree with the methods and instruments currently available. In addition, many of these capabilities are so inefficient or impractical as to restrict the routine use of such evidence unless exceptional demands are made by the particular circumstances of a criminal case, for example, the assassination of a celebrated person.

The processes by which advances in forensic science capabilities for physical evidence analysis can be achieved are by improving existing techniques and by developing new techniques. Potential improvements and new developments will be discussed by grouping the physical evidence into the two primary evidence types described in the Introduction, that is, personal and nonpersonal evidence. In the first group, an analysis of the evidentiary materials yields information that can be shown to be unique to a specific person. This

*Additional discussion of the desirable characteristics of evidence analysis procedures and equipment is presented in Chapter IV.

information can be used to search data files to identify a suspect or connect an otherwise developed suspect with the crime. The second group, which consists of nonpersonal materials found at the crime scene or on the perpetrator, has the potential to connect or associate a suspect with a particular crime.

2. Individualization of personal evidence. In a survey of judges and prosecutors in the greater Los Angeles area,* fingerprints, body fluids, and hair were mentioned most frequently as the types of evidence included in the personal evidence group where improved or new analysis capabilities would be highly beneficial. These are discussed in the following sections.

a. Fingerprints. Currently, the primary method for identifying a crime scene latent fingerprint is the manual search of selected fingerprint files. However, when the file size exceeds several thousand fingerprint cards, the manual search becomes so time consuming that it is not routinely conducted and, as a consequence, the potential utility of fingerprints is generally not realized. Only in criminal cases where a renowned victim is involved, for example, the Martin Luther King murder case, are manual searches undertaken of very large files.

Introduction of semi-automated and automated equipment could overcome the current problems restricting widespread use of latent fingerprint evidence. The technology for this improvement is available either in the form of systems that use digital computers to compare fingerprints or that use analog matching

*See Appendix F.

techniques such as optical or holographic correlation. Such systems are evaluated in detail in two documents[13, 14] which summarize a LEAA-sponsored assessment of the current systems under development and the potential for improved systems through application of advanced technology. These reports conclude that the technical state of the art is sufficient to permit complete automation of the identification process of coding and matching. However, these systems need further refinement to make their use feasible on a routine basis and to reduce false and "missed" identifications.

In the digital fingerprint file and search systems, problems have been encountered with the supporting software, with processing poor quality prints (particularly latent), and with alignment during print comparisons. The FBI, LEAA's Project Search, and numerous industrial organizations have programs to develop and implement digital-based fingerprint systems, but none of these are in operational use, although the state of Arizona with support from LEAA will evaluate a Sperry Rand system for ten-fingerprint search.

The principal problem to be solved in the holographic correlation systems for automatically identifying latent fingerprints is the limited search speed due to mechanical methods of card handling. A field test of the most advanced holographic system, built by McDonnell Douglas Corporation, is under way in New York City.

b. Blood. Most crime laboratories in the U. S. only perform simple ABO blood grouping analyses, which yield a discrimination probability--the probability that two randomly selected individuals will have the same genetic markers--of one in three. However, in Great Britain where forensic blood analysis studies were pioneered and refined, much more precise individualization of serological evidence is being performed and successfully used in investigation and in court testimony.[15] This is possible because the British have large, centralized forensic laboratories operating under the jurisdiction of a national police organization and can maintain a staff of specialized forensic serologists to perform the highly technical and time-consuming procedures involved. In contrast, the U.S. crime laboratories are widely scattered, generally service small districts, and operate autonomously under the jurisdiction of a variety of local governments. The resulting small volume of cases involving blood evidence prevents most U.S. laboratories from staffing the necessary specialists in serology.

Since human blood contains many genetically determined constituents, the identification of these specific variants offers a potential for the identification of its source. In fact, with the genetic markers already discovered in medical and genetic studies, it is theoretically possible to establish that a blood specimen originates from a specific individual. Thus, a degree of individualization equivalent to that of fingerprints is possible through blood analysis.

Research studies[16] are under way to develop simple, rapid methods requiring relatively low analyst skill for antigen typing and enzyme/protein determination of blood and bloodstains. Further, the persistence of genetic markers in stains as well as data on the distribution of these genetic markers within the U.S. population are being established. These studies indicate the potential of achieving a discrimination probability of one in a million for a six-month-old stain.

c. Hair. Despite the frequent discovery of hair at crime scenes, the actual use of this evidence is limited by the lack of a definitive method of analysis. Criminalists are still applying the methods published in 1941 by Kirk.[17] These methods are primarily based on microscopic examination of morphological characteristics such as color, diameter, cross-section, scale count, cuticle pattern, and pigment distribution. Because of the variations in these properties within a single individual, the similarity of the hair from different individuals, and the subjectivity of these methods, only the suspect's race and possibly his age and sex can be determined.

However, the potential for a more definitive individualization of hair has been demonstrated. Hair has been shown to possess identifiable genetic markers.[18, 19, 20] Furthermore, medical research, especially of hereditary hair disorders, has notable forensic implications.[21] It is also possible that the individualization of hair could result from the analysis of the luminescence properties of the amino acids in hair keratin or from the identification of polymorphic variants of the α-keratin by using electrophoretic techniques.

d. Nonblood body fluids. Currently, with the exception of blood, the residue from all body fluids, such as semen, saliva, urine, and perspiration, can only be identified by type. The criminalist cannot state whether a sample of any of these fluids is probably from the same individual as the evidence found at a crime scene. However, genetic markers unique to individuals or small groups of individuals are known to exist in these fluids. For example, major blood group substances, such as the ABO factors, are found in saliva in approximately 77% of the population known as secretors.[22]

These ABO factors as well as the isozymes of phosphoglucomutase are also expressed in seminal fluids.[23, 24] It is reasonable to expect that many more determinants valuable for individualization will be discovered in research, and that methods suitable for use in crime laboratories for identifying these determinants might then be developed.

3. Individualization of nonpersonal evidence.

a. Paint, glass, and metal. At present, a limited degree of individualization can be achieved for nonbiological materials such as paint, glass, and metallic materials (including gunshot residue). The primary techniques in use are (1) microscopic comparison for paint, (2) refractive index and density measurements for glass, and (3) trace element analysis for metallic evidence (and occasionally for paint and glass).

Improved trace element analysis techniques offer a promising means for individualization of paint, glass, and metallic materials. Various instruments and techniques are employed in other scientific fields which have been used to provide trace element analysis of evidence materials, namely, neutron activation analysis, x-ray fluorescence, the electron microprobe, and spark-source mass spectrometry. However, such instruments with their associated minicomputers to analyze the data range upwards in costs from $100,000. In addition, operation of these instruments requires special skills not available in a typical crime laboratory. The cost, time, and inconvenience of sending the evidence to an outside facility for analysis further prohibit the crime laboratory from making effective use of paint, glass, and metal evidence.

Potential instrumental techniques which may be more acceptable to crime laboratories for trace analyses include photoluminescence, electrochemistry, polarography, and atomic absorption. A recent report[25] summarizes research on the application of several of these promising quantitative techniques to the analysis of gunshot residue. Additional research is necessary to determine the costs, effectiveness, and optimum operating procedures for applying these instruments to the analysis of paint, glass, and metal evidence.

b. Tool marks and firearms. The present method for tool mark and firearm examination involves visual comparison of the evidence with test striae under a microscope. Photographs are taken with various light intensities and angles of illumination to obtain clearly visible contour variations. The striation patterns of different areas are then compared in an attempt to find a continuous series of matching lines. In most cases, the striae of the two samples will not be identical, and thus the degree of physical match of the lines required to establish proof that the two patterns were formed by the same object is left to the discretion of the examiner. Success of this microscopic matching process is greatly dependent on the skill and persistence of the examiner in varying the parameters affecting the observable striation patterns.

Improvements in tool mark and bullet individualization are possible which would eliminate its subjectivity. For example, one approach might use a small, low power helium-neon gas laser as recently reported by Peterson[26] for tool mark examination. The incident radiation from the laser is reflected at various angles and intensities by the irregularities in the marked surface. The resulting patterns of light intensities are put in graphical form and could be used to compare the tool marks. A similar approach might also be applied to bullet examination.

c. Fibers. The present methods for the analysis of fibers are relatively superficial involving examinations such as color, size, and type of material (wool, nylon, cotton, etc.) as well as the determination of optical properties (for example, pleochroism and birefringence) by using conventional and polarizing microscopes. More precise individualization of these materials may be possible by analyzing their photoluminescence and thermal-mechanical properties. In addition, organic and trace element analyses performed on dyes extracted from the fibers may provide a means for individualization.

d. Soil. By examining color, particle size distribution, pH, and density, the criminalist currently can compare the gross properties of crime scene soil samples to those found on a suspect. An ability to individualize soil might result from the development of trace element analysis, a technique discussed earlier. Thermoluminescence has been used with some degree of success in limited applications;[27] however, this method still requires further development. Another promising area for research is in the analysis of soil enzymes, since it is possible that specific enzymes may be unique to a particular locality.[28]

CHAPTER III. THE UTILITY OF IMPROVED FORENSIC SCIENCE CAPABILITIES

A. Introduction

Any improvements in physical evidence individualization will require a considerable research effort to develop the necessary procedures and equipment. In addition, major efforts are necessary to collect and analyze sufficient data to establish the definitiveness of a specific analysis by determining the probabilities of a match of randomly selected samples. Moreover, it is not obvious whether the pursuit of advanced evidence analysis capabilities warrants the allocation of criminal justice research resources; nor is it clear how any such allocation should be apportioned among research in the various evidence types. To assist in making such judgments, this chapter is intended to quantitatively evaluate the potential utility of such advanced capabilities.

There are several possible measures of utility that impact the investigation and adjudication processes and the public welfare which stem from the benefits improved forensic science capabilities could provide. From the investigatory standpoint, the following improvements could result:

- An increase in the number of suspects identified.
- An increase in the ability to determine that several crimes were committed by a single individual or group of individuals.
- An increase in the overall case clearance rate.
- An increase in the efficiency of crime investigation processes.

The potential benefits to the adjudication process were highlighted in a limited survey* of judges and prosecutors who indicated they would realistically expect the following improvements:

- A greater percentage of defendants admitting guilt, thereby reducing the costs of adjudication.
- An increase in the overall conviction rate.
- A more realistic use of plea bargaining by permitting more appropriate disposition of the crimes committed.

Finally, the general public will benefit from the increased convictions producing:

- Lower crime rates.
- Decreased property losses.
- Increased deterrence of crime.

For the purposes of calculating a quantitative measure of utility, the benefits listed above were reviewed. The basic measure selected was the number of additional persons convicted by use of evidence analysis capabilities. The second measure was the decrease in crime rate resulting from the increased conviction rates. This decrease was also translated into dollar savings, when there is a measureable savings such as a reduction in property loss.

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*See Appendix F.

The calculations presented in this chapter are performed for the crime of burglary, since it is a high incidence major crime for which conviction rates are currently very low. It is also a high property loss crime for which relatively good statistics exist, so that the cost savings accruing from its reduction can be calculated. In addition, since by definition burglary is a stranger-to-stranger crime which involves illegal entry, the connection of a suspect with the crime scene through physical evidence may be the only basis for prosecution.

Based on the results of the calculations for burglary, some general observations can then be made concerning the effectiveness of improved evidence analysis capabilities for other types of crimes. These observations are presented at the end of this chapter.

B. The Potential Impact on Conviction Rate

1. Method and data. As discussed in Chapter I, the use of physical evidence has been divided into three cases:

Case I. The identification of perpetrators by comparing personal evidence left at crime scenes, such as fingerprints, to those of some segment of the population stored in previously constructed data files.

Case II. The connection of suspects or arrestees with crime scenes by showing that their personal characteristics, such as fingerprints, are identical to those found at the crime scenes.

Case III. The connection of suspects or arrestees with crime scenes by showing that materials on their persons or in their possession, such as glass, fibers, soil or paints, are identical to materials found at the crime scenes or, in the case of tools and guns, by showing that they are the unique source of marks or objects found at the crime scenes.

In order to estimate the increases in the burglary conviction rate for each of these three cases, the method summarized in the flow chart of Figure 1 was used. The various boxes in this figure summarize the successive conditions which must be met if potential physical evidence identified by investigators at a crime scene is to lead to the conviction of an otherwise unconvicted perpetrator. Before presenting the calculated conviction rates, a brief discussion of the various conditions denoted by boxes (a) through (f) and of the parameter values (representing the frequency with which each condition occurs) used for this analysis is presented below. A detailed discussion of the method and the value of the various parameters is presented in Appendix A.

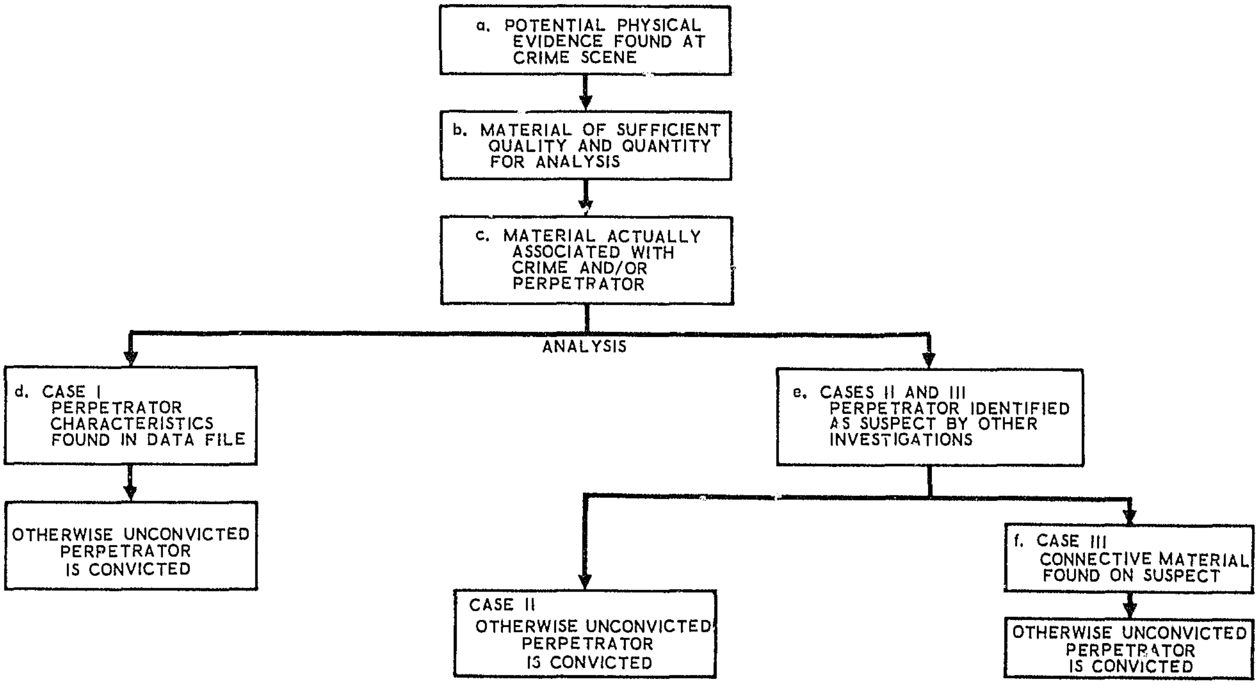

Figure 1. The Relationship Between Physical Evidence and Conviction

<u>Parameter a.</u> <u>The Frequency with which Potential Evidence is Found at the Crime Scene</u>

The frequency with which physical evidence occurs at crime scenes was reported by Parker and Peterson.[7] As discussed in Chapter II, the occurrence of physical objects and impressions in 23 categories was tabulated for the various crime scenes searched. A summary of the frequency of occurrence of each type of evidence for each type of crime is presented in Table A-2 of Appendix A. This study will focus on nine of the 23 types of physical materials tabulated by Parker and Peterson. These nine have some logical association with the crime of burglary, and the frequency with which they are actually due to the commission of a burglary can be estimated. In addition, they are evidence types for which potential improvements in individualization can be identified.

