

Calspan

Technical Report



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Calspan Corporation
Buffalo, New York 14221

Formerly Cornell Aeronautical Laboratory, Inc.

Calspan

ANALYSIS OF CRIMINALISTICS LABORATORY EFFECTIVENESS IN CRIMINAL JUSTICE SYSTEMS

Volume III
MEASURES OF EFFECTIVENESS

October 1974

Calspan Report No. DC 5414-X-1

by

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PREFACE

The research on which this report is based has been performed as part of the National Institute for Law Enforcement and Criminal Justice program of addressing problems of resource allocation within forensic laboratories, performance and effectiveness measurement. The MITRE Corporation, as prime contractor for the program, has been assisted by two subcontractors: The PRC Systems Science Company has developed internal measures of criminalistics laboratory performance and the Calspan Corporation has been responsible for developing external measures of their impact on criminal justice systems. Both subcontractors collected data on on-going operations at three sites: Contra Costa County, California; Dade County, Florida; and Columbus, Ohio.

The study by the Calspan Corporation has been conducted during the period 1 October 1973 to 30 September 1974. Data were collected by resident observers at the three sites from November 1973 to July 1974. Results are reported as "Analysis of Criminalistics Laboratory Effectiveness in Criminal Justice Systems", in four volumes:

- I - The Use of Physical Evidence Examination in Investigation of Crimes
- II - The Use of Physical Evidence Examination in Adjudication of Crimes
- III - Measures of Effectiveness
- IV - Summary and Recommendations

The success of the study was predicated on full cooperation and support by the criminalistics, investigative and adjudicative agencies at the three sites. The cooperation and assistance of the following officials, their staff and colleagues, is gratefully acknowledged.

CONTRA COSTA COUNTY

Harry D. Ramsey, Acting Sheriff - Coroner
Cpt. Harry Deram, Chief, Investigation Division
Duayne J. Dillon, Chief, Criminalistics Laboratory
Gerald T. Mitosinka, Supervising Criminalist
Lourne G. Phelps, Chief, Richmond Police Department
Cpt. Robert W. Wood, Richmond Police Department
Cpt. John Huddleston, Concord Police Department
Lt. Bud Savage, Concord Police Department
Wm. A. O'Malley, District Attorney
Hon. Wm. R. Channel, Presiding Judge, Supreme Court
Wm. R. Higham, Public Defender

COLUMBUS

Earl Burden, Chief of Police
Maj. Lloyd V. Forbus, Chief, Investigative Subdivision
Richard O. Pfau, Supervisor, Crime Laboratory
Hon. Frederick T. Williams, Administrative Judge, Court of
Common Pleas
Hon. G. W. Fais, Chief Judge, Municipal Court
George Smith, County Prosecutor
Daniel Johnson, City Prosecutor
Roy F. Martin, Director, Legal Aid and Defender Society

DADE COUNTY

E. Wilson Purdy, Director, Public Safety Department
Charles Black, Chief, Central Services Division, P.S.D.
Edward Whittaker, Supervisor, Crime Laboratory
Richard Gerstein, State Attorney
Hon. Gene Williams, Administrative Judge, Circuit Court
Phillip A. Hubbart, Public Defender

In addition, the leadership, guidance and assistance by the staff of the MITRE Corporation under Fernando Biagi, Group Leader, Forensic Laboratory Analysis Program, is gratefully acknowledged.

At Calspan, the project was under management supervision by Miles W. Hall, Head, Computer Systems Department. Paul Rosenthal was project manager and Dr. D. A. Travnicek, associate project manager. They were assisted by Dr. R. C. Sugarman, psychologist, and Barbara Frida, computer. The following served as part-time resident field observers: Grady L. Goldman, Keith E. Inman and Enrico N. Togneri, Contra Costa; Wm. F. Jankun, Michael Hohn, John W. Garland, Richard Kettler and John Czeciuk, Columbus; Robert C. Gross, Salli A. Gross, Mark Kaplan, Mark A. Siegel and Edward R. Young, Dade County.

The study was supported by three consultants: Professor Joseph D. Nicol, Criminal Justice Department, University of Illinois, actively participated in all phases of the program. The Hon. Charles Desmond, Chief Judge, New York Court of Appeals (retired) advised on court-related problems and D. M. Lucas, Director, Centre of Forensic Science, Toronto, Canada, provided helpful comment on the program plan during its formative stage.

Section 1

BACKGROUND

The goal of the study reported in these volumes is to develop means to improve the utilization of physical evidence in the investigation and adjudication of felony crimes. Four major problems have prompted initiation of the study:

- a. The low percentage of reported crimes in which physical evidence examination plays any role.
- b. The diversion of criminalistics activity to dangerous drug and sobriety-related analyses.
- c. Lack of user motivation toward increased utilization of criminalistics.
- d. The need for systematic investigation of the use and effectiveness of criminalistics in criminal justice operations.

In Section 1 of Volumes I and II, these problems are outlined and a "criminal justice system" concept is defined and discussed in some detail. Particular attention is placed on the role of physical evidence in four process stages: crime scene search, criminalistics analysis, investigation and adjudication.

The objectives of the study are stated as:

1. Describe the role of criminalistics operations in criminal justice systems.
2. Develop and apply methods for measuring the effectiveness of criminalistics operation.
3. Recommend steps to improve their utilization.

To meet these objectives, detailed information on ongoing criminal justice operations had to be obtained. A major part of the study effort was therefore devoted to data collection and observation of criminal justice operations, in three locations, a California county, a Florida county and a city in Ohio.

The study was designed to concentrate on actual use and on the user's view of criminalistics operations. A concurrent, independently conducted study addressed activities within the criminalistics laboratory at the same three sites. Its results are reported elsewhere⁽¹⁾.

The effectiveness of criminalistics operations is related with two major aspects of their results, frequency of use and value. Any variable of a criminalistics operation is a candidate measure of effectiveness if it can be shown to be highly correlated with frequency and value of use. Further, candidate measures of effectiveness must be tested for validity, the data necessary for their application must be obtainable and they must be "practical". Since it is not known at the outset how many measures of effectiveness would survive the above tests, the study was structured to search initially for data for a large number of candidate measures of effectiveness so as to assure an adequate number of acceptable measures at the end.

The final study objective, recommendation leading to improved utilization of physical evidence examination, could be attained from three sources: Application of the measure of effectiveness to the sites, comparison between sites and observations at the site.

The results of the study are reported in four volumes:

1. The Use of Physical Evidence Examination in Crime Investigation
2. The Use of Physical Evidence Examination in Crime Adjudication
3. Measures of Effectiveness
4. Summary and Recommendations

Volumes I and II describe the use of criminalistics as found at the three study sites, the strengths and the weaknesses observed. These volumes have been written to serve as self-contained qualitative guides for the organization and improvement of criminalistics operations. Further, the data on the role of physical evidence used in these volumes are used to apply and test the validity of measures of effectiveness in this Volume III of the report. Also, some candidate measures of effectiveness have been recognized in the first two volumes through review and discussion of the data.

Volume I presents base line data on offenses occurring and investigative dispositions at two sites in a period preceding the study. While the study has been largely concerned with cases in which physical evidence is collected, a brief survey of all investigative methods employed in 3 offense categories was included and the investigative outcomes associated with these methods are discussed. The principal focus of the Volume is on following the steps in crime investigation from incident report to investigative disposition; on describing the criminalistics aids available at each step; and on presenting data on their use as observed on a case by case basis at each site. These data include arrival times at the crime scene, search duration, number of physical evidence items collected and analyzed, the significance of physical evidence information related to investigative outcome, latent print utilization, and the crime specific utilization of physical evidence by evidence category. Significant findings are that physical evidence information is used predominantly to corroborate when there is a suspect and very little use is made of criminalistics in cases in which there is no named suspect at the outset. Communication between investigator and criminalist is often inadequate and almost never recorded. Incomplete and fragmented record systems are severe blocks to management planning toward increased physical evidence utilization.

Volume II presents baseline data on adjudicatory case disposition in prior years. In keeping with the recognition that the entire process is prosecution-dominated, physical evidence information is followed as the prosecution takes the felony case from warrant or complaint to its termination at trial or earlier. Also discussed are defense use of physical evidence; defense, court and jury perceptions of the role of physical evidence in observed cases; the criminalist's view; training and education; and the communications problem. Data are presented on the role of physical evidence at the pre-trial stages, in guilty pleas to reduced charges, guilty pleas as charged and at trial. The data indicates in several crime categories that often the presence of physical evidence induces guilty pleas as charged or guilty pleas to a reduced charge. Further, the ratio of guilty pleas as charged to guilty pleas to reduced charges is higher in cases in which physical evidence was examined during the investigative stage. General conclusions, based on the data and field observations, are that the potential of physical evidence information is not well enough appreciated by its users, and increased education and training are recommended. As in the Investigation report (Volume I), lack of communication and the fragmented record systems are cited as obstacles to increased physical evidence utilization.

Section 2

PURPOSE AND SCOPE OF VOLUME III

In this volume measures of effectiveness are developed and their application to the sites from which data have been collected is illustrated. The main purpose of the measures of effectiveness is to serve as an evaluation tool for (a) laboratory managers and administrators and (b) planners at various government levels from municipal to state or federal. Application of the measures to the three sites is only incidental to the need to examine the measures with real data.

In the companion project^{(1)*} a methodology for evaluating criminalistics laboratory operations has been developed; that study measured how well the laboratories perform and how efficient they are. The present study has addressed the impact of the laboratory on the criminal justice system; how is the information it produces used by investigators and adjudicators; how effective is the laboratory?

*References are listed in Section 12.

In the following sections, development and selection of measures of effectiveness are followed through their consecutive stages in the study from system definition, Section 3, and initial postulation of measures (4) to data collection (5) and effectiveness measurement (6). Section (7) discusses, in detail, the results of our statistical analysis of paired variables that may be inputs to effectiveness measures. Section 8 presents the effectiveness measures found in the course of this study, with diagrams to illustrate the type, specificity, and objectivity of each. In Section 9 some of these measures will be applied to data from the three sites in order to illustrate their utility. Further, Section 9 introduces a method by which measures of effectiveness may eventually be combined. Finally, in Section 10, a hypothetical model which, we believe, will usefully separate the roles of criminalistics within the investigative area is presented. The model is incomplete at this time, but indicates the direction further analysis might take.

Data collection will be seen to have served the dual purpose of providing information on the use of physical evidence information in present practice as presented in Volumes I and II, and serving as the vehicle for formulation and validation of effectiveness measures in this volume. The study methodology also served both purposes: Data collection was followed by analysis, and analysis was followed by a search for retrospective explanation of results. Neither part of the study started with a hypothesis that was more specific than that increased utilization of physical evidence information is beneficial to the criminal justice system. Analysis of data for suitability in measures of effectiveness was by rigorous mathematical methods, whereas the aggregated use data were analyzed more informally.

Section 3

CRIMINAL JUSTICE SYSTEM DEFINITION

The meaning of "criminal justice system" depends on the context in which the term is used. In the context of the study objectives it must encompass all actual and potential users of criminalistics. In the introductory sections of Volumes I and II, the use of the term is developed and illustrated in two figures. The first depicts the system as encompassing crime scene search, criminalistics operations, investigation and adjudication. The information flow on physical evidence among these elements is the concern of the study. The second figure (No. 2, Volumes I and II) is a flow diagram expanding on information in these categories.

The Criminal Justice System diagram, Figure 1 of this volume, expands on the earlier simplest presentation of the system by including investigative and adjudicatory dispositions which, as system outcomes, have a strong role in measures of effectiveness.

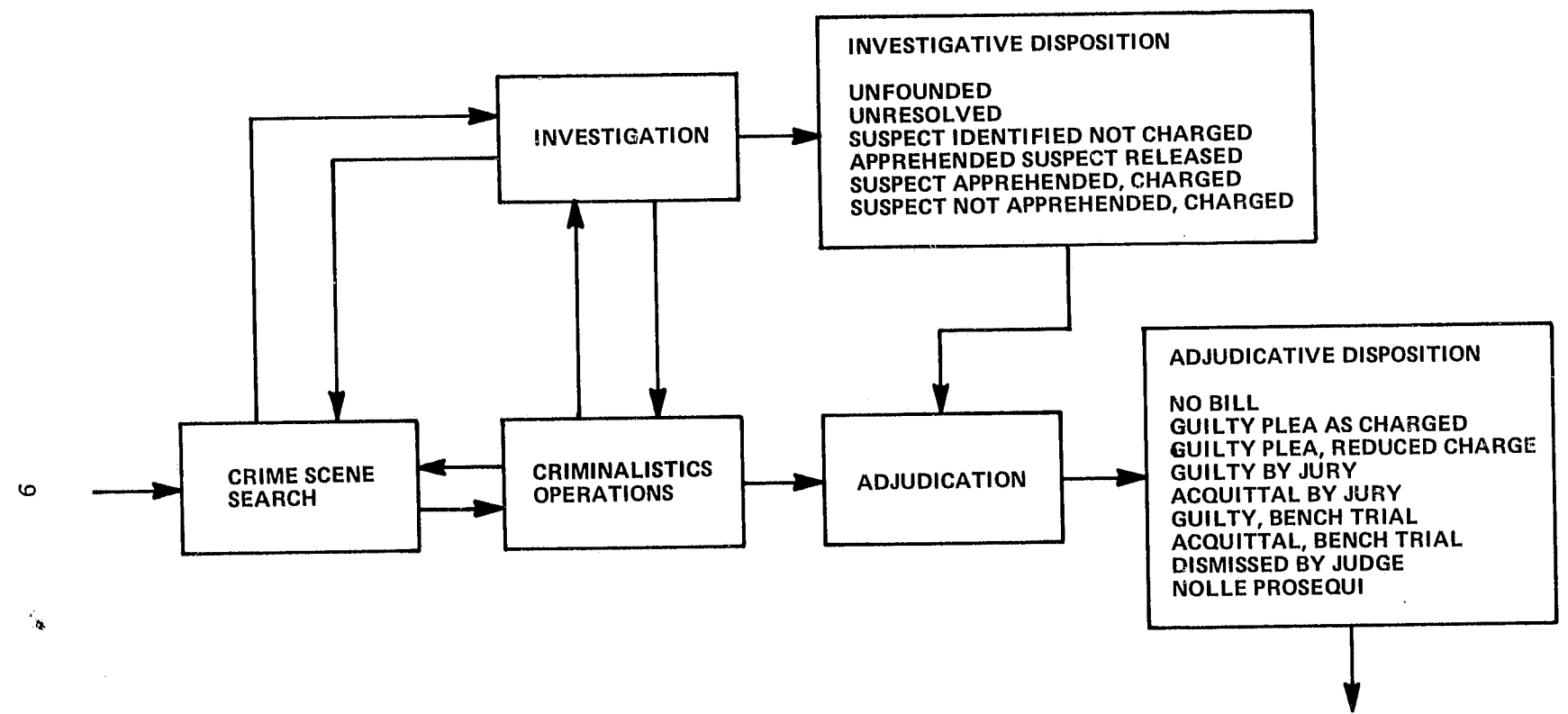


Figure 1 THE CRIMINAL JUSTICE SYSTEM

The arrows in the figure indicate the information flow in the system. The arrow entering the system, which is circumscribed by the largest block, indicates information from, say, a telephoned incident report or, if a police patrol has been at the scene, their offense report. The crime scene is searched by patrol, a special evidence unit or criminalistics laboratory personnel. Physical evidence (including latent prints) is collected and brought to a property room (not shown) or the laboratory with a request for examination. Information on the crime scene search also goes to the investigative unit; sometimes the investigative unit participates in or directs crime scene search. The criminalistics laboratory reports its findings to the investigator and dialog between investigator and criminalist may develop. Information from the criminalistics operation may also be used in "adjudication", which is defined to encompass the entire process from the start of prosecution through trial verdict including the roles of defense, prosecution, court and jury.