These evidence types, their typical association with burglary, and the frequencies with which each type was observed at burglary scenes by Parker and Peterson are presented in Table 4. It can be seen that, as judged by the criminalists examining the burglary scenes, many of the potential evidence types occurred quite frequently. Tool marks, fingerprints, and glass fragments, not surprisingly, occurred the most frequently and blood occurred the least frequently.*

This parameter is only the frequency with which physical materials present at the crime scenes were judged by the researchers to be potential evidence. No assessment was made in the cited study[7] as to whether the evidence was of sufficient quality to permit analysis (Parameter b in Figure 1) or whether it was actually due to the perpetrator's interaction with the crime scene environment (Parameter c in Figure 1). Values for these two parameters were estimated as discussed under the appropriate heading below.

Parameter b. The Frequency with which Material is of Sufficient Quality for Analysis

It was estimated that in 80% of the cases the various physical materials present at the crime scene are of sufficient quantity and quality to permit

*These relative proportions, of course, change depending upon the type of crime. See Table A-2 of Appendix A for detailed data on the frequencies with which physical objects and impressions occur in major crimes.

Table 4. Physical Evidence Associated with Burglary

Group	Evidence Type	Typical Association with Burglary	Frequency Material Found at Burglary Scene
Personally Related	Fingerprints	Perpetrator touching objects at crime scene.	0.42
	Blood	Perpetrator cut during entrance or exit through broken window.	0.03
	Hair	Natural shedding, enhanced by physical motion associated with act of burglary.	0.05
Nonpersonally Related	Paint	Chipped off while perpetrator is prying door or window or while entering or exiting through window.	0.20
	Glass	Perpetrator breaks glass to permit entry.	0.23
	Tool Marks	Transferred to crime scene from tools used to permit entry.	0.46
	Fibers	Transferred to crime scene from clothing of perpetrator, generally at points of constrained entry or exit.	0.13
	Metal	Perpetrator creates chips through act of prying or drilling door latches, safes, or other objects secured by metal.	0.05
	Soil	Deposited by perpetrator because of nonconventional entries into crime scene such as from the yard.	0.12

subsequent analysis. As explained in Appendix A (Section A.2.b), this is a generally conservative estimate based upon the published estimates of criminalists for the case of latent fingerprints, which are generally more prone than other types of potential evidence to be too poor to analyze.

Parameter c. The Frequency with Which Observed Material is Actually Attributable to the Perpetrator

The frequency with which the physical materials identified are actually attributable to perpetrators of the crime (and not to nonperpetrators or to the natural crime scene environment) was estimated by considering the type of materials involved. Because blood is not usually found in the environment of a home or commercial establishment, it was assumed that all blood found at the burglary scenes in the Parker and Peterson study[7] was left by the burglar (for example, from a cut during entry through a broken window). It was also assumed that all of the paint, glass, metal, and tool marks found were the result of the interaction between the perpetrator and the physical environment, since they can probably be linked to the burglary on the basis of their location at the crime scene.

Estimation of Parameter (c) for the remaining evidence types--hair, soil, fibers, and fingerprints--is somewhat more difficult, since they can be attributed to nonperpetrators at the crime scene prior to or immediately after the crime. However, the criminalists engaged in the Parker-Peterson analysis, through their assessment of the location of the potential evidence found, tabulated only the hair, soil, fibers, and fingerprints that they considered to indeed represent potential crime evidence. These judgments are similar to those which experienced investigators make today in the case of latent fingerprints. Therefore, it was assumed that the fraction of cases in which the observed hair, soil, fibers, and fingerprints actually arise from the interaction of the perpetrator with the environment is identical to the currently experienced value of approximately 50% for latent fingerprints submitted for analysis.[29]

Parameter d. The Probability a Perpetrator is Found in the Data File

The identification systems in Case I use a data file containing the fingerprints, blood or hair characteristics of a segment of the population. It was assumed that this data file contained the data of all persons who had been previously arrested. As explained in Appendix A, this results in a probability of 0.71 that the fingerprint, blood or hair characteristics of a perpetrator will be contained in such a data file.

Parameter e. The Frequency with Which a Perpetrator is Identified But Not Convicted

The effective use of the physical evidence in Cases II and III requires that a suspect be arrested in order to permit either his personal characteristics (Case II) or the characteristics of the materials found on his person or in his possession (Case III) to be obtained and compared to those of the evidence left at the crime scene. Although many suspects are arrested and convicted today without the assistance of such physical evidence, its additional weight in these cases should serve to permit more efficient use of court resources by strengthening the prosecution's case. However, the purpose of these calculations is to determine the number of additional convictions that would result from the use of this evidence.

In order to determine the additional convictions which would result from the individualization of physical evidence through advanced techniques, the number of perpetrators arrested but not currently convicted has to be estimated. Today, approximately 18 suspects are arrested and 6.6 are convicted per 100 burglaries.* A detailed analysis was made of the data[30] describing the reasons for dismissal or acquittal of adult burglary defendants in Los Angeles County. As discussed in Appendix A, Section A.2.e., it was estimated that three more of those 18 people arrested are actually perpetrators, but they are not convicted because of a lack of sufficient evidence.

Parameter f. Frequency with Which Connective Material is Found On a Suspect

The basis for the effectiveness of evidence in Case III depends on whether the paint, glass, fibers, soil, metal, or the tools leaving the tool marks found at the crime scene, can be found on the person or clothing or in the possession of an arrested perpetrator. A comprehensive study[31] in the Journal of Forensic Sciences reported that a significant fraction of a random sample of men's suits brought to a cleaning establishment contained paint (97%) or glass (67%) fragments in one or more places--the cuffs, pockets or fibers. This implies that clothing is an excellent retainer of such fragments and of all similar particulate material such as metal and soil.

*State of California data, 1972 (see Table B-1, Appendix B).

For purposes of this study, it was assumed that in 50% of the cases in which particulate connective evidence (paint, glass, soil, metal chips) is observed at crime scenes it is actually transferred from the crime scene environment to the perpetrator and remains there until the time of his arrest. In the case of fibers, it was assumed that the clothing worn by the perpetrator which left the fibers at the crime scene will be in his possession at the time of his arrest. Similarly, it was assumed that the tools used by the perpetrator also will still be in his possession. Consequently, the connective factor for these two evidence types was assumed to be 100%.

2. Results--increases in burglary conviction rate. The data presented above were used in simple equations* (based on the general approach depicted in Figure 2, Section C. 1) to derive the increases in the burglary conviction rate arising from the use of the nine evidence types in Cases I, II and III. Results are summarized in Table 5.

It is seen from the table that a capability for the individualization of blood, hair, and fingerprints, used in combination with data files which contain such individual characteristics for previously arrested people (Case I), yields by far the greatest potential for increasing burglary conviction rates. This is due to the fact that, unlike the other two cases, the utility in Case I

*These equations are presented and discussed in detail in Appendix A.

Table 5. Increases in Burglary Conviction Rates from the Use of Physical Evidence

Case	Evidence Type	Additional Convictions Per 100 Offenses (Current = 6.6)	Percentage Conviction Rate Increase Above 6.6
I	Fingerprints	11.3	171
	Blood	1.6	24
	Hair	1.3	20
	All Three[a]	13.7	208
II	Fingerprints	0.51	7.7
	Blood	0.072	1.1
	Hair	0.061	0.9
	All Three[a]	0.62	9.5
III	Paint	0.24	3.6
	Glass	0.28	4.2
	Fibers	0.16	2.4
	Soil	0.07	1.1
	Metal	0.06	0.9
	Tool marks	1.1	17.0
	All Six[a]	1.7	24.0

[a]Because of the assumed statistical independence of the occurrence of each type of evidence, the conviction rates resulting from use of more than one type of evidence is not simply the sum of the rates resulting from each type (see Appendix A, Section A.2.h).

does not depend on first identifying a suspect by some other means.* As would be expected from its frequent occurrence rate at burglary scenes, fingerprint evidence yields by far the largest potential increase in burglary conviction rates of the three types of personal evidence treated.

For the nonpersonal evidence used in a connective fashion (Case III), the ability to connect tool marks uniquely to the tools causing them offers by far the most potential. This is because tool marks are frequently found at burglary scenes and the assumption is that the tools will be found in the posession of the burglar after his arrest. If tools are found on the burglar only in approximately 25% of the arrests, the effect of using tool marks as evidence in producing additional convictions would be similar to that for paint and glass.

This examination of the increases in the burglary conviction rate permits some preliminary judgments to be made about the relative effectiveness of the various systems. However, these calculations do not permit a ready determination of whether or not a particular capability exhibits sufficient

*Recall that in only three out of 100 burglaries is a perpetrator arrested but not convicted due to lack of evidence. This value represents the upper bound in additional convictions which could be obtained using the evidence in Cases II and III since it is assumed that these cases do not increase the present rate of 18 arrestees per 100 burglaries. It is felt that this assumption is conservative since the number of suspects considered and individuals arrested would probably increase if reliable methods were available to individualize connective evidence.

promise to warrant the costs of its development and implementation. For example, the change in the burglary conviction rate which would result from an ability to individualize blood was from a current value of 6.6 to a value of 8.2 persons convicted per 100 burglaries. Assessment of the magnitude of the increase is not simple. One might reasonably conclude that it is insignificant (since it is an increase of only 1.6 convictions per 100 burglaries) or significant (since it is a 24 percent increase over the current conviction rate).

A knowledge of the decrease in the burglary rate which would result from an increase in the conviction rate would permit more objective judgments to be made of the value of alternative capabilities. It is crime reduction, after all, not conviction in itself, that is the objective of these criminal justice improvements. In addition, a property crime rate reduction can be translated into the dollar savings accruing to the public from crimes which did not occur. This provides a very useful measure to assist in the determination of whether research funds should be allocated to a particular research area.

In the next section the burglary rate reductions and associated cost savings which would result from projected conviction rate increases are estimated using a simplified model of the criminal justice system.

C. The Reduction in Burglary Rate from the Use of Physical Evidence

1. Method and data. A conceptually simple model of the interaction between burglars and the criminal justice system was developed in order to permit the burglary rate to be related to conviction rates. In this model the population of burglars at large commits burglaries at some average rate of

burglaries per burglar per unit time. The size of this burglar population changes with time because of four factors:

- The entry of new burglars--persons with no previous history of burglary.
- The exit of burglars who "retire" from burglary--persons who permanently leave burglary for any reason except incarceration.
- The (possibly) temporary exit of burglars because of their arrest, conviction, and incarceration for some period of time.
- The reentry of burglars who have been released from corrections and return to burglary.

Figure 2 diagrams the relationship between the quantities described above and shows the flow of burglars through the criminal justice process. Note that in this model the rate of crime is impacted by conviction only when the conviction leads to subsequent incarceration. Incarceration guarantees no further burglaries by the convictee until his release, and reduces his future burglaries after release through whatever rehabilitative effect the incarceration process possesses. The effect of deterrence due to an increased likelihood of arrest or a rehabilitative effect due to probation was not included. Thus the subsequent calculations tend to produce conservative estimates of the amount of crime reduction expected from increased conviction rates.

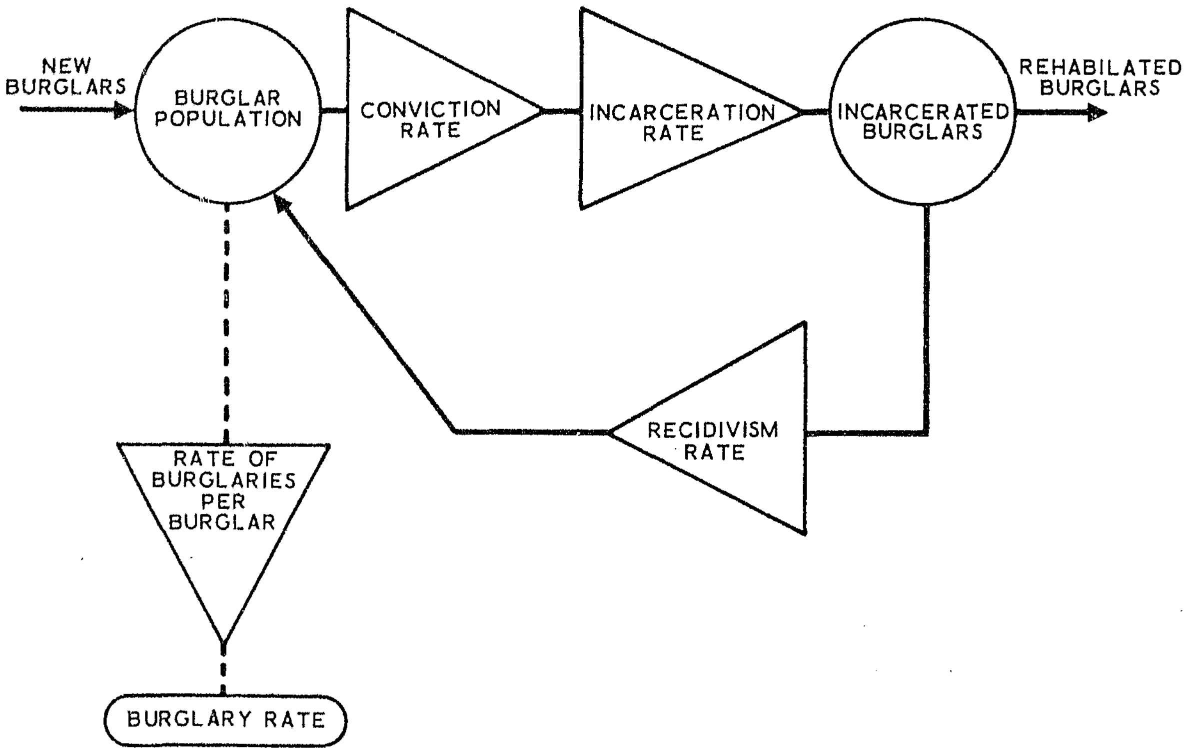

Figure 2. Burglary and the Criminal Justice System

Differential equations based on the relationships depicted above were formulated. These equations and the method for solving them are presented in detail in Appendix B.

Values for the parameters used in the model were in some cases obtained directly from various data sources. In other cases, such as burglaries per burglar per year and the net influx of new burglars, the values were mathematically derived from the available data. Table 6 summarizes the parameter values obtained. A more detailed discussion is also presented in Appendix B.

Table 6. Parameter Values

Parameter	Value	Source
Conviction Rate	To be varied (current value = 0.066 person per burglary)	Current value given by State of California data, 1972 (Note 32)
Incarceration Rate	0.53 person incarcerated per person convicted (includes both juveniles and adults)	Current value given by State of California data, 1972 (Note 32)
Incarceration Period	0.7 year	Current value given by State of California data, 1972 (Notes 32, 33, 34)
Recidivism Probability	0.34	Study of recidivism in California prisons, 1969 (Note 33)
Burglaries per Burglar	8 per year	Analysis of criminal career data presented in FBI Uniform Crime Reports, 1972 (Note 35)
Net Influx of New Burglars Per Year	27% of total projected burglar population (92,000 estimated for 1974, increasing to 190,000 in 1983)	Derived, based on value required to fit previous burglary rates

The baseline conviction and incarceration rates were determined by examining the data for burglary offenders in the State of California in 1972. These data revealed that for the 18 arrestees per 100 burglaries:*

- About 50% of the burglary arrestees were juveniles. Only 10% of the arrested juveniles were convicted and virtually none were incarcerated.
- About 50% of the burglary arrestees were adults. About 62% of the arrested adults were convicted and 63% of those convicted were incarcerated.

The value of 0.7 of a year for the length of incarceration shown in Table 6 reflects the average for California burglars sentenced to jail, to prison, and to the California Youth Authority in 1972.[32, 33, 34] The great majority of the offenders in this data sample were sent to jail as opposed to prisons or youth authorities.

The value of 34% for the recidivism rate was determined by examining California data on the number of prisoners released in 1964 who were returned to prison with a new felony commitment during the subsequent five years. Although this figure is lower than might be intuitively estimated, it is consistent with other authoritative studies of the recidivism phenomenon in which it is reported that about a third of the prisoners released eventually revert to patterns of crime that lead to imprisonment.[36]

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* See Table B-1 in Appendix B for more details.

The value of eight for the average number of burglaries per burglar per year was derived from the arrest frequencies of burglars. This value is the average of a large distribution between burglars who commit as few as one burglary per lifetime and probably some who commit hundreds per year.