Investigation terminates without further action of interest to this study with any of the upper four dispositions listed in the figure. If a charge results, as indicated by the last two dispositions, the adjudication process starts. A total of nine dispositions are listed for Adjudication. The arrow leading out of the system indicates events such as the sentence, detention, parole which are not part of the system as defined here.

Section 4 POSTULATED MEASURES OF EFFECTIVENESS

That the effectiveness of criminalistics operations is related to the frequency of use and the value of their results, has been stated in Section 1. More precisely and in keeping with earlier research (2) we may define this effectiveness as the frequency of use and the value of information on physical evidence examination in obtaining investigative resolution and/or adjudicatory disposition of a reported offense. Note that this definition, as applied to investigation, implicitly rates "resolution" (by arrest, exceptional clearance, or finding the complaint unfounded) as a desirable outcome; as a corollary "unresolved" investigations are implicitly rated undesirable. No such value judgment is implied in adjudicative disposition; here we consider it axiomatic that any contribution to termination of a case (at the pretrial stage, by guilty plea or at trial) is rendering physical evidence examination effective, because physical evidence is considered more valuable than other evidence.

As defined above, the effectiveness of criminalistics operations may be expressed on a crime-specific basis, in objective terms and as perceived by their users. A measure of effectiveness may be any function of a controllable variable that is highly correlated with effectiveness. Before discussing in the section initially postulated measures of effectiveness and their associated variables, the search for measures of effectiveness will be expressed in terms of four questions, each of which refers to one of the four stages of the criminal justice system that were outlined in the previous section. In the tabulation that follows, these questions are listed together with factors that were thought a priori to be relevant.

Question	Influence Factor
1. Under what circumstances does possible physical evidence become an input to the crime lab?	Arrival time, duration of search, training, and experience of personnel responding to incident report
2. What information does the crime lab receive and how does it respond?	Selection, training, communication
3. How is the result of physical evidence examination used in investigation?	Other sources of information; time; perception of relevance; outcome of investigation
4. How is the result of physical evidence examination used in adjudication?	Prosecutor, defense, jury, judges, their perception of relevance; outcome of adjudication; training and experience

The first question is very broad and has already received considerable attention by Parker and Peterson (3), Peterson (4) and Parker and Gurgin (5). The term "possible physical evidence" is used in the sense used by Parker and Peterson (3). Comprehensive treatment of the question was beyond the scope of the study, but it was felt that some key influence factors, for example, those relating to crime scene search time and condition of the scene (i.e. whether distributed or not), should not be neglected even if the entire search problem could not be considered.

The second question requires both narrative and quantitative response. Quantitative information includes the frequency with which evidence is collected and analyzed by evidence category and by crime category.

The third and fourth questions both have their respective "outcome" listed as influence factors. However, both also encompass timing, quality of the information, communication and user perception.

What has been indicated by listing the four questions is that a single measure of effectiveness addressing only one stage would not be adequate, because each of the four stages of the criminal justice system separately influences the effectiveness of physical evidence information. In Table 1 are listed a large number of properties that were measured and the variables used in the measurement. This list of postulated measures of effectiveness was deliberately kept much larger than the number of measures recommended at the end of the study, for in the absence of information with which to make up the final list of measures at the outset, the candidate list had to be kept large enough to assure collection of data on all important elements of the system.

The variables listed in the table are the basis for the questions that had to be answered by the surveys at the study sites. The answers, of course, provided the data base for the use information in Volumes I and II, and for testing measures of effectiveness in this volume.

Table 1
EVALUATION MEASURES

A. SEARCH

PROPERTY TO BE MEASURED

MEASUREMENT

- | | |
|--|--|
| 1. EXTENT OF POSSIBLE LAB UTILIZATION, BY CRIME TYPE | - NUMBER OF CRIME SCENES SEARCHED, BY TYPE
- EXPECTED USEFULNESS OF LAB IN EVALUATING EVIDENCE
- NUMBER CASES EXAMINED FOR LATENT PRINTS, BY CRIME TYPE
- NUMBER OF REQUESTS FOR LAB ANALYSIS
- NUMBER OF CASES LAB PERSONNEL CALLED TO SCENE
- NUMBER OF CASES IN WHICH SERVICES OTHER THAN CRIME LAB WERE REQUESTED |
| 2. SEARCH PERSONNEL | - NUMBER OF EACH TYPE TAKING PART, BY CRIME TYPE (POLICE, EVIDENCE SQUAD, DETECTIVE)
- LEVEL OF TRAINING/EXPERIENCE |
| 3. SEARCH CONDITIONS & PERFORMANCE | - CONDITIONS OF SCENE (i.e., UNDISTURBED OR DISTURBED)
- CONDITION OF PHYSICAL EVIDENCE
- TIME FROM REPORTED OFFENSE TO ARRIVAL
- TOTAL TIME OF SEARCH
- NUMBER OF ITEMS COLLECTED BY TYPE |

B. ANALYSIS

1. LAB BASELINE DATA

- SCOPE
- ANALYTICAL CAPABILITY
- CAPACITY

- LIST OF METHODS; EQUIPMENT, AREAS OF SPECIALITY
- NUMBER OF ANALYSES HANDLED/MONTH, BY ANALYSIS

2. PERFORMANCE

- RATIO OF ITEMS ANALYZED TO NUMBER SUBMITTED
- REASONS FOR FILTERING
- AVG TIME FROM REQUEST FOR ANALYSIS TO FIRST REPORT
- USER EVALUATION OF RESULTS
- USER EVALUATION OF TIMING OF FIRST REPORT
- USER EVALUATION OF DETAIL OF LAB REPORT

C. INVESTIGATION

1. EMPHASIS OF INVESTIGATION ON PHYSICAL EVIDENCE

- NUMBER OF CASES IN WHICH HOLDING OF SUSPECTS REQ'D SCREENING TESTS
- INVESTIGATORS' RELIANCE ON PHYSICAL EVIDENCE IN CONDUCTING INVESTIGATION

2. DIALOG BETWEEN LAB & INVESTIGATOR

- NUMBER OF CASES LAB WAS INFORMED OF SCHEDULING NEEDS
- NUMBER OF CONTACTS WITH LAB BY INVESTIGATOR/CASE
- NUMBER OF CASES IN WHICH LAB PERSONNEL PLAYED ACTIVE ROLE IN DETERMINING: CLUES, RECONSTRUCTION OF EVENTS, DEVELOPMENT OF SUSPECTS, INDIVIDUALIZATION

Table 1 (Cont.)

C. INVESTIGATION (Cont.)

PROPERTY TO BE MEASURED

MEASUREMENT

- | | |
|---|---|
| 3. INVESTIGATION OUTCOME | - HOURS SPENT ON CASE BY INVESTIGATOR(S), BY CRIME TYPE
- OUTCOME (UNRESOLVED, SUSPECT CHARGED, ETC.) |
| 4. ROLE OF PHYSICAL EVIDENCE IN OUTCOME | - NUMBER OF CASES IN WHICH PHYSICAL EVIDENCE ANALYSIS WAS USED
- RELATIVE IMPORTANCE OF PHYSICAL EVIDENCE IN INFLUENCING OUTCOME |
| D. ADJUDICATION | |
| 1. ADJUDICATION PROFILE | - INITIAL CHARGE VS FINAL CHARGE
- STAGE AT WHICH CHARGE WAS DROPPED
- STAGE AT WHICH CASE ENDED
- OF CASES REACHING TRIAL, TYPE OF VERDICTS, BY CRIME TYPE |
| 2. ROLE OF LAB ANALYSIS | - NUMBER OF CASES IN WHICH LAB ANALYSIS INFLUENCED REDUCTION OF CHARGE, BY CRIME TYPE |
| 3. ROLE OF LAB ANALYSIS IN TRIAL | - NUMBER OF CASES LAB ANALYSIS RESULTS WERE USED, BY CRIME TYPE
- REL. IMPORTANCE OF EVIDENCE (BY PROSECUTOR)
- CASES IN WHICH AVAILABLE ANALYSES RESULTS WERE NOT USED BY PROSECUTOR; BY DEFENSE
- TIME-TO-TRIAL (FROM CRIME)
- NUMBER OF STIPULATIONS |

Section 5
DATA COLLECTION

Most of the "measurements" listed in Table 1 require objective data, while a lesser number involves judgmental replies. An example of the latter category is the reliance of the investigator on physical evidence information at the beginning and during his investigation. The former includes all information contained in patrol, detective criminalistics laboratory, prosecution and court case files. A difficulty experienced with collection of these objective data is their frequent incompleteness, as well as fragmented record keeping and indexing practices.

Data were collected by resident observers during 8 month periods at each of three sites: Contra Costa County, California; Columbus, Ohio; and Dade County, Florida. Site selection criteria and site characteristics are reported on in Section 2 of Volumes I and II.

Appendix A reproduces the questionnaires used to collect the data; four separate forms were provided to ask a total of 84 questions on Search, Laboratory Examination, Investigation and Adjudication. Search questions were answered from offense reports and Evidence Squad Logs or Reports. Questions pertaining to laboratory examination were answered from laboratory memoranda and reports. Detective Department files, and Progress Reports and reports to the prosecutor provided data on investigation. Court and prosecution files were searched for adjudication data. As far as possible, objective data were taken directly from these records by the observers. Questions involving judgmental replies were posed, as far as feasible, to the user of the physical evidence information. For instance, the aforementioned question as to reliance on physical evidence was posed to the detective assigned to the case. As can be seen from Appendix A, some of these questions involving judgment were asked identically of prosecutor and defense attorney (e.g. the question on the influence of physical evidence information on a guilty plea) or of investigator and criminalist (e.g. as to time requirements of physical evidence examination).

As far as feasible, data were collected on all four criminal justice stages for each case. One limitation to this practice was, of course, the fact that some cases terminated by investigation, e.g. unfounded or unresolved complaints, do not reach the adjudicative stage. A further limitation is the time lag between offense report and Adjudication, which made it impossible to obtain adjudication data on most cases which were first reported after the fifth month of the observation period. In order to offset the resulting imbalance of the data, a number of cases involving physical evidence examination that were in adjudication in the initial period of data collection or in the time prior to that were included. In these older cases, data collection was limited to information directly obtainable from court or prosecution records, because attorneys or judges could not recall or were not available to provide subjective information.

Some lack of data attributable to recall problems were also experienced in the earlier stages. For instances in offenses that they considered to be of lesser importance, e.g. small residential burglaries, investigators could typically not recall any detail four weeks after the occurrence.

The observers were trained and indoctrinated in the intent and meaning of the questions they had to answer; the need to guard against lack of understanding or bias in their interviews of agency personnel; not to answer themselves those questions which were to be answered by agency personnel, even if the answer appeared obvious. In spite of this instruction, systematic and chance errors were undoubtedly introduced by the observers. The extent of these errors, which are confounded with errors and gaps in agency records, as well as with agency personnel errors upon interview, was not assessed.

Data were collected on a total of 879 cases. Table 2 lists them by source, offense category and questionnaire.

Table 2
SUMMARY OF DATA COLLECTION

	3 SITE TOTALS	ANY I, II, III, IV*			CONTRA COSTA				COLUMBUS				DADE			
		CONTRA COSTA	COLUMBUS	DADE	I	II	III	IV	I	II	III	IV	I	II	III	IV
1. HOMICIDE	153	48	43	62	21	21	15	25	33	27	19	14	51	42	44	15
2. RAPE	166	30	99	37	20	21	20	7	85	85	51	20	31	26	23	7
3. ROBBERY	99	31	8	60	12	11	14	12	2	2	5	3	40	33	38	15
4. ASSAULT	211	53	29	129	28	27	33	15	25	25	17	5	116	113	115	45
5. BURGLARY	200	72	51	77	25	24	38	28	41	41	26	22	59	56	53	19
6. LARCENY	14	4	5	5	2	2	3	1	2	2	0	3	3	2	4	1
7. ARSON	17	13	1	3	9	10	10	2	0	0	0	1	2	3	2	0
8. BOMB EX	4	2	1	1	2	2	2	0	0	1	0	0	1	1	1	0
9. HIT-RUN	15	2	12	1	2	1	2	0	9	8	9	2	1	1	0	0
TOTALS	879	255	249	375	121	119	137	90	197	191	127	70	304	277	279	102

*ROMAN NUMERALS REFER TO QUESTIONNAIRE NUMBERS, SEE APPENDIX A

Section 6

EFFECTIVENESS MEASUREMENT

The term "effectiveness measure" as defined in Section 4 for criminalistics operations will be applied to measurable, quantifiable variables in the criminal justice system. The measures are of two types, direct and indirect. The former are measures that are directly linked with an outcome. In the case of search-related measures of effectiveness an outcome is the result of the search, e.g. collection of a certain type of evidence, say a physiological fluid. In the case of investigation-related measures, an outcome is an investigative resolution, say apprehension and charge of suspect. Indirect measures are those that are linked with an outcome via another variable; for instance, latent prints of value are related to the number of suspects identified which, in turn, is related to resolved investigations.

Note should also be taken that, with a strict interpretation of the effectiveness definition in Section 4, all search-related measures of effectiveness would have to be classified as indirect. However, the search-related effectiveness measures of criminalistics laboratories are in a special class in that they determine the input, hence the operability, of the laboratories. They are classified as direct and indirect by analogy to the investigation and adjudication-related measures.

Measures of effectiveness will also be referred to in terms of objectivity. In most cases, the measures will be based on what is done or what might be done. In some instances, however, it is convenient to speak in terms of perceptual measures, that is, aside from the actual facts of a case, it is useful to measure what features of physical evidence analysis and use are judged to be of particular relevance or importance. Though more difficult to determine, they are potentially valuable since the use of the crime lab services available depends in large part on the predisposition of those who might use them.

6.1 The Data Base

Data collection has been discussed in Section 5, and Table 2 summarizes the data that were obtained by crime, site and criminal justice system stage.

At various stages of data reduction and test planning, it was found convenient to group the variables appearing in the questionnaires in two different ways. Initially, the variables were categorized as being one of five types: baseline, uncontrolled, controllable, outcome and perceptual, as shown in Figure 2. Baseline variables (B) are characterized as being fixed by current conditions, habits, equipment and policy. Uncontrollable variables (U) are typically established by the peculiarities of a particular case, for example, first on scene. By definition, they are out of control of the lab and search units. Controllable variables (C) are those which are most readily varied by the lab or its users. Outcome variables (O) are those which are the culmination of the efforts of those in investigation and adjudication. These represent the final conclusion of a case in these two areas. Finally, perceptual variables (P) are those which relate the lab's performance and operations to the user's evaluation of them. The user may be the investigator, the prosecution, defense, judge or jury.

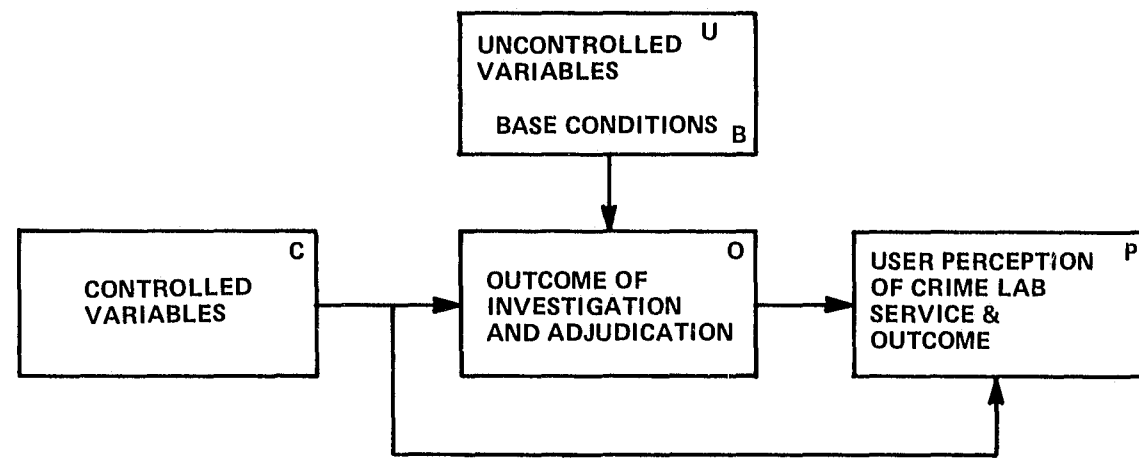


Figure 2 RELATION OF OBSERVED P.E. VARIABLES

The second categorization of variables is that of the criminal justice system itself, namely, search, analysis, investigation and adjudication. The first categorization was useful in determining which comparisons between variables were to be made; the second lends itself more naturally to presentation and is used to group the analyzed variables as described below.

6.2 Approach

The general procedure adopted was to list the variables, group by group (B, C, U, O, P) and choose those pairs which might be expected to show a relationship. The categories initially selected for comparison are listed below:

	U	C	O	P
B		X	X	
U	X	X	X	
C		X	X	X
O				X
P				X

Comparisons made between variables in each of the type combinations listed in the matrix above are shown in Figure 3. The "X"s indicate that a test for independence was performed for that pair. Approximately 250 such comparisons were performed with the aid of an IBM computer.

UNCONTROLLED vs CONTROL

		UNCONTROLLED VARIABLES												
		FIRST ON SCENE	CONDITION OF SCENE	PURPOSE OF REQUEST	FIRST REPORT TO	NUMBER OF LAB REQUESTS	REQUESTS BY OTHER PARTIES	SUSPECT IN CUSTODY	SEARCH OF SUSPECT	RESULTS OTHER THAN CRIME LAB	HYPOTHESIS CONFIRMED	LAB WITNESS CROSS-EXAMINED	CHALLENGE WITNESS	STIPULATED EVIDENCE
C -	CONTROL VARIABLES													
	OTHER SEARCH SCENES													
	DURATION OF SEARCH													
	LATENT PRINT SEARCH													
	EVIDENCE ITEMS COLLECTED													
	STANDARDS COLLECTED													
	GRAPHICS													
	OTHER SERVICES													
	LAB REQUESTS													
	VICTIM IDENTIFICATION													
I	"MAJOR CASES INVOLVING VICTIMS" CHECKLIST													
	COMMUNICATION WITH LAB													
	TIME REQUIREMENTS													
	PE CATEGORIES COLLECTED, ANALYZED, AND IDENTIFIED													
	SCREENINGS TESTS													
	ELAPSED TIME (REQUEST TO REPORT)													
	REPORT CONTENT													
	STANDARDS TAKEN													
	SCHEDULING OF NEEDS													
	# CONTACTS BY INVESTIGATOR													
II	TIME ON CASE													
	USE OF LAB RESULTS													
	ROLE OF PE IN CLEARING OF OTHER CRIMES													
	LAB RESULTS DIFFER FROM EXPECTATION													
	NEW CLUES													
	LEVEL OF DETAIL													
	TIMELINESS OF RESULTS													
	CONFERENCE WITH LAB PERSONNEL													
	PE USED IN COURT													
	DEMONSTRATIVE EVIDENCE													
PROSECUTOR:	PLEA-BARGAINING													
	PROSECUTOR CONFER WITH LAB WITNESS													
	DEFENSE AWARE OF LAB ANALYSIS													
DEFENSE:	PLEA-BARGAINING													
	DEFENSE PRESENT PE													
	AWARE OF PE BEFORE TRIAL													

Figure 3 TESTED VARIABLE PAIRS

U - UNCONTROLLED VARIABLES	O - OUTCOME				
	OUTCOME (DISPOSITION) OF INVESTIGATION	DISPOSITION:	STAGE AT WHICH CHARGE DROPPED	STAGE AT WHICH CASE ENDED	PLEA-BARGAINING
FIRST ON SCENE	•				
CONDITION OF SCENE	•				
PURPOSE OF REQUEST					
FIRST REPORT TO					
NUMBER OF LAB REQUESTS	•			•	
REQUESTS BY OTHER PARTIES					
SUSPECT IN CUSTODY	•				
SEARCH OF SUSPECT	•				
RESULTS OTHER THAN CRIME LAB					
HYPOTHESIS CONFIRMED					
LAB WITNESS CROSS-EXAMINED					
CHALLENGE WITNESS					
STIPULATED EVIDENCE				•	

Figure 3 (Cont'd)

CONTROL vs PERCEPTUAL

C - CONTROL VARIABLES	P - PERCEPTUAL MEASURES										
	RELIANCE ON PE	PE AND PE ANALYSIS CONTRIBUTION TO OUTCOME	NEW HYPOTHESIS	ADEQUACY OF RESULTS	IMPORTANCE OF ANALYSIS EVIDENCE ITEMS	OTHER METHODS MORE VALUABLE	PROSECUTOR:	DEFENSE:	JURY:	JUDGE:	CONTRIBUTION OF L.A.B SERVICE
OTHER SEARCH SCENES	•										
DURATION OF SEARCH	•										
LATENT PRINT SEARCH	•										
EVIDENCE ITEMS COLLECTED	•										
STANDARDS COLLECTED	•										
GRAPHICS	•										
OTHER SERVICES	•										
LAB REQUESTS	•										
VICTIM IDENTIFICATION	•										
"MAJOR CASES INVOLVING VICTIMS" CHECKLIST	•										
COMMUNICATION WITH LAB	•										
TIME REQUIREMENTS	•										
PE CATEGORIES COLLECTED, ANALYZED, AND IDENTIFIED	•										
SCREENINGS TESTS	•										
ELAPSED TIME (REQUEST TO REPORT)	•										
REPORT CONTENT	•										
STANDARDS TAKEN	•										
SCHEDULING OF NEEDS	•										
# CONTACTS BY INVESTIGATOR	•										
TIME ON CASE	•										
USE OF LAB RESULTS	•										
ROLE OF PE IN CLEARING OF OTHER CRIMES	•										
LAB RESULTS DIFFER FROM EXPECTATION	•										
NEW CLUES	•										
LEVEL OF DETAIL	•										
TIMELINESS OF RESULTS	•										
CONFERENCE WITH LAB PERSONNEL	•										
PE USED IN COURT	•										
DEMONSTRATIVE EVIDENCE	•										
PROSECUTOR:											
PLEA-BARGAINING											
PROSECUTOR CONFER WITH LAB WITNESS											
DEFENSE AWARE OF LAB ANALYSIS											
DEFENSE:											
PLEA-BARGAINING											
DEFENSE PRESENT PE											
AWARE OF PE BEFORE TRIAL											

Figure 3 (Cont'd)

CONTROL VS CONTROL

	C - CONTROL VARIABLES	I - OTHER SERVICES	II - SCREENINGS TESTS	III - USE OF LAB RESULTS	PROSECUTOR:	DEFENSE:
OTHER SEARCH SCENES						
DURATION OF SEARCH						
LATENT PRINT SEARCH						
EVIDENCE ITEMS COLLECTED						
STANDARDS COLLECTED						
GRAPHICS						
OTHER SERVICES						
LAB REQUESTS						
VICTIM IDENTIFICATION						
"MAJOR CASES INVOLVING VICTIMS" CHECKLIST						
COMMUNICATION WITH LAB						
TIME REQUIREMENTS						
PE CATEGORIES COLLECTED, ANALYZED, AND IDENTIFIED						
SCREENINGS TESTS						
ELAPSED TIME (REQUEST TO REPORT)						
REPORT CONTENT						
STANDARDS TAKEN						
SCHEDULING OF NEEDS						
# CONTACTS BY INVESTIGATOR						
TIME ON CASE						
USE OF LAB RESULTS						
ROLE OF PE IN CLEARING OF OTHER CRIMES						
LAB RESULTS DIFFER FROM EXPECTATION						
NEW CLUES						
LEVEL OF DETAIL						
TIMELINESS OF RESULTS						
CONFERENCE WITH LAB PERSONNEL						
PE USED IN COURT						
DEMONSTRATIVE EVIDENCE						
PROSECUTOR:						
PLEA-BARGAINING						
PROSECUTOR CONFER WITH LAB WITNESS						
DEFENSE AWARE OF LAB ANALYSIS						
DEFENSE:						
PLEA-BARGAINING						
DEFENSE PRESENT PE						
AWARE OF PE BEFORE TRIAL						

Figure 3 (Cont'd)

CONTROL vs OUTCOME

	C - CONTROL VARIABLES	O - OUTCOME	OUTCOME (DISPOSITION) OF INVESTIGATION	DISPOSITION:	STAGE AT WHICH CHARGE DROPPED	STAGE AT WHICH CASE ENDED	PLEA-BARGAINING	DISPOSITION OF TRIAL	DURATION OF TRIAL
OTHER SEARCH SCENES									
DURATION OF SEARCH									
LATENT PRINT SEARCH									
EVIDENCE ITEMS COLLECTED									
STANDARDS COLLECTED									
GRAPHICS									
OTHER SERVICES									
LAB REQUESTS									
VICTIM IDENTIFICATION									
"MAJOR CASES INVOLVING VICTIMS" CHECKLIST									
COMMUNICATION WITH LAB									
TIME REQUIREMENTS									
PE CATEGORIES COLLECTED, ANALYZED, AND IDENTIFIED									
SCREENINGS TESTS									
ELAPSED TIME (REQUEST TO REPORT)									
REPORT CONTENT									
STANDARDS TAKEN									
SCHEDULING OF NEEDS									
# CONTACTS BY INVESTIGATOR									
TIME ON CASE									
USE OF LAB RESULTS									
ROLE OF PE IN CLEARING OF OTHER CRIMES									
LAB RESULTS DIFFER FROM EXPECTATION									
NEW CLUES									
LEVEL OF DETAIL									
TIMELINESS OF RESULTS									
CONFERENCE WITH LAB PERSONNEL									
PE USED IN COURT									
DEMONSTRATIVE EVIDENCE									
PROSECUTOR:									
PLEA-BARGAINING									
PROSECUTOR CONFER WITH LAB WITNESS									
DEFENSE AWARE OF LAB ANALYSIS									
DEFENSE:									
PLEA-BARGAINING									
DEFENSE PRESENT PE									
AWARE OF PE BEFORE TRIAL									

Figure 3 (Cont'd)

PERCEPTUAL vs PERCEPTUAL

P - PERCEPTUAL MEASURES	PERCEPTUAL MEASURES									
	RELIANCE ON PE	PE AND PE ANALYSIS CONTRIBUTION TO OUTCOME	NEW HYPOTHESIS	ADEQUACY OF RESULTS	IMPORTANCE OF ANALYSIS EVIDENCE ITEMS	OTHER METHODS MORE VALUABLE	PROSECUTOR:	DEFENSE:	JURY:	JUDGE:
RELIANCE ON PE										
PE AND PE ANALYSIS CONTRIBUTION TO OUTCOME	●									
NEW HYPOTHESIS										
ADEQUACY OF RESULTS	●	●								
IMPORTANCE OF ANALYSIS EVIDENCE ITEMS										
OTHER METHODS MORE VALUABLE										
PROSECUTOR:										
IMPORTANCE OF PE										
REASON FOR GUILTY PLEA										
ROLE OF PE IN PRE-TRIAL	●									
ROLE OF LAB EXAM IN TRIAL										
DEFENSE:										
IMPORTANCE OF PE	●									
PURPOSE OF PE CHALLENGE	●									
GUILTY PLEA RELATED TO PE		●								
JURY:										
INFLUENCE OF PE ON VERDICT	●	●				●		●		
PE REVIEWED IN JURY ROOM						●		●		
JURY UNDERSTAND WITNESS						●		●		
JUDGE:										
NECESSITY OF LAB WITNESS						●		●		
PURPOSE OF PRESENTING PE						●		●		
GUILTY PLEA RESULT OF PE						●		●		
INFLUENCE OF PE ON VERDICT								●		
EXPERT WITNESS TESTIMONY WELL PRESENTED								●	●	
CONTRIBUTION OF LAB SERVICE	●					●		●		

Figure 3 (Cont'd)

OUTCOME vs PERCEPTUAL

P - PERCEPTUAL MEASURES	OUTCOME				
	OUTCOME (DISPOSITION) OF INVESTIGATION	DISPOSITION:	STAGE AT WHICH CHARGE DROPPED	STAGE AT WHICH CASE ENDED	DURATION OF TRIAL
RELIANCE ON PE	●				
PE AND PE ANALYSIS CONTRIBUTION TO OUTCOME	●				
NEW HYPOTHESIS					
ADEQUACY OF RESULTS	●				
IMPORTANCE OF ANALYSIS EVIDENCE ITEMS					
OTHER METHODS MORE VALUABLE					
PROSECUTOR:					
IMPORTANCE OF PE					
REASON FOR GUILTY PLEA					
ROLE OF PE IN PRE-TRIAL					
ROLE OF LAB EXAM IN TRIAL					
DEFENSE:					
IMPORTANCE OF PE					
PURPOSE OF PE CHALLENGE					
GUILTY PLEA RELATED TO PE					
JURY:					
INFLUENCE OF PE ON VERDICT					
PE REVIEWED IN JURY ROOM					
JURY UNDERSTAND WITNESS					
JUDGE:					
NECESSITY OF LAB WITNESS					
PURPOSE OF PRESENTING PE					
GUILTY PLEA RESULT OF PE					
INFLUENCE OF PE ON VERDICT					
EXPERT WITNESS TESTIMONY WELL PRESENTED					
CONTRIBUTION OF LAB SERVICE					

Figure 3 (Cont'd)

BASELINE vs OUTCOME

B - BASELINE VARIABLES	O - OUTCOME (DISPOSITION) OF INVESTIGATION			
	DISPOSITION:	STAGE AT WHICH CHARGE DROPPED	STAGE AT WHICH CASE ENDED	PLEA-BARGAINING
SEARCH SCENE PERSONNEL				
PURPOSE OF SEARCH				
SCREENING TEST REQUIRED				
INITIAL CHARGES				
PURPOSE OF PRESENTING PE				
DATE WITNESS NOTIFIED				
LAB BASELINE DATA				
METHODS/EQUIPMENT				
ANALYSIS PROFILE				