The influx of new burglars into the active burglar population was determined by finding that value which resulted in a calculated burglary rate (using the model) which closely approximated the FBI Uniform Crime Reports burglary data for the years from 1960 to 1973. It was determined that about 27% of the burglar population in any year during the past 13 years consisted of persons who had never committed a burglary before that year.

Based on the method and the data described, a projection of the burglary rate with time for the United States is shown in Figure 3 for two values of the burglary conviction rate. The first case, the curve labelled "No Change", is the projected rate when there is no change in the current burglary conviction rate of 0.066.* It can be observed that, under such conditions, the U.S. annual burglary rate will more than double over the next ten years, reaching an annual level of almost six million. A total of some 40 million burglaries will be reported during that ten-year period. The second curve is the projected

*Since the parameter values were determined in such a manner as to reproduce the reported data on burglary rate, this curve is also identical to an extrapolation of that curve which best fits the burglary rate data for the period from 1960 to 1973.

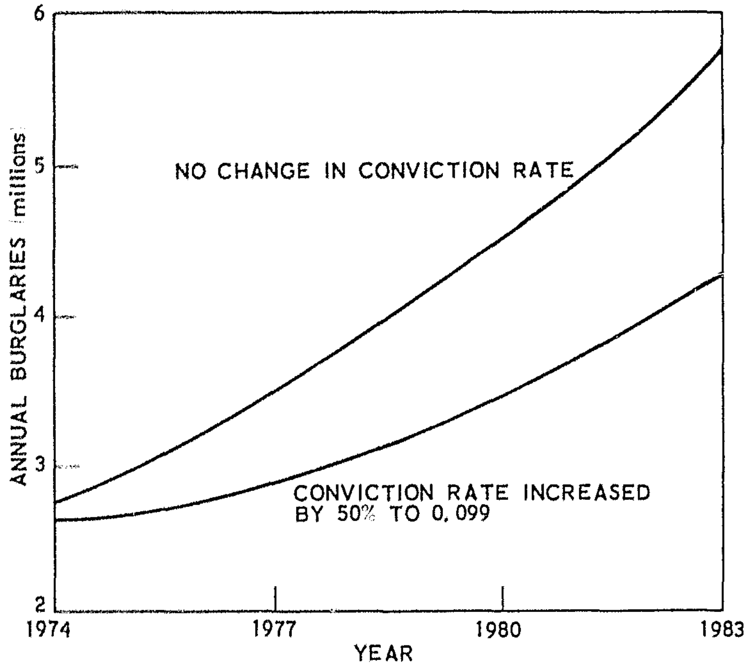

Figure 3. Projection of Burglary Rate

burglary rate for the case in which all conditions remain the same (sentence length, incarceration probability, etc.), except that starting in 1974 the conviction rate per reported burglary is increased from its current value of 0.066 to 0.099 (a 50% increase). It is seen that there is a substantial decrease in the annual burglary rate and total burglaries over the next ten years. The decrease approaches 2 million burglaries per year by 1983.

The large decrease in burglary rate shown by the lower curve of Figure 3 is more than the seemingly small increase of approximately three convictions per 100 burglaries would intuitively suggest. Inspection of the dynamics of the burglary model reveals the reason for this large impact. Because an at-large burglar commits eight burglaries per year, his incarceration definitely prevents 5.6 burglaries from occurring during the average 0.7 of a year, or 8.4-month, period he is confined. In addition, future burglaries are prevented if he does not recidivate after leaving jail or prison.

The relationship shown between burglary rate and conviction rate can be summarized in a single curve which permits the increased conviction rate arising from the evidence analysis systems presented in Table 5 to be transformed to resulting decreases in burglary rates. This basic curve is drawn in Figure 4 which shows the percentage reduction in total burglaries, summed over a ten-year period beginning in 1974, that occurs for various values of the conviction rate.

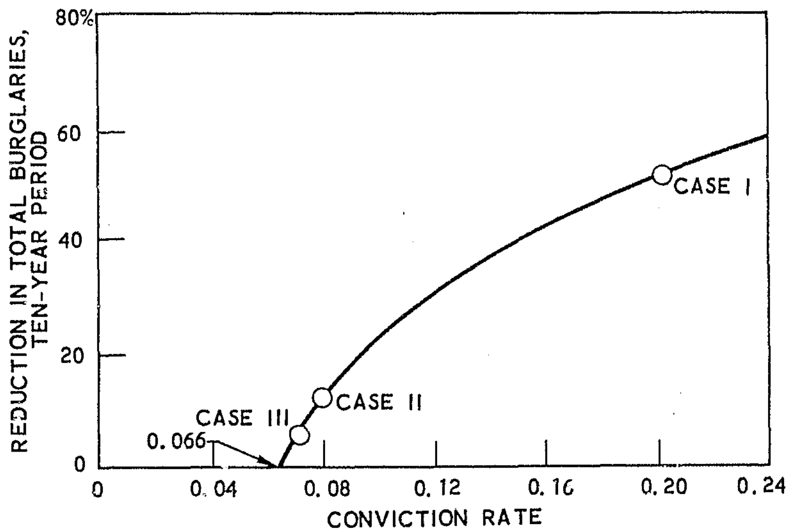

Figure 4. Percentage Reduction in Total U.S. Burglaries Versus Conviction Rate (for 1974 to 1983 Period)

As an example of the use of this figure, the case shown in Figure 3 of an increase in conviction rate to a value of 0.099 is seen to correspond in Figure 4 to a net reduction of 25% in burglaries experienced by the U.S. during the period from 1974 to 1983. This is a decrease of ten million from the total of 40 million burglaries that would be experienced over the next decade (if the conviction rate remained at its pre-1974 value).

The corresponding reduction in property losses due to the reduction in burglaries as a function of an increased conviction rate can also be determined by multiplying the burglary rate reduction by the projected average loss per burglary. The results of this calculation are shown in Figure 5.

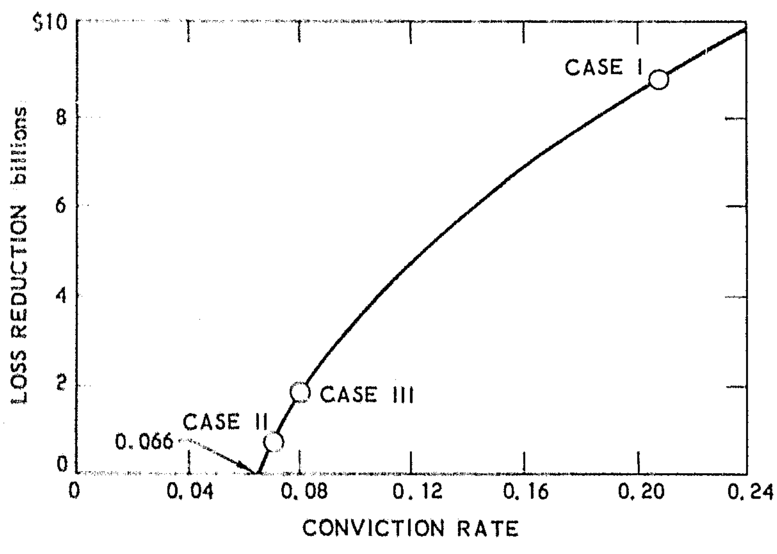

Figure 5. Total Burglary Property Loss Reduction (for 1974 to 1983 Period)

As an example of the use of this figure, the case presented in Figure 3 of an increase in conviction rate to a value of 0.099 is shown in Figure 5 to yield a savings in burglary losses to the public of approximately 3.5 billion dollars over the next ten years.

2. Results--crime reduction due to advanced forensic science capabilities. It is now possible by using Figures 4 and 5 to translate the various conviction rates (Table 5) resulting from the use of advanced physical evidence analysis systems into their corresponding impact on burglary rates and the dollar losses of burglary victims. Table 7 summarizes these results.

It can be observed from Table 7 that certain evidence analysis capabilities could have a very significant impact on burglary rates and losses, particularly latent fingerprint, blood, and hair analysis capabilities used with data files, and a tool mark analysis capability to connect a suspect with a crime. Each system would yield savings from burglary losses over the next decade in excess of a billion dollars.

Full use of the fingerprint evidence alone is projected to reduce burglary losses by almost $8 billion over the next decade. This type of advanced system would more than pay for itself since preliminary estimates are that the additional costs to collect fingerprint evidence and operate advanced filing and searching systems in the 50 states are at a maximum approximately only one-fourth as much as the savings.*

*See Appendix C for preliminary estimates of the costs to operate these advanced offender identification systems.

Table 7. Impact of Advanced Evidence Analysis Systems on Burglary Rates and Losses (for 1974 to 1983 Period)

Case	Evidence Type	Conviction Rate per 100 Burglaries (Current = 6.6)	Percentage Burglary Reduction	Dollar Loss Prevented ($ Billion)
I	Fingerprints	17.9	48	7.9
	Blood	8.2	11	1.8
	Hair	7.9	9	1.5
	All Three[a]	20.3	53	8.7
II	Fingerprints	7.1	4.0	0.6
	Blood	6.7	0.6	0.08
	Hair	6.7	0.5	0.07
	All Three[a]	7.2	5.0	0.7
III	Paint	6.8	1.8	0.3
	Glass	6.9	2.1	0.3
	Fibers	6.8	1.2	0.2
	Soil	6.7	0.6	0.08
	Metal	6.7	0.5	0.07
	Tool Marks	7.7	8.0	1.3
	All Six[a]	8.2	11.0	1.8

[a]Because of the assumed statistical independence of the occurrence of each type of evidence, the conviction rates resulting from the possession of more than one type of evidence is not simply the sum of the rates resulting from each type (see Appendix A, Section A.2.h).

Of greater significance is the fact that even in the case of those types of evidence which result in very small increases in the conviction rate there is a fairly large impact on the burglary rate and burglary losses. For example, the ability to individualize soil and metals (Case III) or hair and blood (Case II) would increase the conviction rate over the current values by fewer than one person per 1000 burglaries. Even so, use of these capabilities could reduce the nation's expected burglary losses over the next decade by about 100 million dollars.

As discussed, the large effect that a relatively small increase in the number of persons convicted per burglary has on decreasing the burglary rate arises from the fact that this type of crime is characterized by several offenses per burglar per year. Sensitivity of the calculated burglary rate to the average number of burglaries committed per burglar per year is shown in Figure 6. The reduction in total burglaries for a ten-year period is shown as a function of conviction rate for three values of the average number of burglaries per burglar per year: the derived value (and assumed to be the actual value) of eight per year, and values of one and 16 per year. It is seen from the figure that the burglary reduction resulting from increased conviction rates provided by the advanced evidence analysis capabilities would be significantly diminished if the crime were characterized by only one burglary per burglar per year (and increased if characterized by 16 per year).

For those crime types which are typically committed just once by an offender in his criminal career, the only crime reduction arising from increased conviction rates occurs as the result of whatever deterrent effect

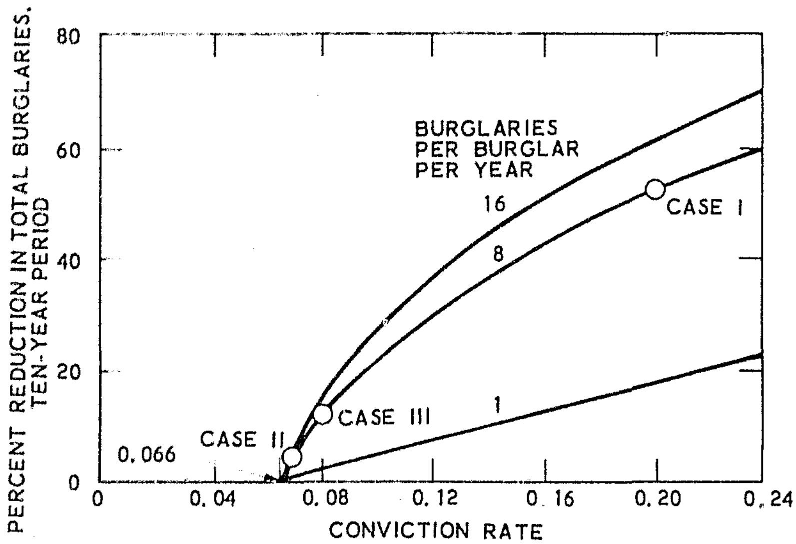

Figure 6. Percentage Reduction in Total Burglaries for Various Values of Burglaries per Burglar per Year (for Ten-Year Period)

is produced by the increased conviction probability. However, most of the major crimes are like burglary in that several offenses per offender per year are committed. These include robbery, auto theft, larceny, and perhaps rape, but generally not murder.* As such, it can be inferred (although the calculations were not performed because of the extensive data required) that the phenomenon seen for burglary also occurs for these crimes, i.e., that relatively small increases in the number of offenders identified and convicted yield significant decreases in the rate of these crimes.

Figure 7 shows how the effect on the burglary rate of changes in the burglary conviction rate due to advanced evidence analysis capabilities compares

*Fortunately, murder is the major crime which has the highest conviction and clearance rate.

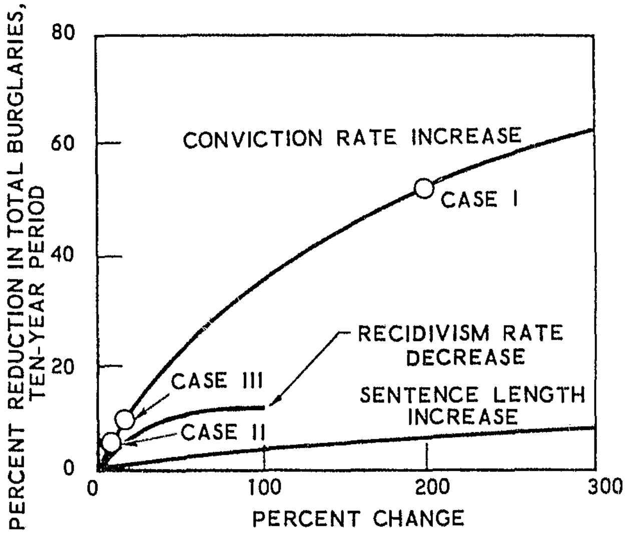

Figure 7. Comparative Effect of Changes in Conviction Rate, Recidivism Rate, and Sentence Length

with that of changes in two other alternatives for control of burglary: increasing the average sentence served by burglars and decreasing the prison-to-burglary recidivism rate. The improvements in these factors are represented in Figure 7 as follows: for conviction rate and sentence length a change of 100% means an increase from their current values of 0.035 and 0.7, respectively, to 0.07 and 1.4. For recidivism rate, a change of 100% means a decrease from the current value of 0.34 to 0. For reference, the percentage change in conviction rate arising from the use of evidence in Cases I, II, and III is also depicted.

It can be observed that, for equivalent percentage changes, a conviction rate increase yields significantly greater reductions in burglary rate than the two correctional alternatives. In particular, no amount of improvement in recidivism rate or increase in sentence length can duplicate the effectiveness of the Case I type of advanced evidence analysis capabilities. Examination of the calculations reveals that when a low conviction rate is coupled with a large entry rate of new burglars, the impact of correctional system changes on the burglary rate is minimized, i.e., burglars are brought into the correctional system too slowly to allow the subsequent correctional programs to which they are subjected to have a significant effect.

In summary, the relatively high impact that small increases in the conviction rate have on decreasing the burglary rate can be inferred to be true also of other crimes which are characterized by several offenses per offender per year and for which conviction rates are currently low, such as larceny, robbery, and possibly rape. Thus the burglary rate calculations performed in this section provide a useful, albeit qualitative, perspective on the overall potential of advanced evidence analysis techniques to reduce these other major crimes. The calculations indicate that these techniques have a potential for reducing major crimes which is significant and equal to that of other major alternative strategies proposed.

CHAPTER IV. THE LEGAL AND OPERATIONAL ACCEPTABILITY OF ADVANCED FORENSIC SCIENCE CAPABILITIES

A. Introduction

Advanced forensic science capabilities cannot realize their previously calculated full potential if (1) legal restrictions severely limit the ability of investigators to obtain evidence from suspects or (2) the methods used in the analyses are not admissible in the courts or (3) law enforcement agencies and crime laboratories do not choose to adopt, on a widespread basis, the advanced equipment and techniques. These three factors will be analyzed in this chapter to permit a better understanding of the limits to the potential of advanced forensic systems and the characteristics they must possess if they are to fulfill that potential.