UNCONTROLLED vs UNCONTROLLED

U - UNCONTROLLED VARIABLES	UNCONTROLLED VARIABLES												
	FIRST ON SCENE	CONDITION OF SCENE	PURPOSE OF REQUEST	FIRST REPORT TO	NUMBER OF LAB REQUESTS	REQUESTS BY OTHER PARTIES	SUSPECT IN CUSTODY	SEARCH OF SUSPECT	RESULTS OTHER THAN CRIME LAB	HYPOTHESIS CONFIRMED	LAB WITNESS CROSS-EXAMINED	CHALLENGE WITNESS	STIPULATED EVIDENCE
FIRST ON SCENE													
CONDITION OF SCENE	●												
PURPOSE OF REQUEST													
FIRST REPORT TO													
NUMBER OF LAB REQUESTS			●										
REQUESTS BY OTHER PARTIES				●	●								
SUSPECT IN CUSTODY													
SEARCH OF SUSPECT						●							
RESULTS OTHER THAN CRIME LAB													
HYPOTHESIS CONFIRMED													
LAB WITNESS CROSS-EXAMINED													
CHALLENGE WITNESS													
STIPULATED EVIDENCE													

Figure 3 (Cont'd)

BASELINE vs CONTROL

C - CONTROL VARIABLES	B - BASELINE VARIABLES								
	SEARCH SCENE PERSONNEL	PURPOSE OF SEARCH	SCREENING TEST REQUIRED	INITIAL CHARGES	PURPOSE OF PRESENTING PE	DATE WITNESS NOTIFIED	LAB BASELINE DATA	METHODS/EQUIPMENT	ANALYSIS PROFILE
OTHER SEARCH SCENES									
DURATION OF SEARCH			●						
LATENT PRINT SEARCH			●						
EVIDENCE ITEMS COLLECTED			●						
STANDARDS COLLECTED			●						
GRAPHICS									
OTHER SERVICES									
LAB REQUESTS			●						
VICTIM IDENTIFICATION									
"MAJOR CASES INVOLVING VICTIMS" CHECKLIST									
COMMUNICATION WITH LAB									
TIME REQUIREMENTS									
PE CATEGORIES COLLECTED, ANALYZED, AND IDENTIFIED			●						
SCREENINGS TESTS									
ELAPSED TIME (REQUEST TO REPORT)									
REPORT CONTENT									
STANDARDS TAKEN									
SCHEDULING OF NEEDS									
# CONTACTS BY INVESTIGATOR									
TIME ON CASE									
USE OF LAB RESULTS			●						
ROLE OF PE IN CLEARING OF OTHER CRIMES									
LAB RESULTS DIFFER FROM EXPECTATION									
NEW CLUES									
LEVEL OF DETAIL									
TIMELINESS OF RESULTS									
CONFERENCE WITH LAB PERSONNEL									
PE USED IN COURT									
DEMONSTRATIVE EVIDENCE									●
PROSECUTOR:									
PLEA-BARGAINING									
PROSECUTOR CONFER WITH LAB WITNESS									
DEFENSE AWARE OF LAB ANALYSIS									
DEFENSE:									
PLEA-BARGAINING									
DEFENSE PRESENT PE									
AWARE OF PE BEFORE TRIAL									

Figure 3 (Cont'd)

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Two types of comparisons were made, specific to crime type and site, and aggregates over crimes and sites:

- a. Means, standard deviations and correlation coefficient. This comparison was used when both variables were of a quantitative nature, e.g., duration of investigation and number of contacts with investigator. Where feasible, variables, such as "contribution of physical evidence to outcome" (none, minor, significant, decisive), were ranked on an ordinal scale in order to allow this calculation.
- b. Use was made of contingency tables when either variable was of a qualitative nature. In this event a chi-square statistic was computed assuming independence, and was compared with the corresponding degrees of freedom associated with the statistic. These tables were of two types. The first is the usual two-way contingency table in which the counts collected in any cell are made up of independent cases, such as Reliance on physical evidence (low, moderate or high) versus Investigate outcome (unresolved, ..., exceptionally cleared). In each factor, the responses are mutually exclusive. The second type of contingency table used handled the case where the response in one of the factors were not mutually exclusive, as with evidence categories collected, where in any given case several categories may be collected. A test procedure and statistic was developed to handle this situation and a corresponding computer program written to execute it. The analytical procedure is developed in Appendix B and an illustrative example of the first type of contingency table is presented in Appendix C.

As noted above, each test consisted of calculation of means, standard deviations, correlation coefficients, and counts, or chi-square statistics, degrees of freedom, and counts, for each site and over all three sites (3+1), and each crime type and over all crime types (9+1) for a total of 40 comparisons per run. In addition, a table was computed which showed the most frequently occurring responses to each of the variables being tested, as well as the most frequent joint response. Thus, a trend peculiar to a crime type or site could be inspected from a single test. For more detailed inspection, the raw counts of each level of both factors were extracted from the data and displayed.

The criteria for assigning association (lack of independence) between any two variables were the following: In the case of contingency tables, a statistical value of at least 1-1/2 - 2 times the number of degrees of freedom, along with a total case count of 3 - 5 times the degrees of freedom was deemed sufficient for assigning association. For the following reasons these criteria are somewhat less stringent than those usually applied in this type of analysis:

1. If the statistic used has the exact X^2 distribution, the ranges listed would result in a significance level of about .10, depending on the degrees of freedom (lower for larger degrees of freedom). Often times a relatively low count of cases contributed to the test statistic, rendering the approximation to its distribution by the X^2 distribution rather imprecise.

2. The second reason is the large number of tests performed, 40 statistics/test X 250 tests = 10,000 statistics computed. It is felt that calculation of probabilities under such conditions would be meaningless, in that the resultant test results would be hopelessly compounded.
3. Thirdly, the emphasis was placed on identifying potential relationships between variables rather than requiring that false or chance associations be ruled out with high probability; that is, in this analysis, it was better to make an error in the direction of association between variables than their independence.

In cases in which correlation coefficients were computed, only a consistent correlation appearing in several sites or several crime types of $\pm .25$ or greater was taken as an indication of dependence.

The results of the test for association between variables are shown in Figure 4. The variables in this presentation have been regrouped according to area of activity (search, analysis, investigation, adjudication). Only those indicating the strongest or broadest association among those tested are presented here. In addition, those combinations which were a priori believed to be related but tested otherwise are noted. Also included are those pairs which at this time appear to have potential value if data collection could be performed.

Links between the major variables determined to be significant by the statistical analysis are presented, in crime-specific format, in Appendix D.

STATISTICAL ANALYSIS OF PAIRED VARIABLES

In this section we present a detailed summary and interpretation of the tests of variable pairs that were performed by the mathematical procedures outlined in the preceding section.

The principal interpretation of "significance" of any variable pair in Figure 4 is merely that the levels of one factor are not distributed uniformly over the levels of the other factor. Significance may therefore be associated with two (opposite) trends; e.g., analysis of a certain evidence type may tend to be associated (1) with unresolved investigation, or (2) with resolved investigations.

In the discussion below discernable trends inferred from the maximum counts and detailed cell counts are discussed for each significant variable pair. It should be noted here that the analytical method employed does not separate observer bias and real site differences influencing these trends.

The presentation is grouped by criminal justice system stage, Search, 7.1, Analysis 7.2, Investigation, 7.3, and Adjudication 7.4. Then, combinations across the above stages are discussed: Search-Analysis, 7.5, Search-Investigation, 7.6, Analysis-Investigation, 7.7. No statistically significant links between analysis and adjudication were found.

	SEARCH								ANALYSIS					INVESTIGATION					ADJUDICATION											
	FIRST ON SCENE	CONDITION OF SCENE	OTHER SEARCH SCENES	SEARCH OF SUSPECT	DURATION OF SEARCH	EVIDENCE TYPES	STANDARDS	LATENT PRINT SEARCH	SUSPECT IN CUSTODY	SEARCH SCENE PERSONNEL	PURPOSE OF REQUEST	PE CATEGORIES	ELAPSED TIME	NO. CONTACTS/INV.	LAB REQUESTS	REPORT CONTENT	STANDARDS	TIME ON CASE	USE OF LAB RESULTS	RELIANCE ON PE	CONTRIBUTION OF PE	INV. OUTCOME	SUSPECT IN CUSTODY	PE USED IN COURT	DEMONSTRATIVE EVID.	PLEA BARG.	DISPOSITION OF CASE	STIPULATED EVID.	GUILTY PLEA	IMPORTANCE OF PE
SEARCH																														
ANALYSIS																														
INVESTIGATION																														
ADJUDICATION																														

Figure 4 SIGNIFICANT VARIABLE PAIRS

Following each discussion of trends is a listing of those sites and crimes for which significance was established. Contra Costa, Columbus and Dade County are referred to as Sites 1, 2 and 3, respectively. Significant relations are listed separately for five crimes and for "all" nine crimes for which data were collected.

7.1 Search

The questions relative to the crime scene search found to be related to any other question in the survey are listed below:

- first on scene
- condition of scene
- other search scenes
- search of suspect
- duration of search
- evidence categories collected
- standards collected
- latent print search
- suspect initially in custody
- search scene personnel

Among these variables, relationships were found to exist among the following pairs:

	First on scene	Condition of scene	Duration of search	Evidence categories collected
Evidence categories collected			X*	
Standards collected		X		
Latent print search	X		X	
Search scene personnel			X	
Suspect initially in custody				X

- First on scene - latent print search: A trend recognized for assault is that when a citizen is first to arrive on the scene, a search for latent prints is more likely to be made. In robbery and burglary, the opposite trend was found. We interpret this to mean: patrols are often called to on-going disturbances and become eye witnesses, alleviating the need for prints.

Offense	Site			All
	1	2	3	
Homicide				
Rape				
Robbery			X	
Aggravated Assault	X		X	X
Burglary	X			
All Crimes			X	X

* Items thus marked are discussed in each sub-section below under "Notes".

- Latent print search - duration of search: A generally negative correlation was found in that prints are more apt to be searched for in a short search than otherwise. This observed trend is in keeping with the generally held view that crime scene search often concentrates on fingerprints to the exclusion of other physical evidence. Our data indicate that in long searches fingerprints are less frequently looked for; we ascribe this finding to the recording practice which omits mention of latents if other physical evidence was collected. The responses to our question relating evidence type collected to duration of search did not support the suggestion that fingerprint search is neglected in long searches.

Offense	Site			
	1	2	3	All
Homicide	X	X	X	X
Rape		X		
Robbery	X			X
Aggravated Assault				
Burglary				
All Crimes				

- Conditions of scene - standards collected: A moderate relation was found indicating that standards were not apt to be collected if the scene had been disturbed.

Offense	Site			
	1	2	3	All
Homicide		X		
Rape	X			
Robbery				
Aggravated Assault				
Burglary	X			
All Crimes	X			

- Search scene personnel - duration of search: Significant relationships were found for one site. Duration between 1 and 2 hours occurs most frequently with evidence squad, as opposed to shorter search durations for patrol, detective, other.

Offense	Site			
	1	2	3	All
Homicide				
Rape			X	
Robbery				
Aggravated Assault			X	
Burglary			X	X
All Crimes			X	X

Notes

1. Duration of search - evidence categories collected. Contrary to expectations, no relation was found at any site for any crime.

2. Suspect initially in custody - evidence categories collected. No relation was found, indicating that the variety of evidence searched for is not influenced by the additional information. This may be because the evidence squad is not necessarily informed of this fact.

7.2 Analysis

The questions specific to analysis which showed a significant relation to others are:

- purpose of request
- categories submitted or analyzed
- elapsed time (request to first report)
- number of contacts with investigator
- lab requests (evidence categories)
- report content

Within this group, those pairs exhibiting a relationship are shown in the following table.

	Purpose of request	Lab requests	PE categories submitted/analyzed
Number contacts with investigator	X	X	X
Report content			X

- Number of contacts with investigator - physical evidence categories submitted: In one site, a relation was found that indicated the lowest number of contacts coincided most often with weapon-related evidence. In another site, this result manifested itself in rapes and physiological evidence. In both instances this finding is consistent with on-site observation: In one site, many rape cases are investigated, but only by physiological specimen analysis. In another site, many routine weapon operability tests overwhelm other evidence examination categories.

Offense	Site			All
	1	2	3	
Homicide			X	X
Rape				X
Robbery				
Aggravated Assault			X	X
Burglary				
All Crimes		X		

- Number of contacts with investigator - purpose of request:
Based on a rather slight data base, the results indicate as noted in the preceding paragraph, that in one site the primary purpose is to determine if a crime has been committed (rape), corresponding to a single contact with the investigator. However, when all crimes are taken together, reconstruction of events or development of suspects are associated with low number of contacts.

Offense	Site			All
	1	2	3	
Homicide				
Rape		X		X
Robbery				
Aggravated Assault				
Burglary				
All Crimes	X			X

- Report content - physical evidence categories analyzed: A very strong and general association was found to exist, with the most frequent pair being "findings" and weapon related material. In one site, however, "findings" and "method used" were listed jointly in three crime categories, significantly in homicides. We conclude that different categories require and receive different reporting methods as dictated by the characteristics of the case.

Offense	Site			All
	1	2	3	
Homicide	X	X	X	X
Rape	X			X
Robbery			X	X
Aggravated Assault	X		X	X
Burglary	X	X	X	X
All Crimes	X	X	X	X

Notes

Lab request - contacts with investigator: It is believed that a relationship could be shown between evidence types and number of contacts by investigator. As discussed in Volume I, measurement of this proved impossible since laboratory files did not contain contact records. The purpose would be to measure (and perhaps enhance) the involvement of the criminalist in determining the potential relevance of evidence items.

7.3 Investigation

The following questions pertaining to investigation were found to be relevant:

- Standards taken
- Investigator's time on a case
- Use of lab results
- Reliance on physical evidence
- Contribution to physical evidence outcome
- Investigation outcome
- Suspect initially in custody

Reliance on physical evidence and contribution of physical evidence to outcome are perceptual measures that were answered by the investigators whenever possible. Use of lab results was determined by the observer in most cases. Relationships were found to exist among the following pairs:

	Standards taken	Investigator's time on case	Use of lab Results	Reliance on PE	Contribution to outcome	Investigation outcome
Reliance on PE	X		X			
Contribution of PE	X	X*		X		
Investigation outcome	X		X	X	X	
Suspect in custody	X					X

- Reliance on physical evidence - standard taken: Significant correspondence between low reliance and lack of standards was found in one site for aggravated assault, in another for burglary. This trend, though not significant, was observed throughout. Collection of standards may be taken as an indicator of quality of search.

Offense	Site			All
	1	2	3	
Homicide				
Rape				
Robbery				
Aggravated Assault			X	X
Burglary	X			X
All Crimes	X		X	

- Reliance on physical evidence - use of lab results: A relation was found for aggravated assault (1 site) and burglary (1 site). There was no consistent trend found between degree of reliance and use between sites or crimes. Low and moderate reliance were the most frequent responses, with the exception of 1 site, in which high reliance was most often cited for homicides, robberies, and burglaries. This relation was not significant, however.

Offense	Site			All
	1	2	3	
Homicide				X
Rape				X
Robbery				
Aggravated Assault			X	X
Burglary		X		X
All Crimes	X	X	X	X

- Contribution of physical evidence to outcome - reliance on physical evidence: Strong and consistent relation was found between low reliance and no or minor contribution to outcome, rendering these two perceptions essentially equivalent. The principal exception to this result appears in one site in which low reliance is the most frequently occurring response coincident with some laboratory contribution. This paradox might be interpreted as an indication of low confidence in the lab on the part of the investigators.

Offense	Site			All
	1	2	3	
Homicide	X		X	X
Rape	X	X	X	X
Robbery	X		X	X
Aggravated Assault	X	X	X	X
Burglary	X	X	X	X
All Crimes	X	X	X	X

- Investigative outcome - standards taken: A relation was found indicating that in general no standards have been taken in cases where a charge is made. Exceptions (charge, with standards) occurred in rape (site 3) and burglary (site 2).

Offense	Site			All
	1	2	3	
Homicide			X	X
Rape			X	X
Robbery		X		
Aggravated Assault		X		
Burglary		X	X	X
All Crimes		X	X	X

- Investigative outcome - use of lab results: One site only showed a relation in which "suspect charged" corresponded to "individualization" for 2 crimes. That is what one might expect at all sites. The absence of the finding at two sites indicates that at those sites the laboratory role is mostly corroborative.

Offense	Site			All
	1	2	3	
Homicide			X	X
Rape				
Robbery				
Aggravated Assault			X	X
Burglary			X	X
All Crimes		X	X	X

- Investigative outcome - reliance on physical evidence: No discernible trends were found, except over all crimes. In one site, high reliance was predominantly associated with "suspect charged". High reliance was frequently cited in another site and seldom in the third site.

Offense	Site			All
	1	2	3	
Homicide		X	X	
Rape				
Robbery				
Aggravated Assault			X	X
Burglary	X			
All Crimes	X	X	X	X

- Investigative outcome - contribution of physical evidence to outcome: The general correspondence observed is high incidence of no contribution and unresolved cases. This trend holds in all three sites over all crimes.

Offense	Site			All
	1	2	3	
Homicide			X	
Rape			X	
Robbery				
Aggravated Assault			X	X
Burglary			X	
All Crimes	X		X	X

- Suspect in custody - standards taken: Generally, a positive association was found between suspect initially in custody and standards. No suspect and no standards occurred most frequently. The converse result, suspect in custody and standards, was found particularly strong in burglary in one site and over all sites.

Offense	Site			All
	1	2	3	
Homicide				
Rape			X	X
Robbery			X	
Aggravated Assault				
Burglary	X	X		X
All Crimes	X	X	X	X

- Suspect in custody - investigation outcome: Not unexpectedly, a strong, general relation was found associating initial custody of suspect with charge. With only two exceptions, this was the case for all sites and all crimes.

Offense	Site			All
	1	2	3	
Homicide		X	X	X
Rape	X	X	X	X
Robbery			X	X
Aggravated Assault	X	X	X	X
Burglary	X	X	X	X
All Crimes	X	X	X	X

Notes

No significant relation was found between physical evidence contribution to outcome and investigators' time on case; i.e., the hypothesis that investigative time is shortened by the criminalistics contribution is not supported by our data.

7.4 Adjudication

The questions that were found to be significant or potentially significant specific to adjudication are as follows:

- Physical evidence used in court
- Demonstrative evidence
- Reduced charge (record)
- Plea bargaining (prosecution, defense)
- Disposition of case
- Stipulated evidence
- Guilty plea induced by physical evidence
- Importance of physical evidence

Within this group relations were found between the following pairs:

	PE used in court	Demonstrative evidence	Plea bargaining (prosecution defense)
Reduced charge (record)			X
Disposition of case	X	X	
Stipulated evidence			X*
Importance of PE (defense)		X	

- Reduced Charge (record) - plea bargaining (prosecution):
Essential agreement was found between the fact of a reduced charge and the occurrence of plea bargaining as viewed by the prosecutor. Taken over all sites or all crimes, the conclusion reached is that plea bargaining is responsible for most reduced charges.

Offense	Site			All
	1	2	3	
Homicide				X
Rape				X
Robbery				X
Aggravated Assault				X
Burglary				
All Crimes		X	X	X

- Reduced charge (record) - plea bargaining (defense): The inference is made that the defense is in essential agreement with the fact of reduced charge being a result of plea bargaining. In one site, the results were positive, linking reduced charge with plea bargaining over most crimes.

Offense	Site			All
	1	2	3	
Homicide	X			X
Rape				
Robbery				X
Aggravated Assault				X
Burglary				X
All Crimes	X		X	X

- Trial Disposition - physical evidence used in court: A positive trend was found at one site for homicide, over all crimes at each site, and over all crimes, all sites. The nature of the relation is to imply that, when physical evidence is used in court, it is associated most frequently with guilty verdicts, as opposed to acquittals.

Offense	Site			All
	1	2	3	
Homicide	X			X
Rape				X
Robbery	X			X
Aggravated Assault	X			X
Burglary	X			X
All Crimes	X	X	X	X

- Trial Disposition - demonstrative evidence: A relation similar to the preceding was found for demonstrative evidence. Over all sites and crimes (for which counts were relatively large, this trend was even more pronounced).

Offense	Site			All
	1	2	3	
Homicide				X
Rape				
Robbery				X
Aggravated Assault	X			X
Burglary	X			X
All Crimes	X			X

- Importance of physical evidence - demonstrative evidence: The question was asked of the defense as to the prosecutor's purpose in presenting physical evidence. Responses were spotty, but when collected over sites or crimes, the trend to present physical evidence to link the suspect directly to the crime appears.

Offense	Site			All
	1	2	3	
Homicide				X
Rape				
Robbery				
Aggravated Assault				X
Burglary				
All Crimes			X	X

Notes

Stipulated evidence - disposition of case: It was interesting to note that no relationship was found. Counts for this question were small, however, (30 over all crimes and sites).

7.5 Search - Analysis

Listed below is a matrix showing which of the two sets of questions relating to search and analysis could be related to one another.

	Condition of scene	Duration of search	Suspect in custody
PE categories (collected submitted analyzed)	X		X
Elapsed time (turnaround)		X	
Lab request	X	X*	

- Physical evidence categories collected - condition of scene: A weak relation was found; contrary to expectation, it would indicate that the condition of the scene has little effect on the type of evidence collected, except perhaps in assault and burglary. In these instances, weapons and print or physical match categories are associated most frequently with an undisturbed scene.

Offense	Site			All
	1	2	3	
Homicide				
Rape		X		
Robbery				
Aggravated Assault	X		X	X
Burglary	X			X
All Crimes				

- Physical evidence categories submitted - suspect in custody: The results, although not significant, indicate that in assault cases, at each site, the fact that a suspect is initially in custody has no bearing on the type of evidence submitted for analysis. However, over all three sites, a difference is noted, indicating an intra-site difference. This is borne out by the fact that at all three sites the most frequent evidence type submitted is weapon-related; in sites 2 and 3, a suspect is most often also initially in custody, while in site 1, most frequently a suspect is not in custody.

Offense	Site			All
	1	2	3	
Homicide				
Rape				
Robbery				
Aggravated Assault				
Burglary		X		
All Crimes		X		X

- Elapsed laboratory time - duration of search: A strong correlation specific to homicide was found at all three sites, robbery (and to a lesser extent, rapes) at one site. Although the counts are small, the magnitude of the correlation coefficient (.97, .76, .46, respectively) indicate there is a negative relation. That is, a case which receives extra attention (as reflected by increased search time) also receives priority treatment as reflected by short laboratory turnaround time.

Offense	Site			All
	1	2	3	
Homicide	X	X	X	X
Rape			X	X
Robbery			X	X
Aggravated Assault				
Burglary				
All Crimes				

- Lab requests (evidence types) - condition of scene: A relation was found over all sites and crimes that indicated that a disturbed scene resulted in a much lower proportion of requests of all evidence types, but to a lesser extent for physiological and structural materials. The latter trend does not appear consistently at each site and for each crime, however.

Offense	Site			All
	1	2	3	
Homicide				X
Rape				X
Robbery				
Aggravated Assault	X		X	X
Burglary				
All Crimes	X	X	X	X

Notes

Lab requests (evidence types) - duration of search: No relation was found here except in one site and all sites together, over all crimes. The inference is that the duration of the search depends more on the general setting of the scene rather than on the evidence types collected, and hence evidence types for which requests for analysis are made. This result is consistent with the relation between search duration and evidence category discussed in Section 7.1.

Offense	Site			All
	1	2	3	
Homicide				
Rape				
Robbery				
Assault				
Burglary				
All Crimes			X	X

7.6 Search - Investigation

This section describes the relations found between pairs of variables, one applying to search, the other to investigation. They are:

	First on scene	Search of suspect	Evidence types collected	Standards collected	Latent print search
Reliance on PE			X		X
Investigation Outcome	X	X		X	X

- Reliance on physical evidence - evidence items collected: In two of the three sites (1, 3), low and high reliance were marked more often than moderate for all evidence categories. This indicates a somewhat binary interpretation to the question, and perhaps truly reflects the attitude of the investigators toward investigative aids in general (little time for "maybe"s). In site 3, weapons were collected more frequently than in the other two sites, while at the same time in most of these cases, low reliance was cited by the investigator. This interpretation is consistent with finding that in site 3 the majority of weapons analyses consist of routine checks for operability of firearms (see Volume I). A second finding is that, in all sites, in burglary and homicide cases, high reliance is associated with structural materials.

Offense	Site			All
	1	2	3	
Homicide				X
Rape				
Robbery				
Aggravated Assault			X	X
Burglary				
All Crimes		X	X	X

- Reliance on physical evidence - latent print search: In 2 of 3 sites, results indicate that in about half the cases, search for latents is made, and in about 2/3 of the cases, low reliance is cited by the investigator. Furthermore, these responses coincide generally; that is, moderate or high reliance is cited in cases in which no search for latents is made (or at least recorded). However, the validity of the finding is somewhat in doubt, because it is not known to what extent investigators considered latent prints as physical evidence in answering the question as to their reliance on physical evidence. The somewhat paradoxical result may also be explained by the fact that latent prints, as currently used as an investigative aid, are of little value unless a comparison with known suspect prints can be made. In site 1, investigators are indifferent in their assessment of reliance whether search for latents was made or not.

Offense	Site			All
	1	2	3	
Homicide		X		X
Rape		X	X	X
Robbery			X	X
Aggravated Assault		X	X	X
Burglary		X		
All Crimes		X	X	X

- Investigative outcome - first on scene: In almost all crimes and sites, first arrival by citizen and suspect charged were the most frequent joint occurrences. However, in burglary, at one site (not significantly) and over all sites, first arrival by official and suspect charged were most frequently coincident. This perhaps reflects a more immediate response time as a factor. Also, it is possible that some burglaries were ongoing upon arrival or that a stake-out was used.

Offense	Site			All
	1	2	3	
Homicide				
Rape				
Robbery			X	
Aggravated Assault			X	X
Burglary			X	X
All Crimes			X	X

- Investigative outcome - search of suspect: A general trend for all crimes and sites was found which associated, in most cases, search of suspect and suspect charged. Search of suspect, as used here, means a search beyond the usual frisking and emptying of pockets; for example, the search for trace materials in trouser cuffs. Included cases in among the no-search responses were which no suspect was in custody initially (and perhaps later), making search of the suspect impossible. This strengthens the results of the findings here. It appears that search of suspect may be regarded as a basic measure of thoroughness whenever a suspect is initially in custody.

Offense	Site			All
	1	2	3	
Homicide			X	X
Rape	X		X	X
Robbery	X		X	X
Aggravated Assault	X		X	X
Burglary	X	X	X	X
All Crimes	X	X	X	X

- Investigative outcome - standards collected: A fairly general trend was noted at two sites. With few exceptions, noted below, the most frequently occurring pair of responses was not standards taken and suspect charged. In the case of burglary, of interest was the finding that charge and standards occurred most frequently together in site 2, while in site 3, no standards and unresolved appeared together most frequently. This is taken to be support for the contention that (a) collection of standards is under-utilized as a goal of evidence collection, and (b) collection of standards is not encouraged by the laboratories, or (c) it can be used as an indicator of the quality of the search.

Offense	Site			All
	1	2	3	
Homicide			X	X
Rape			X	X
Robbery				
Aggravated Assault		X	X	X
Burglary		X	X	X
All Crimes		X	X	X

- Investigative outcome - latent print search: A trend was noted which established a moderate association between suspect charged and latent prints taken. This appears in Sites 2 and 3, with site 1 showing the opposite relation. It must be remembered, however, that site 1 includes agencies whose operations are not similar (Richmond's identification of latent prints standing out as a striking example of high match record - see Volume I).

Offense	Site			All
	1	2	3	
Homicide				
Rape	X		X	X
Robbery	X			
Aggravated Assault				
Burglary	X			X
All Crimes	X		X	X

7.7 Analysis - Investigation

The result of comparisons between the variables relative to analysis and investigation are indicated below:

	PE categories submitted/analyzed	Elapsed time	Number contacts with investigator	Lab requests	Report content
Use of Lab Results			X*		X
Reliance on PE	X		X	X	
Investigation Outcome	X	X*		X	X

- Use of lab results - report content: A fairly general trend was found relating "findings" and individualization. Report content was classified as "findings", "method", "interpretation" and "findings and methods". In site 1, "methods" was the most frequent response together with reconstruction of events and development of suspects. In site 2, findings and methods occurred with individualization, significantly in burglaries.

Offense	Site			All
	1	2	3	
Homicide	X			X
Rape	X			X
Robbery				
Aggravated Assault	X		X	X
Burglary		X		X
All Crimes	X	X	X	X

- Reliance on physical evidence - physical evidence categories submitted: A moderate association was found. The most frequently occurring pair of responses was low reliance and weapon-related evidence. In site 2, a moderate reliance was attached to physiological materials, due primarily to the large number of rape cases. In site 1 moderate to high reliance was attached to physiological materials in homicides.

Offense	Site			All
	1	2	3	
Homicide				X
Rape				
Robbery				X
Aggravated Assault			X	X
Burglary				
All Crimes			X	X

- Reliance on physical evidence - number contacts with investigator: A generally moderate positive correlation was noted in at least 2 sites for homicides, robberies, assaults and burglaries. To the extent that the detective's record and recall are accurate, this is interpreted to mean that the number of contacts between lab and investigator may be used as an objective measure of the investigator's reliance on physical evidence in a given case (or over cases).

Offense	Site			All
	1	2	3	
Homicide	X		X	X
Rape				
Robbery	X		X	X
Aggravated Assault		X	X	X
Burglary	X	X	X	X
All Crimes			X	

- Reliance on physical evidence - lab requests (evidence types):

A moderate association was found. In nearly all sites and crimes, a low reliance occurred most frequently with fingerprint material.

Offense	Site			All
	1	2	3	
Homicide				
Rape				X
Robbery				
Aggravated Assault			X	X
Burglary			X	
All Crimes			X	X

- Investigative outcome - physical evidence categories analyzed:

A slight association was found in assault cases at one site and over 3 sites. The most frequently occurring pair was suspect charged and weapon material. In site 2, the most frequently occurring pair (though not significant) was unresolved and physiological material. A basic difficulty here arose from generally small counts.

Offense	Site			All
	1	2	3	
Homicide				
Rape				
Robbery				
Aggravated Assault			X	X
Burglary				
All Crimes		X	X	X

- Investigative outcome - lab request (evidence types): The results in this case are nearly identical to those immediately preceding.