B. The Accessibility of Physical Evidence

The calculations previously presented showed the significant impact on crime rates that can result from the increased use of physical evidence. In these calculations, it was assumed that physiological or personally related substances or impressions, such as blood, hair or fingerprints, could be legally obtained from suspects (Cases I and II) and that a suspect's body, clothing or personal possessions could be legally searched with a thoroughness sufficient to locate any (often minute) physical materials also found at the crime scene (Case III). Indeed, in the past, almost all these evidentiary materials have been admitted by the courts. By reviewing such past legal decisions,* it is possible to determine their implications on the future use of evidence assumed in Chapter III.

The legality of obtaining a sample of blood from an arrestee can be inferred from the case of Schmerber v. California in 1966 in which blood was obtained from an individual for a blood alcohol test following a traffic accident.[37] The suspect's blood was withdrawn under sterile conditions by a physician using recognized procedures immediately following the suspect's arrest in spite of his protest and the absence of counsel. In its decision, the court said blood is noncommunicative in nature, i.e., it is a physical characteristic of an individual rather than evidence that might communicate the knowledge of a particular crime. Thus the extraction of the evidence was ruled to be outside the purview of the constitutional limitations against self-incrimination.

This decision would imply that the extraction of blood from a suspect by a qualified person using accepted procedures would be legal and the blood sample admissible in court. In addition, it would appear by extrapolation from the Schmerber case that--with the possible exception of semen--all other physiological materials, such as saliva, perspiration, urine, hair, and fingernails, can be obtained legally. The legal basis for obtaining semen for comparison purposes, as in a rape case, is more difficult to assess. Although semen is also noncommunicative evidence, the manner in which this fluid is

*These decisions and their implications are treated in more depth in Appendix D.

obtained must satisfy the criterion that it "not shock the conscience" as ruled in the case[38] of Rochin v. California in 1952.* (However, this problem may be circumvented since it may prove possible to compare the genetic markers contained in a crime scene sample to the markers contained in other physiological material taken from the suspect, such as blood.)

The nonphysiological types of evidence, such as paint, glass, fibers, soil, and tool marks, appear to be accessible if legal search and seizure procedures are followed. These types of evidence have been and are presently used in court trials. For example, surveys of criminalists conducted by The Aerospace Corporation in support of the development programs involving blood and bloodstain analysis[16] and gunshot residue analysis[25] indicate that the present methods of evidence collection have not been restricted on a legal basis and no changes in accessibility are expected.

An important recent decision occurred in Cupp v. Murphy in 1973 where evidence obtained was ultimately ruled to be admissible.[39] The case involved the murder of an estranged wife in which the defendant voluntarily came to the police for questioning. While questioning the defendant, the officers noted that there were dark-colored materials under his fingernails. Without any arrest being made or any search warrant issued, and under protest by the defendant, the officers scraped the materials from under his fingernails. The evidence obtained was used against him in a trial resulting in his

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*In this case, a suspect's stomach was pumped to obtain swallowed narcotics.

conviction. After several appeals based on motions of illegal search and seizure, the U.S. Supreme Court upheld the conviction, ruling that the evidence obtained in this case was admissible The implication is that evidence obtained directly from an individual without arrest and under protest can under certain circumstances be legally introduced into court trials.

It appears, then, that the potential of improved forensic science techniques is not diminished by the legal inaccessibility of physical evidence.

C. The Admissibility of Advanced Forensic Science Analysis Techniques

There are several evidence analysis techniques available to investigators whose results cannot presently be used in court, such as "truth serum," speech pattern analysis and comparison, and the polygraph. It is useful, therefore, to examine the factors which may similarly limit the admissibility and potential utility of innovative or advanced forensic analysis techniques.

The three most important cases[40, 41, 42] which provide the legal tests for the admissibility of new techniques are Frye v. U.S. (1923), People v. Williams (1961), and Coppolino v. State (1969).* The Frye decision required that a new technique be accepted in the general scientific field in which it is based. Later, recognizing that scientists cannot be experts over the entire range of evidence analysis techniques within their general scientific field, the Williams decision allowed for the acceptance of a new technique if the method is established within the field of specialization. The most recent of

*These decisions and their implications are treated in more depth in Appendix D.

the three cases, Coppolino in 1969, further relaxed the admissibility test by allowing recognition of a new technique which may not be generally known, even within the field of specialization, if it is based on a variation of an already proven scientific principle. However, substantiation by other expert witnesses is required for admissibility.

Despite the fact that the Coppolino decision is the most recent, it does not replace the more stringent criteria of the Frye and Williams cases. An example of a recent application of the Frye test was in the rejection of the speaker identification results in the case[43] of People v. Law (1974). The exact words used in the Frye case were repeated in rejecting the technique. Speech individualization or voiceprint comparisons have not been admissible because the technique has not received general scientific acceptance and experts frequently disagree in their interpretation of the same voiceprint. Thus the courts still regard this technique as an experimental one.

Similarly, the results of the polygraph, or "lie detector," are generally considered inadmissible as evidence in a criminal trial since many variables affect their reliability, especially those that bear on the competency of the examiners. The courts view the polygraph technique as lacking general scientific recognition of its reliability.

Results of narcoanalysis, often referred to as "truth serum," are also inadmissible as evidence in a criminal trial, again because there is no consensus on the validity of the technique in the scientific community.

In contrast, neutron activation analysis as a technique for forensic analysis was generally and rapidly accepted by the scientific community, and its results were accepted by the courts as admissible evidence. The first detailed publication of the procedure[14] appeared in 1961 and the first use in trial court was in 1964. Since the general technique is based on accepted scientific principle, most questions concerning the admissibility of neutron activation analysis in the courts concern the qualifications of the expert witness and the procedure used in his analysis.

For the more innovative forensic science capabilities discussed in this report, the courts will apply the most stringent admissibility criterion, i.e., Frye v. U.S., upon their introduction. This criterion would be particularly applicable, for example, to the introduction of body fluid and hair individualization techniques, since they would represent analyses that are based on recent research. It can be expected that their admission will not occur quickly and will not occur at all unless there is a widely recognized scientific basis for them.

Introduction of those advanced forensic science capabilities, such as gunshot residue, paint, glass, and blood analysis, which are improvements or adaptations of accepted existing principles, falls within the purview of the more lax Williams or Coppolino criteria for admissibility. For example, it is expected that most of the techniques emanating from research and development of bloodstain analysis would be judged under Coppolino because they are adaptations of currently used methods for identifying genetic markers in whole blood. Thus it is expected that the admissibility of these techniques will be quickly established after their development.

Research and development in latent fingerprint technology involves automated or semi-automated retrieval procedures to expedite the identification of criminal suspects. Automation affects only the speed of the search process and should not affect the basis of admissibility of either latent fingerprint identification (or that of firearms). To the extent that this technology only assists the forensic expert and the final identification performed by him, automated search procedures are legally admissible under current judicial procedures.

In all applications, statistically significant samplings of the parameters of interest among the population are needed by criminalists to evaluate their discrimination probabilities. Such statistical samplings must be presented concomitantly to ensure the admissibility of a novel technique.

D. Crime Laboratory Acceptance of Advanced Forensic Capabilities

The calculation of the potential effectiveness of the advanced forensic science capabilities previously presented assumed that the various evidence types were collected and analyzed routinely for each crime occurrence on a national basis. However, the availability of an advanced technique does not ensure its widespread adoption. There are certain characteristics these techniques must exhibit if a degree of use sufficient to warrant their development is to be realized. These characteristics, generalized from the past history of crime laboratory acceptance or rejection of new techniques and from surveys of crime laboratories to be discussed, are described below.

There is no doubt that the foremost criterion for acceptance of a new forensic science capability is reliability. For example, use of the dermal nitrate paraffin test for gunshot residue has been generally rejected because it sometimes indicates positive results in the absence of actual gunshot residue. But reliability is not the only factor. For example, neutron activation analysis is a technique with high reliability and sensitivity and is nondestructive. It showed great promise for the individualization of many varieties of physical evidence by analyzing their trace element composition. However, the technique requires that the evidence be submitted to one of the few nuclear reactor facilities in the U.S. equipped for such analyses. Long turnaround time and high costs have, as a result, greatly limited its actual use.

Therefore, in-house analysis capability is a feature strongly desired by crime laboratories. The principal reason for this is the need to maintain the legal chain of custody--continuous possession of the evidence must be safeguarded. This requirement compounds the inconvenience created by shipping evidence to an outside agency.

The preference for in-house analyses was expressed by criminalists in response to the recent survey conducted by The Aerospace Corporation.[25] Various criminalists were queried as to the expected use of gunshot residue analysis under two hypothetical conditions. In the first, a rapid, simple and inexpensive technique that yielded a somewhat definitive result suitable for screening purposes was available in their own laboratories. The second assumed a completely definitive method of analysis in which specimens had to be sent to an outside laboratory and the analysis was rather time consuming (two weeks) and expensive ($500 per case). Evaluation of the responses of the criminalists indicated that for a "typical" crime laboratory in the first situation, gunshot residue analysis would be performed in approximately 200 cases per year despite the lack of completely definitive results. In the second situation, it was estimated that analysis would occur in only three cases per year.

A new technique should be inexpensive to use to ensure widespread adoption. Therefore, it should be capable of being performed on existing equipment or on equipment that can be inexpensively purchased by the crime laboratory. The survey discussed in the previous paragraph indicates that the limit on the cost of equipment acquired by the average crime laboratory is about $10,000 per year.

Both ease of operation and ease of interpretation are criteria for a new technique. In the small crime laboratory, the wide variety of physical evidence encountered dictates that the criminalist's skills be general in scope. Thus special skills or expertise should not be required by a new forensic science technique. Equipment available today for drug and alcohol analyses typically meets these criteria as attested to by the current heavy use of the crime laboratory for such work. This would not be the case if these materials required highly complex analyses such as those conducted by the British on blood.

Nondestructive analyses are preferred by criminalists to ensure that physical evidence can be preserved for additional analyses. Frequently, more than one analysis must be performed to obtain the desired level of individualization (for example, blood analysis), and it is often necessary to repeat the analysis to verify accuracy either by the original criminalist or by another expert witness if one is retained by the defense counsel.

In summary, then, the likelihood of widespread acceptance of new or improved forensic science capabilities by crime laboratories will be enhanced if they (1) can be purchased with typical crime laboratory resources, (2) do not require highly specialized skills for conducting and interpreting the analysis, and (3) are nondestructive.

APPENDICES

APPENDIX A. THE IMPACT OF EVIDENCE USE ON CONVICTION RATE: METHODS AND DATA

1. Approach

The purpose of this Appendix is to present the method and supporting data used to calculate the increased conviction rate which would occur by using various advanced evidence analysis techniques for each of the three cases described in Table 1 of Chapter I.

Case I is that of the use of fingerprints, blood or hair left at crime scenes in the same manner in which latent fingerprints are used to a limited degree today--namely, to implicate an otherwise unknown person through search and comparison of a data file containing individual characteristics. To estimate the number of perpetrators which would be identified and convicted in this case, the following relation is used

$$C_I = a \times b \times c \times d \times u \quad \text{(A-1)}$$

where

C_I = additional convictions per crime resulting from use of personal evidence and an identification file

a = the frequency with which the particular type of physical material occurs at crime scenes

b = the fraction of the potential evidence which is of sufficient quality to permit laboratory analysis and court presentation

c = the fraction of the potential evidence attributable to the perpetrator rather than to a person who had legitimate access to the crime scene

d = the probability that the perpetrator's fingerprints, blood or hair characteristics are stored in the data file and can be successfully retrieved and compared

u = the current fraction of crimes in which the perpetrator is not convicted

Case II is that of the use of fingerprint, blood or hair evidence by comparing the personal characteristics of an available suspect identified by other investigatory processes (such as the use of modus operandi, informants or eyewitnesses) to the characteristics of the evidence found at the crime scene. To estimate the additional perpetrators who would be convicted in this case, Equation (A-2) is used

$$C_{II} = a \times b \times c \times e \qquad \text{(A-2)}$$

where

C_{II} = additional convictions per crime resulting from the use of evidence of the type and method assumed for Case II

a, b, c = as defined above

e = the fraction of cases in which a perpetrator is identified as a suspect, but is not convicted because of a lack of evidence

Case III differs from Case II only in the fact that, unlike fingerprints, blood or hair, the evidence involved (paint, glass, fibers, and soil) is not necessarily present on a perpetrator who is an identified suspect. The equation presented below is used to calculate the increased conviction rates for Case III and reflects this additional consideration.

$$C_{III} = a \times b \times c \times e \times f \qquad \text{(A-3)}$$

where

C_{III} = additional convictions per crime resulting from the use of evidence of the type and method assumed for Case III

a, b, c, e = as defined above

f = the fraction of perpetrators to or from whom the physical material found at the crime scene is transferred during the commission of the crime and on whose person or in whose possession the evidence remains for a sufficient period of time to be found by investigators

2. Parameter Values

The parameter values for the nine types of evidence treated in the study for the crime of burglary are summarized in Table A-1 and the assumptions and data are discussed below. The data were obtained from available sources or estimated when necessary.

a. <u>The rate of occurrence of potential evidence (a)</u>. The occurrence rate, Parameter a, was obtained from data in the Parker and Peterson study.[7]

Table [illegible]. Parameter Values

Case	Evidence	Occurrence Rate (a)	Quality Factor (b)	[illegible] (c)	[illegible] (d)	[illegible] (e)	[illegible] (f)	[illegible] (g)
I	Fingerprints	0.42	[illegible]	[illegible]	[illegible]	NA	NA	[illegible]
	Blood	[illegible]	[illegible]	[illegible]				
	Hair	[illegible]	[illegible]	[illegible]				
II	Fingerprints	0.42	0.8	0.51	NA	[illegible]	NA	NA
	Blood	0.03	0.8	1.0				
	Hair	0.05	0.8	0.51				
III	Paint	0.20	0.8	1.0	NA	0.03	0.5	NA
	Glass	0.23	0.8	1.0			0.5	
	Fibers	0.13	0.8	0.51			1.0	
	Soil	0.12	0.8	0.51			0.5	
	Metal	0.05	0.8	1.0			0.5	
	Tool Marks	0.46	0.8	1.0			1.0	

NA — Not Applicable

Table A-2 summarizes the frequencies with which the participating criminalists identified various categories of potential evidence at crime scenes. However, the physical materials tabulated were only those judged by the criminalists to be potential evidence. No assessment was made in the study as to whether the evidence was of sufficient quality to permit analysis (Parameter b) or whether it was actually attributable to the perpetrator (Parameter c).

b. <u>The qualify of potential evidence (b)</u>. Parameter b representing the quality of the evidence, was estimated as follows. Kingston and Madrazo[29] estimated that 80% of the latent fingerprints found at crime scenes were of sufficient quality to permit subsequent analysis. This value was used for fingerprint evidence in the present study. Because of smudging, fingerprints are likely to be more often poor in quality than paint, glass, and similar physical materials which preserve their integrity if they exist at all. Therefore, a value of 0.8 for the quality factor for most of the other evidence types is a conservative one except for tool marks and blood. Tool marks can be reasonably assumed to be similar to fingerprints in terms of quality. The value of 0.8 for bloodstains is simply an estimate, since additional research is required to establish the effect of aging on the genetic factors in dried bloodstains.

c. <u>The frequency with which potential evidence is actually attributable to a perpetrator (c)</u>. Parameter c, which is the fraction of the evidence actually attributable to the perpetrator's commission of the crime (the remainder either left by nonperpetrators or part of the natural environment), was estimated as follows.

Table A-2. Rate of Occurrence of Potential Evidence

Physical Object Category	Occurrence Rate								
	Burglary	Auto Theft	Larceny	Robbery	Rape	Assault Battery	Murder	All Others	Total
Toolmarks	0.46	0.39	0.24	0.19	0.0	0.2	0.4	0.32	0.43
Fingerprints	0.42	0.45	0.45	0.29	0.3	0.4	0.4	0.27	0.41
Organic Substances	0.28	0.31	0.18	0.15	0.5	0.2	0.4	0.14	0.27
Glass	0.23	0.15	0.06	0.00	0.2	0.2	0.2	0.50	0.21
Tracks	0.22	0.10	0.09	0.10	0.3	0.2	0.2	0.18	0.20
Paint	0.20	0.24	0.12	0.00	0.5	0.0	0.2	0.32	0.20
Clothing	0.15	0.20	0.09	0.19	0.8	0.2	0.2	0.18	0.16
Wood	0.20	0.04	0.00	0.05	0.0	0.0	0.2	0.09	0.16
Dust	0.17	0.13	0.09	0.10	0.3	0.0	0.0	0.05	0.15
Cigarette	0.11	0.29	0.18	0.38	0.5	0.0	0.2	0.14	0.15
Paper	0.10	0.31	0.12	0.19	0.2	0.0	0.0	0.18	0.13
Soil	0.12	0.23	0.03	0.05	0.2	0.2	0.4	0.05	0.12
Fibers	0.13	0.01	0.03	0.14	0.0	0.0	0.0	0.05	0.11
Tools	0.09	0.09	0.09	0.19	0.2	0.4	0.4	0.05	0.10
Grease	0.07	0.09	0.12	0.00	0.2	0.0	0.0	0.05	0.07
Construction Materials	0.08	0.04	0.00	0.00	0.0	0.0	0.0	0.14	0.07
Documents	0.07	0.10	0.06	0.05	0.0	0.0	0.0	0.05	0.07
Containers	0.05	0.09	0.12	0.00	0.0	0.2	0.2	0.41	0.07
Metal	0.05	0.05	0.09	0.00	0.2	0.0	0.2	0.14	0.05
Hair	0.05	0.03	0.03	0.10	0.5	0.0	0.0	0.09	0.05
Blood	0.03	0.05	0.03	0.14	0.2	0.6	0.6	0.23	0.05
Inorganic Substances	0.04	0.03	0.00	0.00	0.0	0.0	0.0	0.14	0.04
Miscellaneous	0.09	0.14	0.09	0.05	0.2	0.2	0.2	0.09	0.10

In the case of latent fingerprints, Kingston and Madrazo determined that 51% of all fingerprints submitted for analysis by experienced investigators were left by perpetrators, and this value is used for fingerprint evidence.

Because blood is not usually found in the environment of a home or commercial firm, it was assumed that all burglary scene blood found by Parker and Peterson[7] was left by the perpetrator (for example, from a cut during entry through a broken window). It was also assumed that all of the paint, glass, wood, metal, and tool marks found by Parker and Peterson were the result of the interaction between the perpetrator and the physical environment. These materials can probably be linked to the burglary on the basis of their location at the crime scene as indicated in Table 4 in Chapter III.

Estimates of the values of Parameter c for hair, soil, and fibers are somewhat more difficult to make since these items, like latent fingerprints, can be easily due to nonperpetrators present at the crime scene prior to or immediately after the crime.* The criminalists engaged in the Parker-Peterson analysis, through their assessment of the location of the potential evidence found, tabulated only the hair, soil, and fibers that they considered to indeed represent potential crime evidence. These judgments are similar to those which experienced investigators make today in the case of latent fingerprints. Therefore, it was assumed that the fraction of these three materials which

*For example, a typical person sheds some 200 hairs per day, soil can be tracked by anyone, and everyone's clothi g contains fibers.

actually arises from the interaction of the perpetrator with the environment is approximately the same as that for latent fingerprints, i.e., 0.51.

d. The probability a perpetrator is in the data file (d). The identification system in Case I was a data file containing the fingerprints, blood or hair characteristics of a segment of the population. Parameter d represents the probability that a perpetrator's characteristics are in such a file and can be successfully retrieved. Three possible data file types are:

- A file containing these data for every person in the U.S., in which case d = 1.0.
- A file of all persons previously arrested in the U.S. Since 71% of burglary arrestees have been arrested at least once previously for some crime,[35] the assumption is made that 71% of the burglaries are committed by persons arrested at least once, so that d = 0.71.
- A file of all persons previously convicted in the U.S. Since 40% of all burglary arrestees have been previously convicted once for some crime,[35] the assumption is made that 40% of all burglaries are committed by persons previously convicted, so that d = 0.4.

For the base case in this analysis, it is assumed that the file contains data for all previously arrested persons and so d = 0.71.

e. Fraction of cases with unconvicted guilty suspects because of lack of evidence (e). The effective use of physical evidence in Cases II and III requires that a suspect be arrested to permit either his personal characteristics

(Case II) or the characteristics of the materials found on his person or in his possession (Case III) to be obtained and compared to those of the evidence found at the crime scene.

In order to determine the additional convictions which would result from the full use of physical evidence, the number of perpetrators arrested but not currently convicted has to be estimated. To permit an estimate of this number, a detailed analysis was made of the data[30] on the prosecution of adult burglary defendants in Los Angeles County.

Examination of these data, summarized in Table A-3, indicates that the availability of physical evidence could reasonably be expected to assist in the conviction of otherwise unconvicted arrestees in four of the dispositions. These are cases in which charges were dropped because of:

- Insufficient evidence to connect the suspect to the crime (12%)
- Insufficient evidence existed, the circumstances of which were unspecified (2%)
- The victim would not participate (4%)
- A witness would not participate (1%)

The cases dropped for these four reasons comprise 19% of all adult burglary arrests, or two-thirds of the cases where no charge was filed by the District Attorney. Since dismissals and acquittals are caused by reasons similar to those that result in the rejection of cases during screening by the District Attorney, it is assumed that two-thirds of these result in the release of the defendant primarily because of one of the four reasons. Thus an additional two-thirds of 12%, or 8%, of adjudicated defendants are released primarily because of lack of evidence. Combining this percentage with the previous

Table A-3. Disposition of Burglary Defendants

Disposition	Percentage of Adult Arrests	
Felony Conviction	18	
Misdemeanor Conviction	33	
Acquittal	6	
Dismissal	6	
Diverted	2	
Routed to a New Jurisdiction	7	
Subtotal		72
Released without being charged		
Reason:		
Insufficient evidence of corpus of crime	4	
Insufficient evidence - suspect	12	
Insufficient evidence - unspecified	2	
Restitution made to victim	1	
Victim does not participate	4	
Witness does not participate	1	
Other	4	
Subtotal		28
TOTAL		100

percentage computed for the case of suspects released without trial implies that 27% of arrested suspects are released because of lack of evidence. Finally, it is assumed that 27% of the 7% of the rerouted cases are similarly adjudicated which implies an additional 2% of arrested suspects will be released because of lack of evidence. Summing these various dispositions, it is seen that the total fraction of all adult arrests where there is no conviction because of lack of evidence is given by 19% + 8% + 2% = 29%. It is assumed that half of these, or 14.5%, are actually guilty. This is based on subjective estimates provided by prosecutors polled in the survey. Thus, since there are 18 arrests per 100 burglaries reported, the number of persons arrested and found guilty but not convicted because of lack of evidence is 18 x 0.145, or approximately three per 100 burglaries.

f. Evidence transferred and remaining (f). In Case III, the evidence produces convictions only if the paint, glass, fibers, soil, metal, or the tools leaving tool marks found at the crime scene, are also found on the person, clothing, or in the possession of an arrested perpetrator.

It has been reported[31] that 67% of a random sample of men's suits brought to a cleaning establishment had glass fragments in one or more places--the cuffs, pockets or fibers and 97% contained paint chips. This indicates that clothing is an excellent retainer of glass and paint fragments, and it can be inferred that it is also an excellent retainer of other particulate material, such as wood, metal, and soil. However, there is no guarantee that these materials will actually be transferred from the crime scene environment to the perpetrator and, if they are, that the perpetrator will not clean his clothing. For these types of evidence, a value of 0.5 is assumed for Parameter f.

In the case of fibers, it is assumed that the clothing worn by the perpetrator which left the fibers at the crime scene will still be in his possession at the time of his arrest, yielding a value of $f = 1.0$ for this type of evidence. A similar assumption was made concerning tool marks, i.e., the tools used by a perpetrator during the commission of a crime will still be in his possession at the time of his arrest, so that $f = 1.0$.

g. The fraction of perpetrators who are unconvicted (u). The value of Parameter u was obtained from California burglary disposition data presented in Table B-1 in Appendix B. As shown, only 6.58%, or approximately 7%, of all burglaries lead to the conviction of the offender; therefore $u = 1 - 0.07 = 0.93$.

h. Combined effect of several evidence types. It was assumed that the rates of occurrence of good quality evidence attributable to perpetrators (and transferred, in Case III) for the various evidence types are statistically independent. Then the probability of finding one or more of n types at a crime scene is

$$1 - (1 - a_1b_1c_1)(1 - a_2b_2c_2)(1 - a_3b_3c_3) \dots (1 - a_nb_nc_n)$$

where the subscripts refer to evidence types 1, 2, and 3, and a, b, c are the parameters defined previously.

Thus the burglary conviction rate increases using all three types of evidence (Cases I and II) or all six (Case III) are

$$C_I = [1 - (1 - a_1b_1c_1)(1 - a_2b_2c_2)(1 - a_3b_3c_3)] \, d \times u$$

$$C_{II} = [1 - (1 - a_1b_1c_1)(1 - a_2b_2c_2)(1 - a_3b_3c_3)] \, e$$

$$C_{III} = [1 - (1 - (1 - a_1b_1c_1f_1) \cdot \cdot \cdot (1 - a_6b_6c_6f_6)] \, e$$

When these equations are applied, the total conviction rate from using the various evidence types is less than the sum of the conviction rates from the individual evidence types.

APPENDIX B. MODEL OF BURGLARY AND THE CRIMINAL JUSTICE SYSTEM

1. Method

The purpose of this model is to provide a mechanism by which to estimate the sensitivity of the future burglary rate to changes in (1) such criminal justice parameters as the rates of apprehension, conviction, and incarceration of burglars, and their average sentence served, and (2) such attributes of the burglar population as the average number of burglaries per burglar per year, the next influx rate of new burglars, and the average rate of recidivism from corrections back to burglary. The approach is to express the rate of change of the burglar population as a function of these variables. The size of the burglar population can then be projected from its present value and its future rate of change, and the future burglary rate calculated frcm the future size of the burglar population and the average number of burglaries per burglar per year.

The base values of the model variables are obtained from current criminal justice data for burglars (Appendix A), and the value of the burglar population is adjusted so that the burglary rates predicted by the equations derived below agree with the burglary rates of the past few years. The effect of a change in a criminal justice parameter or burglar population characteristic can then be determined by solving the equations with the new value(s) (while keeping all other parameters at their base case values) and observing the resulting change in the burglar rate. The basic structure of the model from which the equations are derived is shown schematically in Figure B-1.

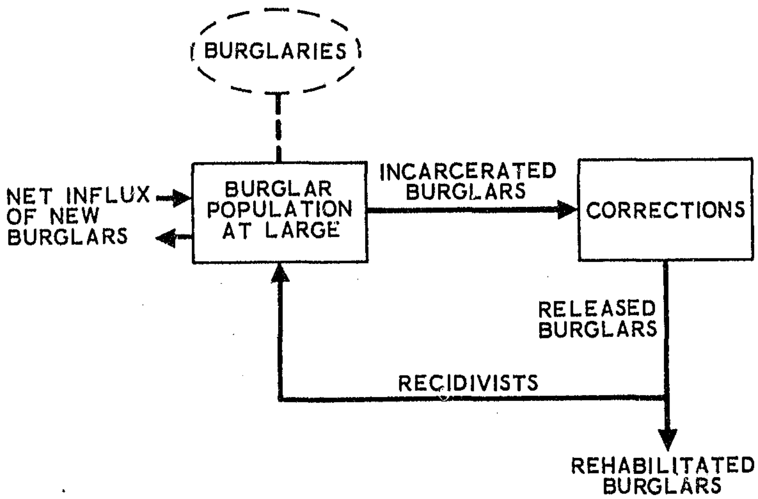

Figure B-1. Basic Model Structure

The burglar population and burglary rate equations can be expressed in words as follows

$$\begin{pmatrix}\text{Burglary}\\ \text{Rate}\\ \text{this Year}\end{pmatrix} = \begin{pmatrix}\text{Burglar}\\ \text{Population}\\ \text{this year}\end{pmatrix} \times \begin{pmatrix}\text{Average Burglaries}\\ \text{per Burglar}\\ \text{per Year}\end{pmatrix}$$

and

$$\begin{pmatrix}\text{Burglar}\\ \text{Population}\\ \text{this Year}\end{pmatrix} = \begin{pmatrix}\text{Burglar}\\ \text{Population}\\ \text{Last Year}\end{pmatrix} + \begin{pmatrix}\text{Rate of Change of}\\ \text{Burglar Population}\\ \text{per Year}\end{pmatrix}$$

$$\begin{pmatrix}\text{Rate of Change}\\ \text{of Burglar}\\ \text{Population per}\\ \text{Year}\end{pmatrix} = \begin{pmatrix}\text{Net Rate of}\\ \text{Influx of}\\ \text{New}\\ \text{Burglars}\end{pmatrix} - \begin{pmatrix}\text{Rate of Entry}\\ \text{of Burglars}\\ \text{into Jail and}\\ \text{Prison}\end{pmatrix} + \begin{pmatrix}\text{Rate of Return to Burglar}\\ \text{Population of Released}\\ \text{Prisoners Who Recidivate}\end{pmatrix}$$

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1 OF 2

a. Definitions. In order to state these equations in more precise mathematical terms, the following definitions are used.

Let

B_t = the total at-large burglar population at time t

b = the average rate of commission of burglaries by burglars

G_t = the burglary rate at time t

So $G_t = bB_t$

Also let

$\frac{dB_t}{dt}$ = the rate of change of the burglar population at time t

Δt = an increment of time

Then

$$B_{(t + \Delta t)} = B_t + \Delta t \frac{dB_t}{dt}$$

Let

N_t = the net rate of entry of new burglars into the at-large burglar population at time t (that is, new burglars minus persons leaving burglary for any reason other than incarceration)

P_{n_t} = the rate of entry of newly incarcerated burglars into corrections

c = the conviction rate based on the number of burglars convicted per offense reported

i = the probability a convicted offender will be incarcerated

Then

$$P_{n_t} = ciG_t = cibB_t$$

Let

P_{r_t} = the rate of return to the burglar population of released prisoners who recidivate to burglary at time t

r = the fraction of released prisoners who recidivate to burglary

s = the average period of incarceration

Recall

P_{n_t} = new prisoners at time t

So $P_{n(t - s)}$ = released prisoners at time t

So $$P_{r_t} = r\,P_{n(t-s)} = rcibB_{(t-s)}$$

Thus the model equations are

Burglary rate:

$$G_t = bB_t \qquad \text{(B-1)}$$

Burglar population:

$$B_{(t + \Delta t)} = B_t + \Delta t \frac{dB_t}{dt} \qquad \text{(B-2)}$$

$$\frac{dB_t}{dt} = N_t - P_{n_t} + P_{r_t} \qquad \text{(B-3)}$$

or

$$\frac{dB_t}{dt} = N_t - cibB_t + rcibB_{(t - s)} \qquad \text{(B-4)}$$

So

$$B_{(t + \Delta t)} = B_t + \Delta t\left[N_t - cibB_t + rcibB_{(t - s)}\right] \qquad \text{(B-5)}$$

b. Method of Solution. The basic equation, Eq. (B-5), which is diagrammed in Figure B-2, is solved numerically using a time increment, Δt, of 0.1 year (conveniently large, but small enough for reasonable accuracy). The explicit parameters, b, i, c, r, s, may be viewed as functions of time and may be changed in value at any time increment in any manner whatsoever to determine the effect on the burglary rate. The equation which is solved on the computer then is

$$B_{(t + \Delta t)} = B_t + \Delta t \left[N_t - c_t i_t b_t + r_t c_{(t - s)}\, i_{(t - s)}\, b_{(t - s)}\, B_{(t - s)}\right] \qquad \text{(B-6)}$$