- Investigative outcome - report outcome: A minor significance was established with respect to assaults in one site and over all sites. The consistently recurring pair for crimes and sites was suspect charged and findings.

Offense	Site			All
	1	2	3	
Homicide				
Rape				
Robbery				
Aggravated Assault			X	X
Burglary				
All Crimes				

Notes

Use of lab results - number of contacts with investigators: A slight significance was found only for all sites and crimes taken together; the counts for joint responses were low. It is felt that the active role of the lab assisting the investigator might be determined if the investigator's needs as reflected by the number of contacts with the lab could be associated with the use to which lab results and consultation are put.

Investigative outcome - elapsed laboratory time: Timeliness of results, as measured by turnaround time, is thought to be an influence on the investigator's efficient handling of a case. Low data yield failed to show significance except over all cases; the most frequently occurring pair was suspect charged and turnaround time of 1-2 days. The exception was in site 1 (rape and burglaries - 5-6 days).

Section 8

CANDIDATE EFFECTIVENESS MEASURES

In this Section we present a list of candidate effectiveness measures. They are of two types, direct and indirect, as defined in Section 6.

The list of effectiveness measures, Figure 5, also includes performance measures, e.g. the ratio of analyses performed to evidence items collected. Such measures are indicators of performance that do not, of themselves, evaluate effectiveness. A change in their magnitude should, however, alert management to ascertain the underlying causes for the change, which may be related to effectiveness.

In the figure, the basis of each subsystem is indicated by A, O or P. "A" denotes statistical analysis of paired variables (Section 7); "O" denotes observation at the sites, in most instances supported by data reported in Volumes I and II; "P" stands for "potential", denoting that a data base for the measure has not been established, but data collection and test of the measure is recommended. In most of the "P" measures data collection would require active cooperation by the involved agencies, e.g. the number and type of communications between criminalist and investigator as recorded by the criminalist when he makes his laboratory report.

	EFFECTIVENESS MEASURE	BASIS			IMPORTANCE	PRACTICABILITY	
		A	O	P			
SEARCH	DIRECT	% SCENES SEARCHED		X		HIGH-BASIC	REQUIRES MERGING OF RECORDS OF OFFENSES AND SEARCH UNIT
		EVIDENCE TYPES COLLECTED/SEARCH	X			HIGH	REQUIRES LARGE DATA BASE (OVER LONG TIME OR MANY SITES)
		a) LATENT LIFTS/SEARCH	X			MCDERATE	EXISTS IN SEARCH UNIT RECORDS
		b) STANDARD TYPES/SEARCH	X			LOW-MODERATE	REQUIRES EXPANSION OF SEARCH UNIT RECORDS
		SUSPECT SEARCHED/SUSPECT INITIALLY IN CUSTODY	X			HIGH	MAY REQUIRE POLICY AND RECORD KEEPING CHANGES
	INDIRECT	CONDITION OF SCENE	X			LOW	REQUIRES MODIFICATION OF SEARCH UNIT REPORTS
		AVERAGE RESPONSE TIME		X	X	LOW	EXISTS IN SOME SEARCH UNIT RECORDS
		DURATION OF SEARCH	X	X		LOW-MODERATE	EXISTS IN SOME SEARCH UNIT RECORDS
		LATENTS OF VALUE/LATENTS LIFTED	X			MCDERATE-HIGH	REQUIRES MERGING OF LAB, SEARCH AND IDENTIFICATION UNIT RECORDS
	ANALYSIS	DIRECT	LAB REQUESTS, BY EVIDENCE TYPE & CRIME CATEGORY	X			HIGH-BASIC
		ELAPSED LABORATORY TIME	X	X		MCDERATE	EXISTS (CASE BY CASE) IN LABORATORY REPORTS
		ANALYSES PERFORMED, BY EVIDENCE TYPE	X			BASIC	REQUIRES REFINEMENT OF LAB RECORDS
		REPORT CONTENT	X			LOW	REQUIRES REFINEMENT OF LAB RECORDS
INDIRECT		SUBMISSIONS/COLLECTIONS	X			MCDERATE	REQUIRES MERGING OF SEARCH, LAB, AND PROPERTY ROOM RECORDS
		ANALYSES/SUBMISSIONS	X			LOW-MODERATE	REQUIRES REFINEMENT OF LAB RECORDS
		EVIDENCE CATEGORIES ANALYZED (RANKING)			X	MODERATE (LONG RANGE)	
		NUMBER CONTACTS WITH INVESTIGATOR			X	MODERATE-HIGH	REQUIRES REFINEMENT OF LAB RECORDS (SEE TEXT)
		% CASES, SCHEDULING NEEDS			X	LOW	
INVESTIGATION		DIRECT	% P.E. CASES RESOLVED/% ALL CASES RESOLVED	X			HIGH
		AVERAGE TIME ON CASE	X			LOW	REQUIRES EXPANSION OF SQUAD RECORDS
	INDIRECT	% CASES, SUSPECT INITIALLY IN CUSTODY	X		X	MODERATE-HIGH	EXISTS IN OFFENSE RECORDS
		% CASES, COMMUNICATION WITH LAB	X		X	HIGH	REQUIRES EXPANSION OF LAB RECORDS (SEE FURTHER DISCUSSION IN VOL. IV)
		% CASES ANALYSIS REQUESTED		X		HIGH	REQUIRES MERGING OF OFFENSE, SEARCH AND LAB RECORDS
		% CASES PRINT ID MADE		X	X	HIGH	EXISTS IN ID AND SQUAD RECORDS
		RELIANCE ON P.E.	X			HIGH	
		CONTRIBUTION OF P.E. TO OUTCOME	X			HIGH	DIFFICULT TO MEASURE - SUBJECTIVE
		DECISION TO INVESTIGATE	X			HIGH	
	ADJUDICATION	DIRECT	% GUILTY VERDICT P.E. CASES/% GUILTY VERDICT ALL CASES	X			HIGH
		GUILTY PLEAS: AS CHARGED/REDUCED CHARGE (P.E. CASES/ALL CASES)		X	X	HIGH	
		% GUILTY VERDICT (P.E. TESTIMONY CASES/ ALL P.E. CASES)	X			HIGH	
		% GUILTY VERDICT (DEMONSTRATIVE EVIDENCE/ALL P.E. CASES)	X			HIGH	
INDIRECT		% TRIALS P.E. USED IN COURT		X	X	HIGH	
		% TRIALS, DEMONSTRATIVE EVIDENCE		X	X	HIGH	
		STIPULATIONS + P.E. TESTIMONY/P.E. TRIALS		X	X	HIGH	
		STIPULATIONS/STIPULATIONS + P.E. TESTIMONY		X	X	HIGH	REQUIRES MAJOR RECORD KEEPING CHANGES PERMITTING FOLLOW-UP OF ALL CASES INVESTIGATED RESULTING IN FELONY CHARGE, AND SUBSEQUENT PROSECUTION.

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Figure 5 LIST OF EFFECTIVENESS MEASURES

The figure further lists the ranking of the candidate measures as to importance, the most relevant crimes, and the practicality of obtaining such measures. The measures selected must meet the following criteria:

- a) they must be readily measurable
- b) the direct measures must reflect overall performance or outcome of their respective subsystems, and
- c) the indirect measures must be composed of variables showing significant relationship with other measures, or variables related to other measures

The list, Figure 5, contains 35 candidate measures of effectiveness. The number of measures that will eventually be recommended for introduction as a matter of routine practice will be less. At this stage in the program, further culling, e.g. retention of only those measures having a high importance ranking, is not advisable for a number of reasons: The record-keeping requirements for implementation of the measures should first be reviewed by a number of criminalistics laboratories and user agencies. Also, some elimination of impractical measures will follow recommended limited application of the entire set at demonstration sites. Further, as elaborated in Volume IV of this report, it is recommended that introduction of certain formal record keeping practices be preceded by a series of inter-agency workshop seminars. Finally, full development of an effectiveness model explored in Section 9 below may modify the list of measures.

8.1 Search

DIRECT MEASURES

- Percentage of reported offenses in which search is made - A fundamental measure relating to the potential use that may be made of the lab. In one of the sites, no clear policy regarding the selection of scenes to be searched was noted, and in no site was there found an accurate record of this fraction. We believe that it is basic to determining allocation of effort and resources.
- Evidence collected (relative frequencies by crime category and evidence type) - The basic output of the evidence units' activity. While data were gathered on evidence types on a crime specific basis, the resulting counts were small. However, underrepresentation of transfer materials became apparent in all crimes.
 - a) Latent Print Collection per search has been found to be positively related to resolved investigations in that it makes identification by print matching possible. Although the latter practice has been found in need of improvement at all sites (with some exception in Dade County and Richmond), latent print collection measurement is recommended. Records should be crime-specific and, in keeping with our results, should record by search scene personnel (patrol, evidence unit and detective).

- b) Collection of standards (fraction of cases in which standards are taken) - viewed as an indicator of quality of search. A relation was found to exist with suspect in custody, distribution of lab requests, and investigative outcome.
- Cases suspect searched/cases suspect initially in custody - is recommended as a basic effectiveness measure, again indicating quality and thoroughness of search. The relation between search of suspect and investigative outcome is discussed in Section 7.6. Suspect in custody of course is in turn related directly to investigative outcome.

INDIRECT MEASURES

- Condition of scene (fraction of disturbed scenes) - an uncontrollable variable except perhaps through response time. It tends to explain variation in lab request made. Once consideration of scene condition in effectiveness measurement becomes a practice, some exercise of management control may be necessary so that the "disturbed scene" classification is not abused.
- Response time (average) - is important as it may affect condition of scene, and in turn be affected by number of scenes searched. A performance measure.
- Duration of search (average) - again, a performance measure. Has been found to be related to search scene personnel (generally), and, in different crimes, to time on case (investigation) and lab turn-around time.

- Latents of Value/Latents Lifted (per case) - a further measure of the potential use that can be made of latent prints. Together with latents collected per search discussed above, this measure may be used to indicate quality of latent search.

8.2

Analysis

DIRECT MEASURES

- Evidence items (types submitted) - relative frequencies by crime type and evidence category. This is a major tangible item relating search and analysis area. (Note should be taken that this measure addressed variety and quantity of evidence analyzed, not quality of analysis!)
- Evidence items analyzed (Relative frequencies by crime type and evidence category) - measures the primary output of the lab.
- Elapsed time in laboratory (average) - a measure chosen since it reflects performance and affects user satisfaction. It is included because over the course of the study frequent references were made by investigators to their reluctance to use the lab due to slow turnaround. Generally, statistical significance was not found relating elapsed time to the other variables examined. One important exception to this occurred in the case of homicides, in which elapsed time was found to be highly correlated with duration of search (long searches - short turnaround) indicating that priority treatment is given by both the search and lab areas and can be measured if the situation demands it. In cases of lesser importance, it is observed that a state of equilibrium appears to prevail between the investigator's needs and lab capabilities.

CONTINUED

1 OF 2

- Report content (findings, methods, interpretation) (Relative frequency) - is included to characterize and alternate form of communication with users. Mixed relationships were found, in different crime categories, with lab requests (evidence types), use of physical evidence, reliance on physical evidence, and contribution of physical evidence to investigative outcome. While listed here as a laboratory output measure, the measure also is an indirect one for outcome of investigation.

INDIRECT MEASURES

- Analysis requests/evidence items collected - by evidence type and offense category. This is derived from the direct measures (evidence items collected and analysis requests) above. It is included as a measure of performance, indicating the degree of selection taking place in the submission of request for analysis. (Tells how much evidence stays in property room.)
- Analysis performed/analyses requested - by evidence type and offense category. Again a performance measure, this measure indicates the further selection of evidence material after initial submission.

- Evidence categories analyzed/offense, ranking by crime type

No. Cases	Finger-prints 1	Physiol. Material 2	Physical Match 3	Weapons 4	Struc-tural Material 5	Trans-fer Material 6	Docu-ment 7	Chemi-cal Problems 8
Homicide	3	2	4	1		5		
Rape	3	1	4	2		5	6	7
Robbery	1	5	3	2	4			
Assault	2	4	3	1	5			
Burglary	2	6	1	4	3	5	7	

Ranking of evidence frequency by offense type to be used as a management tool for establishing areas of emphasis. Points out over and under-utilization of evidence types and corresponding analyses. For example, in Figure 23, Volume I, fingerprints (latents) are shown highly used in each of the first five crime categories. However, the contribution to investigation outcome noted in the data indicates low or no contribution, indicating that (a) either too much effort is being expended in the collection of prints, or more likely, (b) insufficient use is being made of lifted prints.

- Contacts between lab personnel and investigator (per case, and fraction of cases with contact) - is related generally to contribution of physical evidence and reliance on physical evidence, as assessed by the investigators.

- Cases with scheduling needs (percent) - it was possible to collect only very little data on this measure due to sketchy records regarding priority. However, on the basis of the analysis specific to homicide, and the turnaround time - duration of search interaction already noted, such a measurement of priorities is recommended.

8.3 Investigation

DIRECT

- Cases resolved (Fraction of resolutions in physical evidence cases/fraction of resolutions in all cases, by crime type) - generally recognized as a measure of effectiveness of investigation. Resolution as used here includes suspect charged, exceptional clearances, and cases determined to be non-criminal. Numerous relations were found to exist with other variables and resultant measures, as discussed in Section 7.
- Time on case - a gross measure of efficiency of the investigation effort. It has been found to be related (weakly) with suspect in custody and duration of search.

INDIRECT

- Cases suspect initially in custody (percent) - found to be related to (and judged to be partially responsible for) standards collection and charge filed in investigative outcome. It is felt that this is an important factor which must be accounted for in assessing the contribution of physical evidence.
- Cases contact with lab (percent) - an important objective measure indicating the extent of aid beyond analysis by the lab. This was found to relate with investigator's reliance on physical evidence and hence is seen as a replacement (although not a perfect one) for the more difficult subjective assessment of reliance on physical evidence. The relative frequencies of multiple contacts would also be useful, and could easily be generated by including on the lab final report a space for numbers of contacts.
- Cases analysis requested (percent) - a basic measure of utilization. It could be derived from measures already discussed above (percent cases searched, cases evidence collected/cases searched, requests for analysis/evidence collected, and analyses/requests).
- Cases, suspect identification/cases, latents of value - indicates the effectiveness of collecting latents.

- Cases, cold identification/cases, latents of value - shows the degree of capability of cold search when compared with the measure immediately above. The very low ratios reported in Figure 22, Volume I, document the need for improved criminalistics capability in this area.
- Reliance on physical evidence (distribution in cases involving physical evidence) - is included here because it was found to be a pivotal construct relating to many direct and indirect measures. It must be measured subjectively. For the purposes of assessing lab utilization, periodic measurement would be adequate, rather than collection on a case-by-case basis.
- Contribution of physical evidence to investigative outcome (distribution) - yields the perceived effectiveness of lab support. The same remarks apply as those immediately above.
- Contribution of lab evidence to decision to investigate (percent) - perceptual measure found to relate to use of physical evidence in a significant way. In order to employ this measure, it must be assumed that in cases in which the response is affirmative, investigation might not have taken place without evidence.*

* This measure was recommended by L. W. Bradford, PRC Company

8.4 Adjudication

Adjudication-related measures of criminalistics laboratory effectiveness may be applied wherever a case terminates or may terminate, at the grand jury hearing, at preliminary hearing, guilty pleas or dismissals between arraignment and trial, and trials.