2. Supporting Criminal Justice Data

This part of Appendix B contains the criminal justice data for the crime of burglary which are required to make projections of the burglary rate using the model described on the previous pages.

a. Burglary rate data. Figure B-3 shows the U.S. burglary rate for 1960 through 1973 as reported in the FBI Uniform Crime Reports (circles). The solid line is a fit of these data using an exponential curve passing through the 1960 and 1973 burglary rates. The formula for the curve is

$$\text{Burglaries per Year} = 903{,}400\ (1.0828)^{t-1960}$$

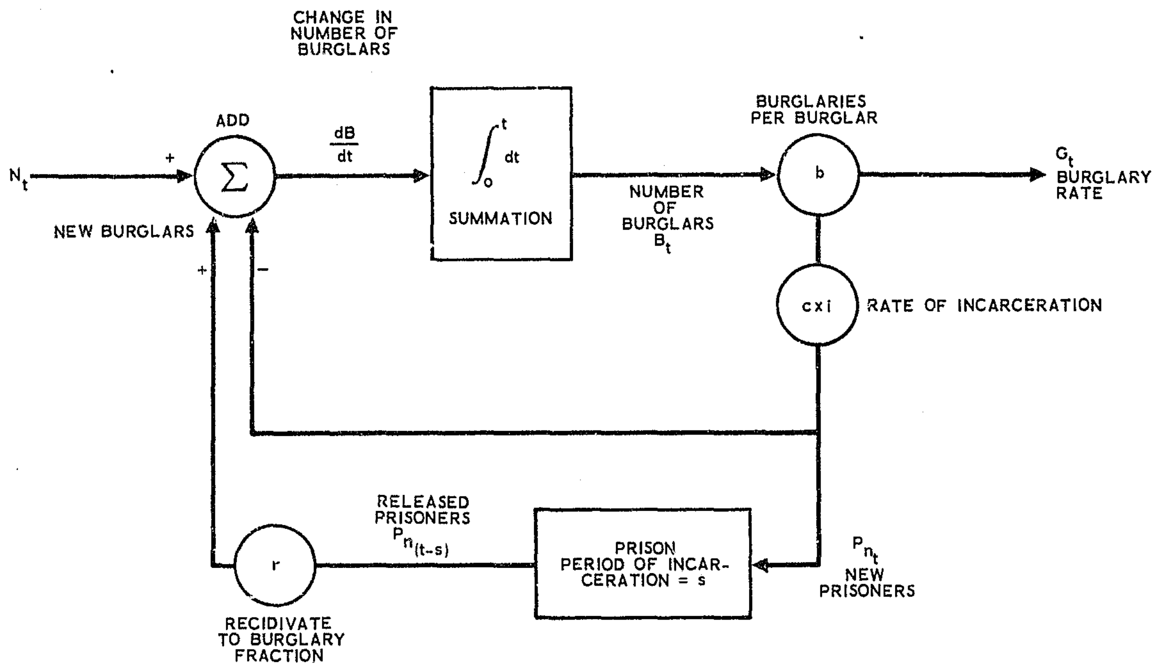

Figure B-2. Model Structure and Variables

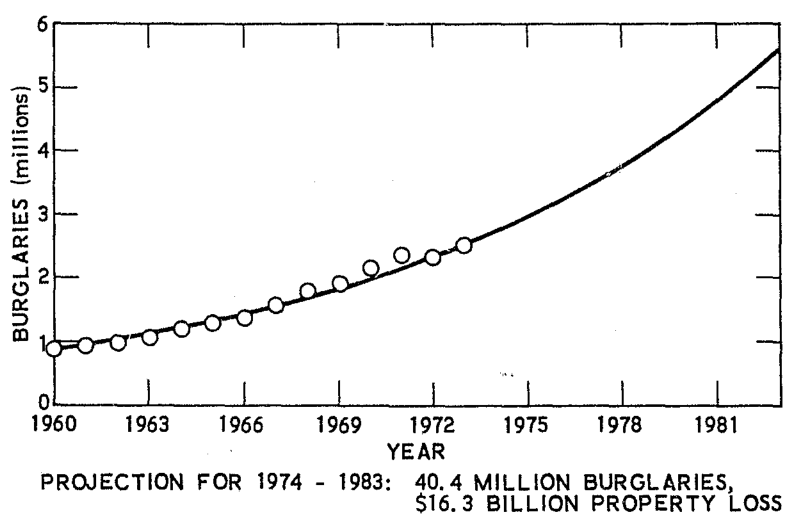

Figure B-3. Burglary Rate from 1960 to 1973 and Projection for Next Ten Years (Circles, FBI Data)

The average annual increase in burglaries during the 1960 to 1973 period was thus calculated to be 8.28%. The curve has been extended to 1983 to project the burglary rates for the subsequent ten years assuming the 1960 to 1973 trend continues. The total projected burglaries for the ten-year period from 1974 to 1983 is 40.4 million.

b. Average loss. In order to project total property losses due to burglary, the average loss per burglary is projected from FBI Uniform Crime Reports data as shown in Figure B-4 (circles). Between 1967 and 1973 the average loss rose from $273 to $337. If this trend continues, the average loss in year t, L_t, will be given by the function

$$L_t = 337 + 10.67\,(t - 1973)$$

which is the solid line in Figure B-4. Multiplying the projected average loss per burglary by the projected number of burglaries gives the projected annual property loss (Figure B-5, solid line). The circles in Figure B-5 are FBI Uniform Crime Reports data from 1967 through 1973. The total projected property loss for the ten-year period from 1974 to 1983 is $16.26 billion.

c. Disposition of burglary cases. Burglary arrest, conviction, and incarceration rates were obtained from California data[32] assumed to be representative of the country as a whole. These are shown in Table B-1. In the case of juveniles (persons under 18 years of age), only the number arrested is for the specific crime of burglary. The fractions of those

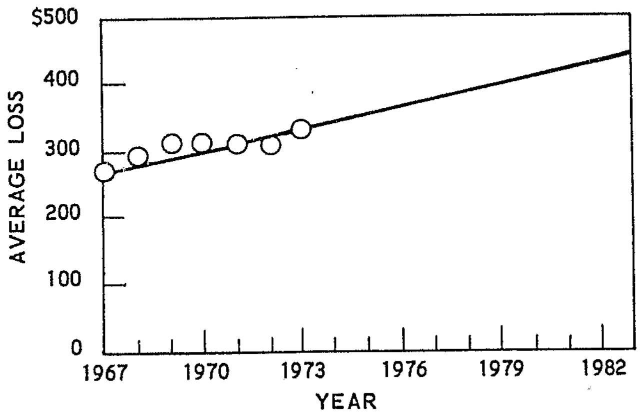

Figure B-4. Average Property Loss per Burglary from 1967 to 1973 and Projected for Next Ten Years (Circles, FBI Data)

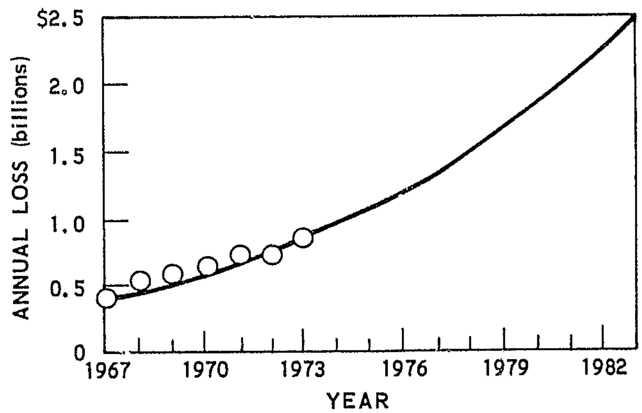

Figure B-5. Total Annual Property Loss from 1967 to 1973 and Projection for Next Ten Years (Circles, FBI Data) arrested who are prosecuted, convicted, and incarcerated are averages for all crime types. This procedure was made necessary by a lack of juvenile burglary disposition data.

d. Average sentence served. California data[32,33,34] were also the source of the average sentences served by adults (for burglary) and juveniles (all crimes). The overall average for both groups was 0.7 year as shown in Table B-2.

e. Average burglaries per burglar per year. The average number of burglaries per burglar at large per year is calculated as the product of the average arrests per burglar at large per year, times the expected number of offenses between arrests, times the fraction of the offenses which are burglaries. The arrest frequencies are drawn from the Computerized Criminal History data of the National Crime Information Center published in the 1972 FBI Uniform Crime Reports[35] and are shown on the second line of Table B-3.

In order to convert arrests per year into arrests per year at large, California data (Tables B-1, B-2) on incarcerations per arrest and average sentences served were used to find average jail time per year. Data for juveniles arrested for burglary were lacking, but if it is assumed that juvenile burglars at large--like juvenile offenders as a whole--experience 75% more arrests per year than their adult counterparts, the arrest frequency is then 2.4 times per year. The overall average for persons at large arrested for burglary is then 1.9 arrests per year.

Table B-1. Burglary Arrests, Convictions, and Incarcerations Per 100 Offenses Reported

Disposition	Juveniles	Adults	Total
Arrested	9.15	8.85	18
Referred to Juvenile Probation Department	5.13		
Prosecuted	1.52	7.03	8.55
Convicted	1.08	5.5	6.58
Incarcerated	0.008	3.47	3.48
Youth Authority	0.008	0.14	
Jail		3.05	
Prison		0.29	

Table B-2. Average Sentence Served for Burglary

Institution	Average Sentence (years) Served	Persons Incarcerated Per 100 Burglaries
Youth Authority (juveniles and some youthful adults)	0.5	0.15
Jail (adult misdemeanants)	0.5	3.05
Prison (adult felons)	2.7	0.29

Table B-3. Arrests Per Year at Large

	Juveniles (all crimes)	Adults (all crimes)	Adults (arrested for burglary)
Fraction of those arrested	0.26	0.74	0.49
Arrests per year	4.0	1.4	1.0
Incarcerations per arrest	0.001	0.35	0.39
Average time served (years)	0.5	0.8	0.68
Jail time per year	0.002	0.4	0.27
Arrests per year at large	4.008	2.3	1.37

The expected number of offenses between arrests, E, is obtained from the clearance-by-arrest rate. Let a be the probability of arrest given that an offense has been committed. Then

$$E = a + 2(1 - a)a + 3(1 - a)^2 a + \cdots$$

$$= a \sum_{n=1}^{\infty} n(1 - a)^{n-1}$$

But for $0 \leq X < 1$

$$\sum_{n=1}^{\infty} nx^{n-1} = \sum_{n=1}^{\infty} \frac{d}{dx}(x^n) = \frac{d}{dx} \sum_{n=1}^{\infty} x^n = \frac{d}{dx}\left(\frac{1}{1 - x}\right) = \frac{1}{(1 - x)^2}$$

so (letting $x = 1 - a$)

$$E = \frac{1}{a}$$

Furthermore, since the average probability of arrest is equal to the clearance-by-arrest rate, which is 0.19 (1972 FBI Uniform Crime Reports), the expected number of offenses between arrests is 5.3. Thus persons at large arrested for burglary commit $1.9 \times 5.3 = 10.07$ offenses per year. The question remains as to what fraction of these offenses are burglaries. Although data are not available, it seems likely that there is some degree of specialization and that most offenses (say 75%) committed by persons who are arrested for burglary are burglaries. This gives a value of eight burglaries per burglar per year.

Because of the uncertainty in the number of burglaries per burglar at large per year, and because of its importance in the analysis of the sensitivity of the burglary rate to other parameters, the analysis will be done for a range of values of burglaries per burglar per year.

f. Corrections-to-burglary recidivism rate. The first thing to notice is that the corrections-to-burglary recidivism rate is equal in value to the corrections-to-corrections recidivism rate. This is because for any person returning to burglary from prison the probability of his arrest and incarceration approaches unity as time passes, and he will eventually return to prison.

Figure B-6 shows the cumulative fraction of burglars released from California prisons (Ref. 4) during 1964 who returned in subsequent years with a new felony commitment (rather than for a technical parole violation). As can be seen, the fraction who eventually return--which is the asymptote of the curve--is 0.34. Thus the corrections-to-burglary recidivism rate is 0.34.

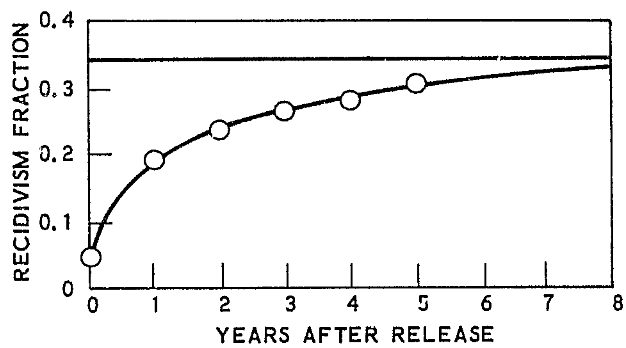

Figure B-6. Cumulative Fraction of Burglars Returned to Prison with New Felony Commitment

g. Calculation of net new-burglars-per-year entry rate, N_t. The net rate of the entry of burglars into the burglar population for all reasons (except entry into or return from prison) is defined as N_t. One may think of N_t as the net change in the at-large burglar population due to incoming new burglars and outgoing "retiring" burglars. Since there is no known data for N_t, its value was derived mathematically from Eq. (B-5) by using known values of the other parameters. Solving for N_t, Eq. (B-5) becomes

$$N_t = [B_{(t + \Delta t)} - B_t]/\Delta t + fcbB_t - rfcbB_{(t - s)}$$

The burglar population in year t, B_t, is obtained from the curve fitting the 1960 to 1973 burglary rate data (Figure B-3), by dividing by the number of burglaries per burglar per year (which is eight):

$$B_t = 112,925\ (1.0828)^{t-1960}$$

The other parameter values are f = 0.53, c = 0.066, b = 8, r = 0.34, and s = 0.7. For a time increment, Δt, of 0.1 year, $B_{(t + \Delta t)} = B(t + 0.1) = 1.0080B_t$. Also, $B_{(t - s)} = B_{(t - 0.7)} = 0.946\ B_t$. Thus

$$N_t = 0.08B_t + 0.28B_t - 0.09\ B_t = 0.27B_t$$

or

$$N_t = 30,490\ (1.0828)^{t-1960}$$

This is the function N_t which causes the model to fit the 1960 to 1973 burglary rate data. This indicates that, in any year, the next influx of persons into the burglar population is 27% of the burglar population at that time. Further, there was a net influx of 30,490 persons into the burglar population in 1960 and the rate of influx increased by 8.28% each year just as the burglary rate did. In 1973, the influx was calculated to be 88,900.

In performing the analysis of the sensitivity of future burglary rates to changes in the conviction rate and other parameters, it was assumed that N_t would continue to have the same form in the future. The deterrent effect of increased conviction rates on active and prospective burglars was ignored because the value was not known. Thus the estimates of the reductions in the number of burglaries are conservative since one would expect some deterrent effect.

APPENDIX C. PRELIMINARY COST ANALYSIS FOR AN ADVANCED OFFENDER IDENTIFICATION SYSTEM (FINGERPRINTS)

In formulating a preliminary estimate of the operating cost of a nationwide advanced identification system, the following assumptions were made for a latent fingerprint-based system:

- Each state would have a single conveniently located file search capability.
- Files for each state could be of three sizes containing either the fingerprint cards for known repeat criminals at large, all previously convicted persons, or all previously arrested persons.
- An average state will have a total population of 4.5 million (over the next ten years) and the various file sizes would average:
  - 50 thousand for known repeat criminals at large
  - 300 thousand for previously convicted persons
  - 1 million for all previously arrested persons
- A holographic or optical system would best handle files of less than 100 thousand; electronic or digital systems are best for files greater than 100 thousand.
- A state will average approximately 220 burglaries per day (80,000 per year) over the next ten years if no new systems are installed. Prints would be found in approximately half of these burglaries.

- Manpower costs average $25 per hour including overhead (approximately $50,000 per year).

Based on these assumptions, the following projections were made for personnel and equipment operating costs of the state systems for various file sizes:

Support Personnel

Optical System - known repeat criminals file size (50,000)

Aperture card operator	1
Key punch operator	2
Comparator operator	1
Maintenance	1
Fingerprint analyst	5
Total	10
Yearly cost ($50,000 per man)	$ 500,000

Digital/Electronic Systems

	File Size	
	Previously Convicted (300,000)	Previously Arrested (1,000,000)
Computer operator	2	2
System analyst	1	1
Key punch operator	2	2
Scanner operator	2	2
Maintenance	1	1
Fingerprint analyst	7	12
Total	15	20
Yearly costs ($50,000 per man)	$750,000	$1,000,000

Equipment Rental and Maintenance Cost per Year

Optical (50,000 file)		Digital/ Electronic Systems	File Size: Previously Convicted (300,000)	File Size: Previously Arrested (1,000,000)
Photo convertor/ Aperture cards; Card readers; Key punchers; Optical comparator	$50,000	Computer and disc files; Key punchers; Card readers; Readout equipment	$1,000,000	$1,500,000

Total Equipment Operating Costs Per Year

By State	Known Criminals (50,000)	Previously Convicted (300,000)	Previously Arrested (1,000,000)
Personnel costs	0.5	0.75	1.0
Equipment rental	0.5	1.0	1.5
Total (millions)	$0.55	$1.75	$2.5
Total for 50 states	$25.5 million	$80.75 million	$125 million
Total for ten years	$275 million	$810 million	$1250 million

The estimates above are baseline equipment operating costs to which must be added the additional costs to search crime scenes. Estimates were made for searching burglary crime scenes assuming:

- Two man-hours per search
- $25 per man-hour, including overhead

Thus it would cost approximately $50 to search a burglary crime scene. If in the next ten years new systems are introduced to hold burglary in check, there will be approximately a total of 20 million burglaries committed throughout the U.S. (see Chapter III, Figure 3). If it is assumed that 100% of these burglary crime scenes are searched, then the total cost to do this would be

Ten-year crime scene search costs = 20 million × $50 = $1 billion

Thus the total estimated costs (in billions) to search burglary crime scenes for fingerprint evidence and operate file search systems for various file sizes would be:

	File Type		
	Known Criminals	Previously Convicted	Previously Arrested
Equipment operation	0.275	0.81	1.25
Crime scene search costs	1.0	1.0	1.0
Ten year total costs (billions)	$1.275	$1.81	$2.25

It would appear that any of the systems using various file types could be justified in terms of savings to the public, since the projected operational costs would represent, as a maximum, only approximately one-quarter of the projected ten-year burglary savings of almost $8 billion.

APPENDIX D. LEGAL DECISIONS IMPACTING ACCESSIBILITY

The accessibility and admissibility of physical evidence is closely interwined with the legal aspects of search and seizure. It is necessary then, before proceeding with any further discussion, to discuss the types of physical evidence legally available to the forensic investigator in the search-and-seizure process.

The four basic forms of evidence are the fruits of crime, contraband, instruments of crime (used in its commission), and items of mere evidentiary value. The fourth type of evidence, only made legally accessible at the state and federal level in 1967 and 1970, respectively, is physical evidence that tends to connect an individual with a crime. This includes clothing, documents, stains of blood and semen, glass, hair, soil, fibers, and various kinds of prints as items of mere evidentiary value. A 1921 Supreme Court decision (Gouled v. United States[45]) made mere evidence inaccessible during lawful search and seizure. However, practically speaking, mere evidence remained accessible. The 1967 Supreme Court decision clarified the issue by legalizing the accessibility of mere evidence during search and seizure. It is important to note that mere evidence is the most common type of evidence being submitted to the forensic scientist except for narcotics, blood, and alcohol submitted for analyses required by statute. The incorporation of mere evidence into the Federal Rules of Criminal Procedure and the applicability of mere evidence to the states by Supreme Court decision (Warden, Maryland Penitentiary v. Hayden[46]) have enhanced the accessibility of evidence for forensic analysis.

The next important area deals with the limitations placed upon search and seizure, and the impact of these limitations upon accessibility and admissibility. The basis for limitations placed upon search and seizure can be found in a landmark Supreme Court decision in 1961, Mapp v. Ohio,[47] which made the exclusion of illegally obtained evidence applicable to the states. The Constitution demands the use of a warrant in search and seizure (though there are exceptions to the rule). In order to issue a warrant, and invade an individual's privacy, "probable cause" must be established. In other words, information must be obtained and presented before a magistrate which would give cause to a "man of reasonable caution" that a crime is being or has been committed.[48]

The scope and manner of search and seizure was further limited in a 1969 decision, Chimel v. California,[49] which defines in concise terms the area and items which can be searched for. Chimel construes justified search and seizure to be limited to weapons and any destructible evidence on the immediate person, and the area within the suspect's immediate control.

As mentioned earlier, the Constitution demands the use of a search warrant; however, realistically speaking, the preponderance of search and seizure is done without the use of a search warrant. There are six exceptions to the warrant requirement for search, and two for seizure of evidence. If the search is made incident to a lawful arrest, with consent, under exigent circumstances, during stop-and-frisk procedures, when probable cause exists that a mobile object (plane, car, boat, etc.) contains that which is subject to seizure by an officer, and within the scope of lawful inspection, then

The evidence was ruled to have been legally obtained and admissible. Search beyond the fingernail scrapings would have been illegal and inaccessible.

Finally, it is noteworthy to mention the Supreme Court decision in the case of Kirby v. Illinois.[51] In writing this decision, the Supreme Court stated that most physical evidence is obtained during the period of suspect development when the assistance of counsel is not required. With this in mind, then, the accessibility of physical evidence is maximized because many of the constitutional problems that occur once prosecutorial proceedings begin are not involved.

Two conclusions may be drawn: first, in obtaining physical evidence the initial search and seizure must be legal and, in most cases, based upon legal arrest. Second, most physical evidence lies outside the purview of the Fourth, Fifth, Sixth, and Fourteenth Amendments to the Constitution and this is also true for its forensic applications. This evidence is both immediately accessible and eventually admissible in criminal trial. Therefore, with these limitations of search and seizure in mind, no real problems are foreseen for the forensic scientist and evidence technician in regard to the accessibility of physical evidence.

APPENDIX E. LEGAL DECISIONS IMPACTING THE ADMISSIBILITY OF NEW SCIENTIFIC TECHNIQUES IN CRIMINAL TRIALS

The issue to be examined is that of the legal tests used in the determination of the admissibility of a new technique. Before discussing the pertinent casework, it is important to recognize two factors outside the substantive issues.

First, judicial determination of almost any issue, whether it be admissibility of evidence, procedure or substantive issues, rests heavily on precedence set by prior cases. Issues and arguments in a case before a court are determined upon parallel issues and arguments from past cases. In the development of arguments for the admissibility of a new technique, a judgment favoring them will be based on past successful demonstrations of admissibility as well as past failures. The ultimate consequence of this process will be the formulation of various admissibility tests. That is not to say that original ground is never broken, but a majority of decisions are the cumulative result of case precedence.

The second factor in judicial determination deals with the circumstances of the particular situation of each case. No two cases are identical in the amount of evidence found. Furthermore, the technique employed to analyze the evidence found, the way the investigation was handled, the person who analyzed the evidence, and the amount of time spent analyzing it are all important.

That is to say that in order to set guidelines a great deal of uniformity would be necessary. Since each case is unique in its nature and entirely situational, the necessary uniformity cannot be found. Only trends and patterns can be examined. Precedence in combination with the circumstances of the situation will determine the admissibility of a new forensic technique, as well as current techniques.

Three prominent cases provide the main precedent for the admissibility of scientific evidence. The first case[40] used in testing admissibility of new forensic techniques is Frye v. United States in 1923. The use of this particular decision is dependent, as mentioned earlier, upon judicial discretion. This precedent is more likely to be used on forensic techniques that are entirely new than on techniques that are variations of already proven procedures.

The major tenet of the Frye case was that before a new forensic science technique could be admitted into the trial court, it had to obtain a level of general acceptance within the scientific community, it had to be more than experimental, and had to be based upon recognized and sound scientific principle.

A factor inherent in the general acceptance of a new technique is the time period involved. Common sense suggests a long period of time for general acceptance to come about. In terms of time alone, the impractical nature of this test for admissibility is obvious. Judicial process cannot afford to stop while waiting, perhaps for years, for an entire profession to accept a new technique. Furthermore is it right to assume that an entire profession would have enough knowledge to pass judgment on a technique that might require quite specialized expertise?

Questions of this nature concerning the Frye test for admissibility were constantly the issues for further testing of new techniques. It was not until

1961 that another test for admissibility of new techniques was developed to help clarify the obvious problems with Frye.

People v. Williams (1961) became the second prominent case[41] to establish a precedent for determining the admissibility of new techniques. Through this case, the courts became aware of the fact that "general acceptance" was too broad a test to determine the admissibility of techniques that often required specialized, not general, knowledge. The question posed by the court was: just because a particular technique is generally unknown does that make it any less reliable? The forensic technique in question was the nalline test for opiate addiction. This particular technique was generally unknown within the pertinent scientific community (in this case, the medical profession) and only accepted by those who either developed the technique or were familiar with its use.

The cognizance of specialization was especially important in this decision. The broad nature of the Frye decision had made it an impractical test. People v. Williams restructured the admissibility test to recognize the special nature of most techniques and the implausibility of their being generally known, let alone generally accepted by the scientific community.

However, even this principle can be further narrowed. Even within the field of specialization, new concepts are continually being developed that would not be familiar to a majority of experts. Though the techniques may be valid, their admissibility, because of the lack of acceptance even within the field of specialization, would be in question. The case[42] of Coppolino v. State (1968, 1969) seems to have resolved this issue.

The forensic technique developed specially for this case was substantiated at first by the developer, whose qualifications were examined by the court, and by a second expert who verified the procedures used. His credentials were also examined. The technique, although new, was based upon previously recognized toxicological procedures, or in other words it was basically a variation of already proven scientific principle. With that in mind, it can be said that all a new technique requires for admissibility is that it be based upon existing technique and have the substantiation of a few court-qualified experts within a field of specialization.

The Coppolino case, the most recent decision, emphasizes the more narrow approach, while that of Frye, represents the more broad, and that of Williams is somewhere in the middle. Merely because Coppolino is the most recent case, however, does not mean it overrules or limits the others. Only in some instances does it take precedence over those of Frye and Williams; in other instances the Frye and Williams' cases do the same. As mentioned earlier, it is the combination of circumstances and precedence as well as judicial discretion that determines the admissibility of technique.

APPENDIX F. SURVEY OF CRIMINAL COURT JUDGES AND PROSECUTORS

The Aerospace Corporation conducted a brief survey of criminal judges and prosecutors in the greater Los Angeles area to assess the effects of recent U.S. Supreme Court decisions on physical evidence use and to determine the influence of improved forensic capabilities on its present and future use. The survey was conducted both by interviews and by a questionnaire distributed through personal contacts.

A LEAA-funded related study,[2] which includes a survey of the judiciary, is also in progress at the Calspan Corporation (under subcontract to the Mitre Corporation). This study evaluates the present effectiveness of the crime laboratory and the potential influence of the increased use of existing capabilities, while the primary objective of the Aerospace survey was to determine the potential influence of increased capabilities from the viewpoint of the judges and prosecutors.

Results of the Aerospace survey reflect the opinions and data furnished primarily by judges as well as a few prosecuting attorneys. The identities of the contributors were purposely kept anonymous. Emphasis was placed on the judges since they preside in court where physical evidence is presented on both sides of issues and can observe the resulting impact from a relatively unbiased point of view. They can also more readily assess its impact on the determination of guilt or on plea bargaining, since they are directly involved in the ultimate outcome. The survey was limited in scope and in number as well as restricted in geographic location. Thus the results are to be interpreted only as an indication of the impact of improved capabilities of physical evidence identification on the criminal justice process.

1. Survey Results

The survey results are summarized in the questionnaire form at the end of this Appendix. Responses to one of the questions (No. 14) are tabulated separately in Table F-1 following the questionnaire. Not all 14 individuals surveyed answered all the questions posed in the questionnaire; thus the data are tabulated in fractions where the numerator represents positive responses and the denominator the total number responding to the specific question. For the purpose of this discussion, the results are grouped into four major subject areas related to physical evidence: (1) effects of Supreme Court decisions, (2) current use, (3) expected effects of increased capabilities, and (4) cost effects.

2. Effects of Supreme Court Decisions

Results of recent landmark Supreme Court decisions,[9, 10] such as Escobedo, Miranda, Wade, and Gilbert have had little or no effect on the frequency of physical evidence use in court. The respondents, on the whole, do not anticipate that these decisions will have an appreciable effect in the future, and even among those who replied in the affirmative there was no consensus on whether the decisions would result in greater or less reliance on physical evidence. With regard to the legal accessibility and admissibility of mere physical evidence in criminal trials, the results suggest that there is a strong legal basis in the precedential case of Warden v. Hayden,[46] so that there appears to be no problem.

3. Current Use of Physical Evidence

Data obtained in the survey on the current use of physical evidence in criminal trials are summarized in Table F-1. The number of cases handled during the last five years by the 14 respondents varied from 40 to 5000 with the median being 2000. For a majority of the respondents, the percentage of cases involving the use of technical expertise, both testimonial and written reports, pertaining to physical evidence was estimated to be in the 10%-30% range. Among the offenses of homicide, rape, assault, robbery, burglary, and arson the use of physical evidence in specific crime categories was highest for arson, homicide, and rape with median values of 90%, 80%, and 50%, respectively. Among the same offenses burglary (20%), assault (17.5%), and robbery (13.5%) were quoted as having the highest incidence. These offense frequency values are the percentages of all cases reaching the judges surveyed and are not the frequencies with which the crimes are committed. As can be seen from the table, considerable variations in values for both the use of physical evidence and for the frequency of a particular crime were reported.

With regard to any observable trend in the extent of the use of technical expertise in physical evidence analysis, the majority (nine of 14) replied that there is no consistent trend or that the use has not changed. However, it is of interest to note that the remainder (five) reported observing a definite increase whereas none observed a decrease. Their attitudes toward the use of technical expertise as persuasive evidence were unanimously favorable and a substantial impact from such use was expected. Among the 17 types of physical evidence mentioned, where improved capabilities could highly benefit the judicial system, the most frequent were fingerprints, body fluids, hair, handwriting, firearm identification, and recording tapes.

4. Expected Effects of Increased Capabilities

A high majority of the survey responses indicated that increased capabilities in forensic science techniques would result in a greater percentage of the defendants admitting guilt, more guilty verdicts, and an increased conviction rate for burglary, assault, robbery, rape, and arson cases. Further, such capabilities would lead to more frequent and more realistic plea bargaining (realistic refers to the disposition appropriate for the crime committed). The responses regarding their effect on the backlog of criminal cases were inconclusive. It can, nevertheless, be inferred--from the strong agreement on answers to questions regarding the larger number of defendants admitting guilt and the increase in plea bargaining--that the backlog of criminal cases would be reduced. Increased capabilities in physical evidence identification were not expected to result in more cases using trial by jury. Half of the responses indicated that the ability to define the harshness or viciousness of the criminal act through improved physical evidence analysis would have a large effect on sentencing, whereas the remainder indicated that the effect would be minimal, if any.

5. Cost Effects versus Improved Capabilities

The quantitative impact of improved capabilities in forensic science on the overall cost of the administration of criminal justice is difficult to assess.

Nevertheless, certain qualitative estimates can be made based on the survey results. In criminal cases, the greater dependence on physical evidence would lead to an increase in the length of trials with concomitant increased costs. However, it is believed that a decrease in the total number of trials will occur because a greater percentage of the defendants will admit guilt when confronted with the convincing results of physical evidence analysis, and a greater percentage of the cases will be resolved by plea bargaining. The overall effect from the reduction in court trials will be a cost savings. This point was specifically mentioned by one judge responding to the questionnaire.

Another consideration is the increased conviction rates that will ultimately result in the reduction of crime. Moreover, although difficult to assess, the establishment of a consistently higher conviction rate over a long period of time should be a strong deterrent force against the commission of most crimes. Thus the net result of improved forensic science capabilities would be an increase in the effectiveness of the criminal justice system.