DIRECT MEASURES

Fraction of guilty verdicts in trials involving physical evidence/ fraction of guilty verdicts in all trials. - This is a measure of the influence of physical evidence on the likelihood of guilty verdicts. The trend in the magnitude of the total fraction is of interest rather than absolute values; however, care must be taken that the number of trials involving physical evidence is large enough to warrant the comparison. Crimes or site specific trends could not be established in our statistical analysis, because the counts were too small. Further, adequate court records must be available if the measure is to be implemented.

Ratio of guilty pleas as charged/guilty plea to reduced charge in physical evidence cases to guilty pleas as charged/guilty pleas to reduced charge in all cases. This measures the impact of physical evidence on obtaining guilty pleas to the original rather than the reduced charge. This impact was found to be large in the one site in which data for the measurement was available (see Figure 14a, Volume II). While the counts were small, the trend was seen clearly for burglary, assault, robbery and rape. The physical evidence case fraction was from just under unity to more than unity, whereas the fraction for all cases was consistently less than 0.1. In the other two sites, data for all cases were not available, but the physical evidence case fraction showed trends similar to those at the first site. Verification of the trend through additional measurement and quantification through larger counts are advisable.

- Ratio of: Guilty verdicts in trials with physical evidence testimony/trials with physical evidence testimony to guilty verdicts in physical evidence cases/trials in physical evidence cases.
- Ratio of: guilty verdicts in trials with demonstrative physical evidence/trials with physical evidence testimony to guilty verdicts in physical evidence cases/trials in physical evidence cases. These are measures of the impact of physical evidence testimony and demonstrative evidence on guilty verdicts in physical evidence trials.

While a significant relation between physical evidence testimony at trial and outcome could be established, a stronger trend linking the use of demonstrative evidence and guilty verdicts was found, even though the counts were relatively low. It is suggested that both measures be further investigated with larger counts.

INDIRECT MEASURES

- Trials involving physical evidence testimony/trials involving physical evidence.
- Trials involving demonstrative physical evidence/trials involving physical evidence. These are measures of physical evidence utilization.

- Stipulations to physical evidence plus physical evidence testimony at trial/trials, physical evidence cases. This measures the utilization of physical evidence information at trial.
- Stipulations to physical evidence analysis/stipulations plus physical evidence testimony at trial. This measures the reputation of the laboratory. Data collected at the sites were insufficient to document the applicability of the measure, as can be seen from Figure 11, Volume II. Further investigation with larger counts is advocated.

Section 9
APPLICATION

In this section, application of the candidate effectiveness measures just discussed is treated in two respects:

- (1) a few of the measures are used, with pertinent site observations and data, to illustrate intra and inter-site effectiveness differences; and
- (2) an effectiveness equation is explored which will permit combination of measures of effectiveness without the need for arbitrary weighting factors.

9.1 Intra and Inter-Site Comparisons

- (a)
$$\frac{\text{Guilty Pleas: As Charged/to Reduced Charge, (Physical Evidence Cases)}}{\text{Guilty Pleas: As Charged/to Reduced Charge, (All Cases)}}$$

This measures the effect of physical evidence information in plea bargaining situations. The effect is "beneficial" if the magnitude of the ratio exceeds unity.

From Figure 14a, Volume II, the following crime-specific measurements can illustrate intra-site differences:

	Cases	Magnitude of Ratio
Homicide	$\frac{0}{9}$ $\frac{0}{8}$	-
Rape	$\frac{2}{3}$ $\frac{1}{8}$	5
Robbery	$\frac{6}{4}$ $\frac{0}{48}$	large
Aggravated Assault	$\frac{5}{7}$ $\frac{1}{21}$	15
Burglary	$\frac{13}{6}$ $\frac{6}{149}$	54

With the exception of homicide, the magnitude of the ratio is consistently much larger than unity. Because the case counts are low, the precision of measurement is also low and the listed magnitudes of the ratio for four crimes should not be compared numerically. The absence of pleas of guilty-as-charged to homicide with or without physical evidence renders the effectiveness measure inapplicable for this offense. The absence of these pleas may well be related to the gravity of the consequence which may tend to induce more active plea bargaining and a tendency to take the risk of going to trial if plea bargaining fails. The latter explanation is consistent with the data in Figure 14a, Volume II, which indicate a large proportion of trials in the observed homicide cases involving physical evidence.

A similar intra-site comparison at the other two sites and inter-site comparison for this effectiveness measure is not possible because detailed data on adjudicative disposition was not available.

(b) Suspect Identification, (Cases)
Latents of Value

The higher the magnitude of the ratio, the higher is the effectiveness of latents of value. From Figure 22, Volume I, the following measurements are possible.

	Cases	Magnitude of Ratio
Richmond	33/183	.18
Contra Costa Sheriff/Dept.	9/150	.06
Columbus	11/109	.10
Dade County PSD	30/234	.13

The first two rows in the tabulation permit an intra-site comparison, i.e. of two agencies at one site. The third and fourth row permits inter-site comparison.

As pointed out in Volume I, the absolute count of identifications is low in all sites. The inter-site variation of the magnitude of the ratio is as high as 3. In Volume I reasons for the disparity in effectiveness are discussed in terms of known differences in methods at the sites.

(c) Fraction of Investigative Resolutions in Physical Evidence

Cases/Fraction of Investigative Resolutions in all cases

The criminalistics laboratory is effective, if the magnitude of the above ratio exceeds unity. The data collected during the observation period at the three sites provide the following values for the numerator of the measure:

	Site		
	1	2	3
Homicide	.87	.84	.86
Rape	.75	.68	.78
Robbery	.69	.40	.65
Assault	.81	.82	.96
Burglary	.74	.92	.68

Using data from the 10% survey of investigations completed in 1972 at Sites 1 and 2 for offenses in which the counts were high, the following effectiveness measurements can be calculated:

	Site	
	1	2
Robbery	1	1.2
Burglary	4	2

The measurements for robbery indicate that for this offense the effectiveness of physical evidence examination in bringing about investigative resolution is higher in site 2 than in site 1; bearing in mind the fact that the counts are too low to attach full force to the findings, the result for site 1 indicates that physical evidence examination in robbery cases does not contribute to investigative resolution.

For burglary investigation, both sites indicate substantial effectiveness of physical evidence examination, site 1 being twice as effective as site 2. A closer look at the selection of physical evidence cases in burglary is advocated in evaluating this result. A selection bias in favor of cases in which a suspect is named or apprehended at the outset of investigation was noted in Volume I and in Section 10 of this volume. A method for studying the laboratory role is suggested which takes this bias into account.

9.2 An Effectiveness Equation

In this section we suggest uses that may be made of the effectiveness measures developed in Section 8 with the final goal being the establishment of guidelines that may be applied generally to enhance the effective and efficient utilization of criminalistics laboratory support. A stepwise process, which encompasses both this project and demonstration projects currently being planned, is viewed as a feasible means of meeting this goal. The key steps, illustrated in Figure 6, are discussed below.

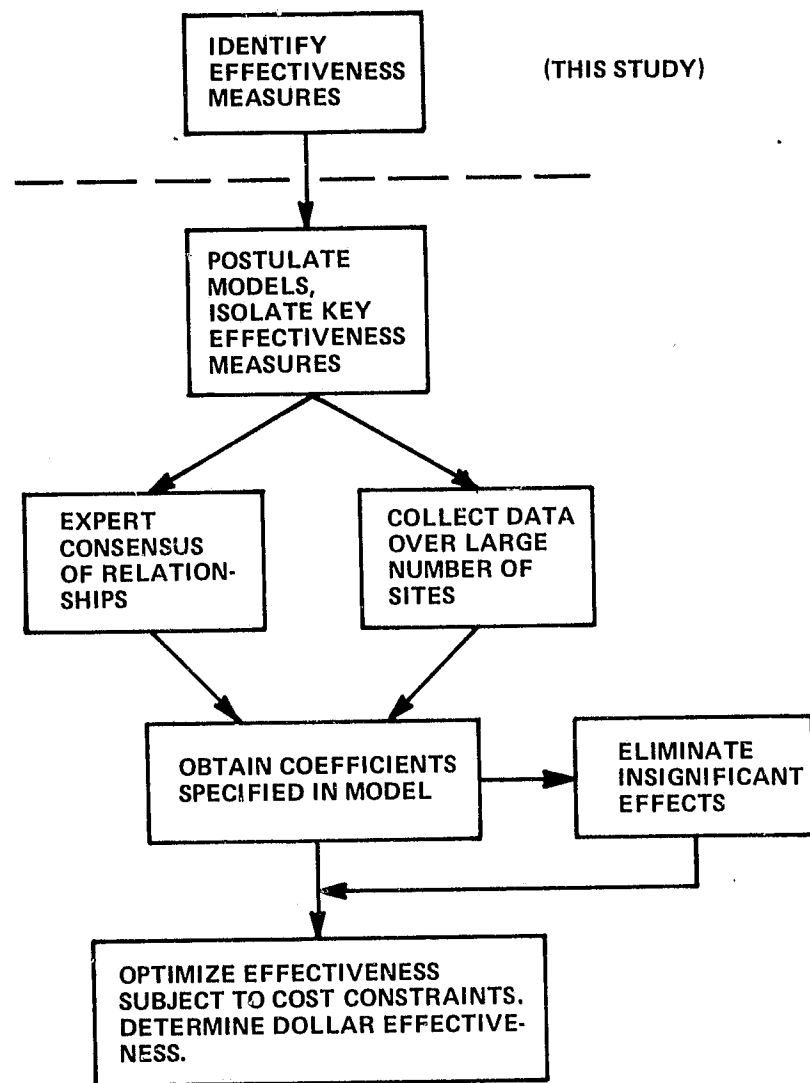


Figure 6 APPLICATION OF EFFECTIVENESS MEASURES

a. Postulate models for the effectiveness of the laboratory in terms of selected direct (outcome) and indirect measures. The model may take the form of a linear combination in terms of unknown coefficients. For example, with respect to effectiveness in the investigation of a given crime type (see Figure 5), we may assume the relation

$$e = \sum_{i=1}^4 a_i e_i$$

where e = % physical evidence cases resolved/% cases resolved

e_1 = % physical evidence cases, suspect initially in custody

e_2 = % physical evidence cases, communication with lab

e_3 = % physical evidence cases, analysis requested

e_4 = % physical evidence cases, print ID made

and a_1, \dots, a_4 are unknown coefficients. In particular, e_3 may be broken out as 8 individual knowns of the same form representing each of the 8 evidence categories used in the study. Additional terms from search and analysis sections may be included, such as: % cases, scheduling needs. Guidance for the selection of such variables is given in sections 7 and 8, and Appendix D. If the values of a_1, \dots, a_4 were known, a given agency would have at its disposal a tool for identifying weaknesses in its operation, and for giving emphasis to such areas that would be productive, in the sense already defined, that is, in increasing the effectiveness (e in the above example). Use of this tool would at the least require that the agency in question measure, or estimate, the existing values of e_1, \dots, e_4 over a sufficient period of time.

b. Determine the values of the unknown coefficients a_1, \dots, a_4 (continuing the example in part a.). Initially, planners may wish to prescribe a set of weights that would reflect a consensus among experts as to the relative effects and relationships inherent in such functional representations.

An alternative not requiring subjective weighing calls for collection of data over a large number of agencies, each yielding the quantities to be measured (e and e_1, \dots, e_4). Statistical techniques may then be employed, such as linear regression analysis, to estimate the unknown coefficients a_1, \dots, a_4 , and to eliminate the insignificant ones (and the corresponding e_i from the effectiveness equation). The resulting effectiveness equation could then be used as a model for a given agency to use, as described above in a.

The necessity for obtaining these observations (e, e_1, \dots, e_4) over a large number of sites is seen from the fact that the measures given in Section 8 are: 1) slowly generated, and 2) relatively static (within a given site). That is, there is little in the measures that can fluctuate over a short period of observation, say a month; rather, they were chosen to reflect the state of the system under its own particular conditions of equilibrium. This multi-site data collection and measurement procedure could also be used to eventually establish norms for laboratory effectiveness.

c. Implement the results of a and b at any interested agency. The applications range from identifying the weakest area in the agency's operations to finding the optimum allocation of emphasis and resources under constraints of budgetary and personnel limitations.

Section 10

AN INVESTIGATION-CENTERED MODEL OF CRIMINALISTICS

In this section we explore a model which, we believe, can become a tool for improving physical evidence utilization in investigation. In Volume I we reported as a general observation that criminalistics aid is infrequently used in those cases in which there is not a suspect named or apprehended at the beginning of investigation. By defining criminalistics aid in investigation in three distinct roles--of which the above is one--the model will permit assessment and stimulation of criminalistics effectiveness in each role. The roles are:

- A. Determination at the preliminary investigation stage whether or not a criminal offense was probably committed. Most drug and alcohol offenses require the lab's services in this capacity. Questionable deaths, though primarily the coroner's concern, may call for lab activity in this role.

- B. Support of investigation in developing clues, suspects, and reconstruction of events in the effort to identify a suspect. It is in this role that the criminalist has potentially the most to offer and his services are least utilized. Critical examination of evidence and careful interpretation of results may suggest new approaches to the investigator in a particular crime that otherwise would go unnoticed. The criminalist is in a unique position to apply the range of technical methods at his disposal to the discovery of information hidden in physical evidence. Ideally, the investigator requesting service would be familiar with criminalistics practices and methods, and the criminalist would have investigative experience over a range of crime categories.
- C. Corroboration of case against suspect with supportive analytical results. This role appears to dominate the scope of the criminalist's activities. Typically, a case involving physical evidence is one in which physical evidence and the possible information to be derived from its analysis is apparent from the outset of the investigation. The role is generally passive in that what the criminalist does in analysis is limited by what the investigator believes to be of potential value.

We propose the following effectiveness measure (μ) and apply it to each of the roles A, B, and C.

Definition: The effectiveness measure (μ) of the physical evidence of interest (pe^*) on the outcome of type x (o_x) is given by $\mu(o_x/pe^*) =$ fraction of cases with property pe^* that result in outcome o_x divided by the fraction of all cases that result in outcome o_x .¹

As defined, μ may take values between zero and infinity. Values less than 1 indicate a detrimental effect of pe^* ; values ≈ 1 indicate no effect; values greater than 1 indicate a positive effect. Figure 7 illustrates the sequence of events and the various stages in the course of investigating a typical crime. The model is resolution-oriented. The roles A, B, and C discussed above are shown by the three circled areas in the figure.

The effectiveness measure μ is applied in the following way:

- A. o_x - determination that a reported offense is unfounded.
 pe^* - lab analysis for purpose of verifying or ascertaining criminal offense.
- B. o_x - identification of a suspect.
 pe^* - lab analysis for purpose of narrowing class of suspects.

¹ This formalization may be recognized as a generalization of effectiveness measures recommended for investigative and adjudicative outcomes, see Figure 5.