6. Conclusions

The Supreme Court decisions affecting the use of physical evidence in courts have had and are expected to have relatively little effect on the frequency with which physical evidence testimony is introduced into criminal trials. The judges and the prosecutors surveyed unanimously favored the use of technical expertise as persuasive evidence and a high majority of them believed that increased capabilities in forensic science would result in higher conviction rates in all crime categories. Despite the fact that individual trials will be more costly, the overall effect of increased capabilities will result in dollar savings because of the reduction of cases reaching the trial stage. Most important, such capabilities, as indicated previously, should reduce crime.

7. Questionnaire and Tabulated Results

NOTE

a) In the absence of hard data, please give "best estimate" answers.

b) Technical expertise as used refers to expertise regarding physical evidence identification.

1. Have you observed any trend in the utilization of technical expertise in trials?

   A. Constant

   3/14

   B. Definite increase

   5/14

   C. Definite decrease

   0/14

   D. Inconsistent

   6/14

2. Please express your attitude toward the use of technical expertise as persuasive evidence in a trial.

   A. (1) Unfavorable

   0/13

   (2) Favorable

   13/13

B. (1) Substantial impact

13/13

(2) Limited impact

0/13

3. Homicides, comparatively, have the highest use of physical evidence, and the highest conviction rates. Could a similar use of physical evidence in the following areas have a significant effect on the conviction rates?

		(1) No Effect	(2) Increase	(3) Decrease	(4) Quantity of physical evidence too small to have an effect
A.	Burglary	0/14	13/14	0/14	1/14
B.	Assault	2/14	8/14	0/14	4/14
C.	Robbery	1/14	11/14	0/14	2/14
D.	Rape	1/14	12/14	0/14	1/14
E.	Arson	0/14	14/14	0/14	0/14

4. How would greater use of technical expertise affect backlogs of criminal cases: i.e., an increase in the use of plea bargaining, shortened trials, few delays?

A. No change

1/14

B. Increase

5/14

C. Decrease

4/14

D. No obvious trend

4/14

5. How are the lengths of trials affected by the introduction of physical evidence?

		(1) Increase	(2) Decrease	(3) No change	(4) Too variable to judge
A.	Attorney time	8/14	2/14	2/14	2/14
B.	Jury time	2/14	4/14	2/14	6/14
C.	Clerical time	9/14	0/14	4/14	1/14
D.	Overall trial	5/14	2/14	3/14	4/14
E.	Delays	2/14	3/14	4/14	5/14

6. What is your assessment of the legal basis for the admissibility of mere physical evidence in criminal trials as distinguished from instrumentalities of the crime, contraband, and fruits of the crime?

A. Strong

9/13

B. Weak

0/13

C. None

1/13

D. Still to be resolved

3/13

7. Effects of landmark Supreme Court decisions dealing with rights to counsel, to remain silent, and to attorney at pre-trial lineups; e. g., Escobedo v. Illinois (1964), Miranda v. Arizona (1966), U. S. v. Wade (1967), and Gilbert v. California (1967).

A. Do you feel these decisions have had any effect on the frequency of physical evidence?

(1) Minimal effect

4/14

(2) Increased utilization

3/14

(3) Decreased utilization

2/14

(4) No relationship

5/14

B. Do you anticipate any effect in the future?

(1) Yes

5/14

(2) No

9/14

C. If yes,

(1) Increase 3/5 , or (2) decrease 2/5 .

8. Possible relationships between the use of physical evidence and the outcome of a criminal trial process.

A. Does it tend to lead to greater or more realistic use of plea bargaining?

(1) Yes

12/14

(2) No

1/14

(3) No effect

0/14

(4) No obvious trend

1/14

B. Greater percentage of defendants admitting guilt?

(1) Yes

10/14

(2) No

0/14

(3) No effect

0/14

(4) Inconsistent, no trend apparent

4/14

C. More cases using trial by jury?

(1) Yes

2/14

(2) No

5/14

(3) No effect

1/14

(4) Inconsistent, no trend apparent

6/14

D. Greater number of guilty verdicts in court trials?

(1) Yes

9/14

(2) No

0/14

(3) No influence

0/14

(4) Indeterminable

5/14

9. Does physical evidence affect the sentence of a convicted individual through its ability to define the harshness or viciousness of the act?

A. (1) No effect

3.5/14

(2) Minimal effect

3.5/14

(3) Large effect

7/14

B. (1) Increased/decreased severity of sentence?

6/12

(2) No relationship between sentencing and evidence?

6/12

10. Can a relationship of cost to the greater dependence upon physical evidence be seen in the following areas?

		(1) No effect	(2) Increased cost	(3) Decreased cost	(4) No relationship
A.	Attorney time	4/14	6/14	3/14	1/14
B.	Expert witness	0/14	14/14	0/14	0/14
C.	Clerical duties (paper work)	6/14	5/14	1/14	2/14
D.	Administrative	7/13	2/13	1/13	3/13
E.	Court time	4/14	3/14	3/14	4/14
F.	Trial length	4/14	4/14	5/14	1/14

11. Do you know of any statistics compiled from evidence records, court clerks records, evidence receipts, lab reports, etc., which are pertinent to physical evidence?

A. (1) Yes

1/14

(2) No

13/14

B. If yes, please reference. Data at one source mentioned were found to be not readily available.

12. What areas of physical evidence have you encountered which could benefit substantially from improved techniques?

Number of responses: 11

Total number of areas mentioned: 17

Most frequently mentioned items with number of times listed in parenthesis: fingerprints (4), body fluids (3), hair (2), firearm identification (2), handwriting (2), recording tape (2).

13. What would be the effect of increased capabilities of forensic science techniques on case clearance and/or conviction rates? e.g., individualization (identification of its uniqueness) of bloodstain, hair, glass, etc.

(1) Negligible

2/14

(2) Increase

11/14

(3) Decrease

1/14

(4) No relationship

0/14

14. Criminal cases handled during the last five years

A. Number of cases

See Table F-1

B. What percentage involves the use of technical expertise, both testimonial and written reports, pertaining to physical evidence?

(1) 0-5%

(2) 5-10%

(3) 10-30%

(4) Greater than 30%

See Table F-1

C. Of the number of cases, what are the percentages by crime category? What are the percentages within each category utilizing physical evidence?

		(a) % of Total	(b) % Utilizing physical evidence
(1)	Alcohol and Drug Abuse	______	100% by statute
(2)	Homicide	______	______
(3)	Rape	______	______
(4)	Assault	______ (See Table F-1)	______
(5)	Robbery	______	______
(6)	Burglary	______	______
(7)	Arson	______	______

Table F-1. Summary of Responses to Question No. 14, Parts A, B, and C

Parts	Respondent											
	1	2	3	4	5	6	7	8	9	10	11	12
Part A Total Number of Cases in 5 Years	5000	4000+	4000	2500	2500	2000	2000	1500	1000+	1000	500	40
Part B Percent of all Annual Cases Involving Expert Testimony on Physical Evidence	5-10	>30	10-30	0-5	0-5	10-30	10-30	10-30	10-30	0-5	10-30	10-30
	Breakdown of Cases - Percentage of Total (Percentage Involving Physical Evidence)											
Part C												
Alcohol and Drug Abuse[a]	30 (100)	30 (100)	20 (100)	56 (100)	40 (100)	43 (100)	25 (100)	-	80 (100)	5 (100)	-	0
Homicide	5 (75)	1 (75)	5 (100)	5 (>90)	10 (90)	5 (75)	15 (100)	-	5 (80)	15 (5)	-	20 (100)
Rape	5 (50)	4 (50)	13 (60)	3 (30)	6 (10)	1 (100)	10 (50)	-	5 (80)	5 (1)	-	20 (40)
Assault	15 (10)	12 (10)	20 (30)	10 (<5)	20 (2)	20 (5)	15 (25)	-	1 (10)	20 (0)	-	20 (10)
Robbery	20 (5)	7 (10)	20 (30)	10 (<5)	12 (2)	10 (5)	15 (35)	-	1 (10)	20 (2)	-	30 (40)
Burglary	20 (15)	20 (35)	20 (40)	15 (5)	20 (2)	20 (5)	15 (50)	-	1 (10)	30 (2)	-	10 (0)
Arson	5 (80)	0.5 (50)	2 (>90)	1 (>90)	2 (2)	1 (100)	5 (100)	-	2 (90)	5 (10)	-	0 (0)
Total, Part C (Weighted Average)[b]	100 (11)	75[c] (11)	100 (34)	100 (7)	100 (11)	100 (7)	100 (36)		100 (10)	100 (2)		100 (42)

[a] Percentage involving physical evidence is 100 by statute.

[b] Average is for Part I crimes only; excludes alcohol, drugs, and arson.

[c] Does not add to 100; data recorded as received.

NOTES

1. Planning Research Corporation, Systems Science Company, "The Crime Laboratory: A Conceptual Model" and "Analysis of Criminalistics Laboratory Operations: Crime Laboratory Performance Measures," Los Angeles (1974).
2. Calspan Corporation, "Analysis of Criminalistics Laboratory Effectiveness on Criminal Justice Systems," Vols. I, II, III, and IV, Calspan Report No. D. C. 5414-1. Buffalo, N.Y. (August, 1974).
3. E. S. Gardner, "Need for new concepts in the administration of criminal justice," J. of Crim. Law, Crim., & Pol. Sci., Vol. 50, 1959, p. 20.
4. Brian Parker, "The status of forensic science in the administration of criminal justice," Revista Juridica de La Universidad de Puerto Rico, Vol. XXXII, No. 2, 1963, p. 417.
5. Paul Rosenthal, "Planning Study for Evaluation of Laboratory Services in Erie, Niagara, and Wyoming Counties, New York," Buffalo, N. Y., Cornell Aeronautical Laboratory, Inc. (1969), pp. 49-50.
6. Barbara Zuniga, "Scientific Evidence and Juvenile Offenses," Berkeley, Calif., School of Criminology, University of California, Unpublished study (1969) cited in J. Peterson's "Utilization of Criminalistics Services by the Police: An Analysis of the Physical Evidence Recovery Process," LEAA/NILECJ Monograph (March 1974).

7. B. Parker and J. Peterson, "Physical Evidence Utilization in the Administration of Criminal Justice," LEAA Grant NI-032, Washington, D.C., U. S. Department of Justice (1972).

8. Brian Parker and Vonnie Gurgin, "The Role of Criminalistics in the World of the Future," Final Report, Stanford Research Institute Project PYU-1359, NSF Grant GI-30011, Menlo Park, California (July 1972).

9. Escobedo v. Illinois 1964, Miranda V. Arizona 1966.

10. U. S. V. Wade 1967, Gilbert v. California 1967.

11. Alexander Joseph, "John Jay College of Criminal Justice, Study of Needs and the Development of Curricula in the Field of Forensic Science," in Crime Laboratories -- Three Study Reports, OLEA Projects #013, #146, and #66-3, Washington, D.C., U. S. Department of Justice (1968), p. 84.

12. Joseph Peterson, "Utilization of Criminalistics Services by the Police: An Analysis of the Physical Evidence Recovery Process," LEAA/NILECJ Monograph, Washington, D.C., U. S. Department of Justice (March 1974).

13. Project Search, "Latent Fingerprint Identification Systems" and "Analysis of Automated Systems for Encoding and Searching Latent Fingerprint Systems," Technical Memorandums 8 and 9, LEAA, Washington, D.C. (March 1974).

14. The Aerospace Corporation, Advanced Technology for Latent Fingerprint Identification, Report No. ATR-75(7922)-1 (Nov. 1974).

15. R. L. Williams, "Forensic science - the present," Anal. Chem., Vol. 45, No. 13, 1973, p. 1076.

16. The Aerospace Corporation, "Survey and Assessment, Blood and Bloodstain Analysis Program, Vol. I, Technical Discussion," Report No. ATR-74(7910)-1, Vol. I (April 1974).

17. P. L. Kirk, "Human hair studies," J. Crim. Law, Crim., and Pol. Sci., Vol. 31, 1940, pp. 486-496, 627-636, and 747-752.

18. S. Yada, M. Mori and M. Okane, "Blood grouping of a single human hair by means of elution technique," Acta Criminologia et Medicinae Legalis Japonica, Vol. 32, 1966, pp. 7, 8.

19. W. Kimura and M. Yokoyama, "ABO blood groups in human hair," Hawaii Med. J., Vol. 28, 1969, p. 384.

20. P. J. Lincoln and B. E. Dodd, "Mixed agglutination as a method for the determination of A, B, and H blood groups of hair," Med., Sci., and Law, Vol. 8, 1968, p. 38.

21. P. S. Porter and W. D. Lobitz, "Human hair: a genetic marker," Br. J. Dermat., Vol. 83, 1970, p. 225.

22. R. R. Race and R. Sanger, "Blood Groups in Man," Chapter 8, Oxford and Edinburg, Blackwell Scientific Publications (1968).

23. M. Sato and F. Ottensooser, J. Forens. Med., Vol. 14, 1969, p. 30.

24. E. T. Blake and G. F. Sensabaugh, "The Role and Information Content of Physical Evidence in Rape Investigation," Paper presented at the 44th Semiannual Seminar of California Association of Criminalists, Berkeley, California (October 24-26, 1974).

25. The Aerospace Corporation, "Gunshot Residue Detection, Survey and Assessment," Report No. ATR-75(7915)-1 (September 1974).

26. J. L. Peterson, "Utilizing the laser for comparing tool striations," J. Forens. Sci. Soc., Vol. 14, 1974, pp. 57-62.

27. L. C. Haag and D. D. Lawson, "A Forensic Examination of Soil Luminescence," Paper presented at the 41st Semiannual Seminar, California Association of Criminalists, San Diego, California (May 18, 1973).

28. J. I. Thornton, "A Forensic Biochemical Characterization of Soils," (doctoral dissertation), Berkeley, Calif., School of Criminology, University of California (December 1973).

29. C. R. Kingston and F. G. Madrazo, "Latent Value Study," Albany, New York, New York State Identification and Intelligence System (1970).

30. P. W. Greenwood, et al., "Prosecution of Adult Felony Defendants in Los Angeles County: A Policy Perspective," Washington, D.C., U.S. Government Printing Office (1973).

31. E. F. Pearson, R. W. May, and M. D. G. Dabbs, "Glass and paint fragments found in men's outer clothing - report of a survey," J. of Foren. Sci., Vol. 16, No. 3, July 1971, pp. 283-300.

32. California Bureau of Criminal Statistics, "Crime and Delinquency in California 1972," Sacramento, California.

33. California Department of Corrections, "California Prisoners 1969," Sacramento, California.

34. National Criminal Justice Information and Statistics Service, "Children in Custody, A Report on the Juvenile Detention and Correctional Facility Census of 1971," Washington, D.C. (1974).

35. Federal Bureau of Investigation, "Crime in the United States: Uniform Crime Reports," Washington, D.C. (1972).

36. D. Glaser, "The Effectiveness of a Prison and Parole System," New York, Bobbes-Merrill (1969).

37. Schmerber v. California, 384 U.S. 757 (1966).

38. Rochin v. California, 342 U.S. 165 (1952).

39. Cupp v. Murphy, 412 U.S. 291 (1973).

40. Frye v. United States, 54 App. D.C. 46, 293 Fed. 1013 (1973).

41. People v. Williams, 164 Cal. App. 2d Supp. 858, 331 P. 2d. 251 (1961).

42. Coppolino v. State, 223 So. 2d 68 (Fla. App. 1968), App. dismissed 234 So. 2d 120 (Fla. 1969), Cert. denied 399 U.S. 927.

43. People v. Law, 40 Cal. App. 3rd 6 (1974).

44. S. Forsherod, H. Smith and A. Wassen, Nature, pp. 192, 103.

45. Gouled v. United States, 255 U.S. 298 (1921).

46. Warden, Maryland Penitentiary v. Hayden, 387 U.S. 294 (1967).

47. Mapp v. Ohio, 367 U.S. 643 (1961).

48. Brinegar v. United States, 338 U.S. 160 (1949).

49. Chimel v. California, 395 U.S. 752 (1969).

50. Fourth, Fifth, Sixth, Fourteenth Amendments to the Constitution of the United States. Respectively: the right against illegal search and seizure, right against self-incrimination, right to counsel, and right to enforce due process of law.

51. Kirby v. Illinois, 406 U.S. 682 (1972).

END