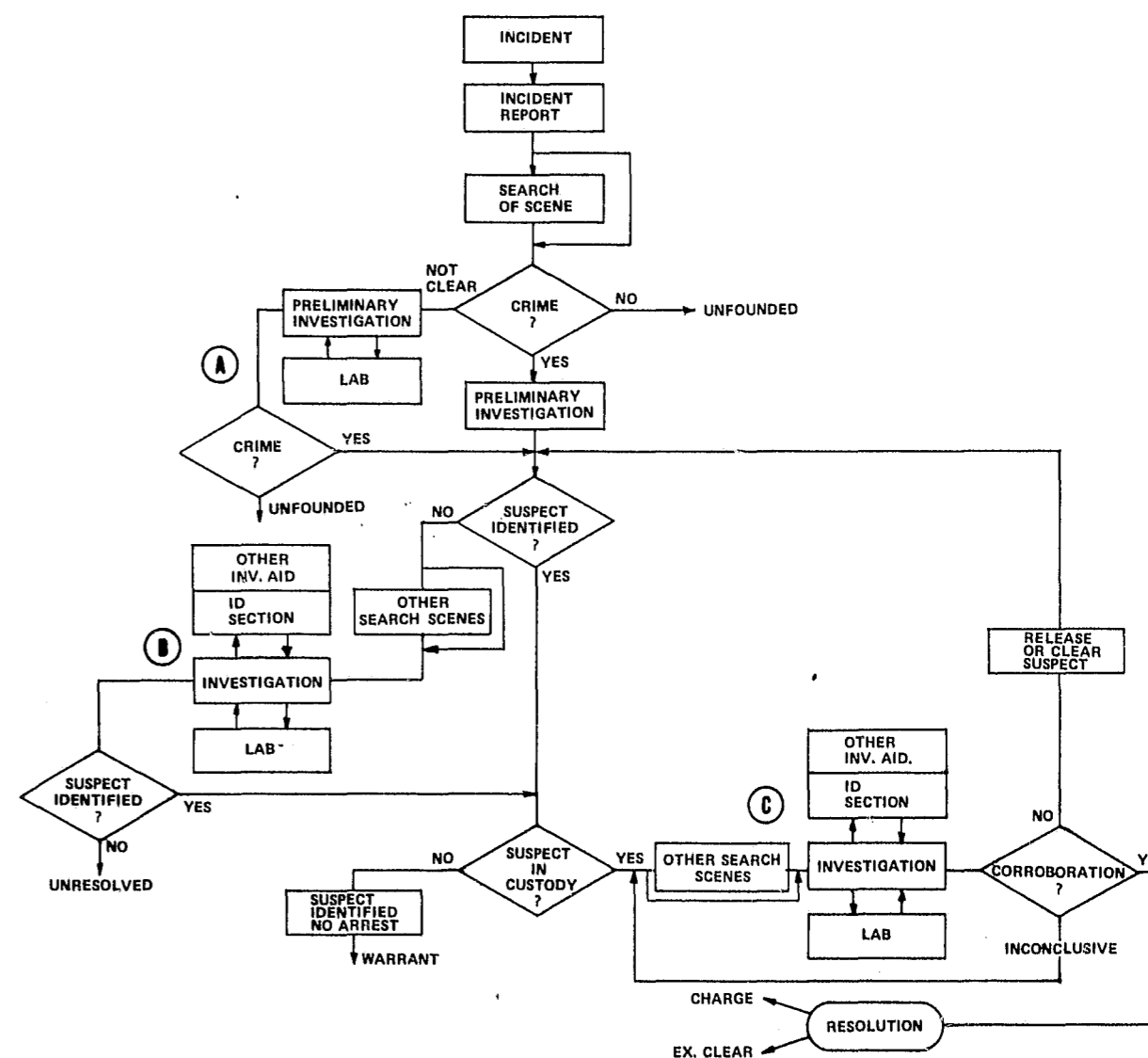


Figure 7 INVESTIGATION CENTERED MODEL

C. o_x - corroboration or refutation of other evidence linking suspect under consideration to crime.

pe^* - lab analysis for purpose of linking suspect to crime.

As an illustration, consider role A, the determination whether the offense is founded or not. In particular, let the outcome o_x be the finding that the offense is unfounded. Let the lab contribution pe^* be simply the lab analysis. Then from data collected, Volume I, Table 10, and for the observed lab cases, we obtain the following results over all crimes.

	Contra Costa	Columbus
$\mu =$	$\frac{3/40}{13/323} = 1.86$	$\frac{1/29}{4/318} = 2.74$

where μ = fraction of unfounded physical evidence cases divided by fraction of unfounded cases.

The results indicate that lab analysis contributes to the identification of unfounded reported offenses. This calculation involves small counts, however, and should not be used at this stage for comparing the effectiveness of the two sites.

Section 11
SUMMARY OF FINDINGS

With the aid of four questionnaires (Appendix A) data have been obtained on the use of physical evidence information at three sites over 8-month periods. A total of 879 felony cases, in nine offense categories, have been investigated and form the basis of our findings.

Data collection has served a dual purpose: to provide information on the use of physical evidence information as presently practiced in three sites and to serve as a vehicle for formulation and validation for measures of criminalistics laboratory effectiveness. Findings on effectiveness as developed in this Volume are summarized in Section 11.1. Findings related to the use of physical evidence information have been reported and summarized in Volumes I and II; in Section 11.2, Applications, we will report results obtained by applying our data to candidate measures of effectiveness. General conclusions will follow in Section 11.3.

11.1 Effectiveness Measures

A definition of criminalistics laboratory effectiveness has been employed which emphasizes the frequency and value of the use to which its information is ultimately put. This "use" is contribution to resolution of felony investigation and/or to the termination of an adjudicatory proceeding resulting from that investigation, although important intermediate uses are included, e.g., testing an investigator's hypothesis. The definition fits the purpose for which the effectiveness measures were developed, which is to serve as an evaluation tool for (a) laboratory managers and administrators and (b) planners at various government levels. The definition is deliberately narrow in that it does not encompass measurement of deterrent effects that may result from, say, speedier and more frequent resolution of investigations. Nor does it explicitly include "quality of justice" although the frequency of criminalistics laboratory service to defense attorneys would be entirely admissible as a measure of effectiveness under the definition adopted in Section 4.

Direct and indirect effectiveness measures have been developed; the former are directly related with an outcome, such as a resolved investigation; the latter are linked to outcomes via one or more system variables. Some of the indirect measures are performance measures, e.g., frequency of stipulations to physical evidence analysis at trial; a change in their magnitude will alert management to look for underlying causes, which may or may not be related to controllable variables. For instance, the frequency of such stipulations may decrease because the reputation of the criminalistics laboratory has suffered, or because attorneys not familiar with some of the laboratory analyses have appeared.

Most of the effectiveness measures have been formulated on the basis of statistical analysis of the data collected on sites. The responses to our questions (variables) were compared pair-wise, the significance of any associations between pairs was calculated and, if the significance could be explained in terms of a plausible trend by subsequent subjective review, a measure of effectiveness was formulated. Other measures are based directly on the field observations. A third set of measures is based on potential observations, i.e., a gap in data base was observed and it was concluded that such data should be recorded by laboratories or user agencies. An example of a recommended potential measure is the number of contacts between criminalist and investigator, whose record would indicate the intensity of laboratory involvement and would serve as a stimulus to desirable collaboration.

In Figure 5, a total of 35 candidate measures of effectiveness have been listed. They are grouped according to their pertinence to the four stages of the criminal justice system that have been recognized throughout this study: search, analysis, investigation and adjudication. In the following paragraphs, measures for each stage are highlighted.

Effectiveness measures for the search stage are included because (1) the collection of physical evidence at a crime scene is a criminalistics operation and (2) this operation largely determines the type, quantity and quality of physical evidence that enters the criminalistics laboratory thereby governing its effectiveness. An example of a basic search measure of effectiveness is the percentage of crime scenes searched; this measure was selected on the basis of field observation. The number of suspect searches/suspects initially in custody was selected as a measure because data analysis indicated a significant relation. It is expected to serve as an indicator of quality and thoroughness of search.

In the analysis stage, classification of laboratory service requests by evidence type and crime category is recommended as the most basic measure. It will be useful in conjunction with measures related to investigative resolution and adjudication, below. High quantity of an evidence type will not by itself enhance effectiveness. Implementation of the measure requires long periods of observation in order to capture enough data on crimes infrequently involving the laboratory, e.g., arson. The number of contacts between criminalist and investigator has already been noted as a potential, high-interest, measure of laboratory effectiveness.

The percentage of resolved investigations with physical evidence examination/all resolved investigations is suggested as the most basic measure of effectiveness in investigation. The criminalistics contribution to investigative outcome has been found to yield the effectiveness of the laboratory as perceived by its users. The measure was selected as a candidate although it is subjective and difficult to implement, because increased utilization of criminalistics must in large part come from user satisfaction, which is what is measured.

The adjudication stage measures differ from the investigation measures in that a single global measure, analogous to percentage of investigations resolved, cannot be defined. Here, the measures are applied to each adjudication substage at which a case may terminate and the measurement determines whether physical evidence information contributed to its termination. These measures are devised so as not to be prosecution-oriented. For instance, the percentage of guilty verdicts in trials involving physical evidence examination is compared with the percentage of guilty verdicts in all trials. (If the prospect of getting large enough counts were high enough, a similar measure could determine criminalistics contribution to acquittals in trials.) A performance-type measure in the adjudication stage, the number of stipulations/stipulations plus physical evidence testimony cases, determines the frequency of stipulation in instances where it might be applicable, because the case went to trial.

A caveat concerning the need to look for causes in interpreting the last-named measure above was given earlier in this discussion. A more general rule also must be pointed out. Measures of effectiveness must be used in some combination. Only the percentage of cases resolved in investigation measure can make any claim to large scope; it too is incomplete in that it does not consider adjudication or detailed information that will guide management and planners in improving criminalistics laboratory effectiveness.

Section 9.2 of the volume addresses the problem of combining individual measures of effectiveness in an effectiveness equation. Steps leading to implementation of such an equation are suggested: A process of isolation of key effectiveness measures at the project sites, subsequent collection of data at a large number of sites enabling the calculation of weights for each measure of effectiveness on an objective, statistical basis. The discussion in Section 9.2 further points out the potential for optimizing effectiveness that is provided by the suggested method.

A complementary approach using key areas in which criminalistics effectiveness can be improved is suggested in Section 10 through an investigation-centered model of criminalistics. The model isolates an area of under-utilization of the laboratory that has been noted at each of the sites: criminalistics aid in cases in which a suspect is not named (or in custody) at the beginning of the investigation. Two other criminalistics aids to investigation identified in the model are: determination whether a crime has been committed or not, and aid in linking a named suspect to a crime. Effectiveness measures can be applied using such a model as a guide through data such as those gathered in this study. Some modification of the data base is required to insure measurement of the allocation of the criminalist aid to the category in which it was rendered.

11.2 Application

With the aid of the data collected, the application of three candidate measures of effectiveness to determination of intra- and inter-site differences has been demonstrated.

At one site, the ratio between physical evidence cases and all cases of guilty pleas as charged/reduced charges could be measured. For rape, robbery, assault and burglary, the ratio substantially exceeds unity, indicating that in the presence of physical evidence information there is a lower incidence of charge reduction (plea bargaining). The result appeared inapplicable to homicide, and plausible reasons therefor are cited in Section 9.1.

Application of the ratio of suspect identification to cases in which latent fingerprint of value were found is demonstrated with data collected at four agencies in three sites. Two agencies are located in one site, permitting an intra-site comparison, that indicates drastic differences in effectiveness. These differences and inter-site differences for the same measure were found explainable in terms of local practice in Volume I. In the same discussion, low effectiveness in this area, i.e., low magnitude of the above ratio, at all three sites is pointed out.

Application of the measure, fraction of investigative resolutions in physical evidence cases/fraction of investigative resolutions in all cases is demonstrated for robbery and burglary in two sites. The ratio indicates effectiveness if it is larger than unity. Higher effectiveness was indicated for burglary than for robbery, in which one site measured only unity, the other 1.2. However, the case counts were low, so that no significance could be attached to small numerical differences.

11.3 General Conclusions

A number of conclusions that have been drawn earlier in this discussion may need general emphasis:

1. The measures of effectiveness suggested herein constitute a first cut at such measurement. Extensive review and selection through practice must follow. The collected data pointed the way to the measures, and areas in which data were expected at the site provided potential measures. Data from other sites will suggest additional measures.
2. While statistical methods have been used to spot potential measures of effectiveness, care has been taken to search for plausible interpretation before recommending a measure. This practice should carry over into application of the candidate measures. Disparities in local practice should be looked for before accepting the rating. Pitfalls such as the peculiarities of rape investigation at one site and the frequent firearms operability tests at another have been pointed out.

3. A number of the effectiveness measures suggested require data from several agencies not under the same administrative management. Therein will lie a difficulty in implementation. (Problems caused by the separate administrative organizations of criminalistics operations and their uses go much further, as will be discussed in Volume IV.)
4. Much emphasis has been placed in Volumes I and II on the need for improved education of users in the potential of criminalistics and of criminalists in the needs of the users; and on the need for improved communication among criminalists and users. While communication has even been included as a detailed measureable, we assert that this issue, coupled with low reliance on criminalistics, pervades and dominates the finding (and premise) that criminalistics is underutilized. Improvements in this area will have only long range effects and remedial action should proceed without waiting for application of the measures of effectiveness reported here.

Section 12

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4. J. L. Peterson, "The Perception, Control and Utilization of Criminalistics Services by the Police: An Analysis of the Physical Evidence Collection Process", Ph.D. Thesis, University of California, Berkeley, 1970.
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Appendix A

THE QUESTIONNAIRES

This Appendix contains a reproduction of the four questionnaires that were the data collection instruments at the three sites: I - Search, II - Lab Input/Output, III - Investigation, and IV - Adjudication. Annotation follows, as needed, referencing the annotated questions by I-1, I-2, etc.

FORM I - SEARCH

Report No. _____

Crime type _____ Date of this report _____

Date & time of crime _____ am
 pm First _____ Supplementary _____
 (estimate if necessary)

Date & time of offense report _____ am
 pm Source of Information _____

Date & time search started _____ am
 pm

Description of case:

Description of scene:

1. Search Scene

Searcher	Agency	Time Arrived*	Time Departed
patrol _____	_____	_____	_____
detective _____	_____	_____	_____
evidence squad _____	_____	_____	_____
mobile unit _____	_____	_____	_____
other (specify) _____	_____	_____	_____

*(give date if different from above)

2. Purpose of Search: search for suspects _____, inventory of stolen goods _____, physical evidence _____, other _____.

3. Other Search Scenes
 suspects' home _____, vehicle _____, alibi area _____,
 other _____, none _____

4. First on scene: private citizen _____, official (specify) _____

5. Condition of scene when searched: undisturbed _____, disturbed _____,
 If disturbed, by: investigators _____, lay _____.

6. Duration of search (hours) _____.

7. Scene searched for latent prints? yes _____, no _____.
 If not, reason: not applicable _____, not needed for evidence _____,
 insufficient time _____, case considered minor _____, other _____

8. Physical evidence collected

Item	Number
_____	_____
_____	_____
_____	_____

9. Physical evidence standards collected? yes _____, no _____

<u>Item</u>	<u>Reasons/Remarks*</u>
_____	_____
_____	_____
_____	_____

*relating to victim, suspect, scene, etc.

10. Graphics made? yes _____, no _____.

	<u>Photo</u>	<u>Scale Photo</u>	<u>Sketch</u>	<u>Impressions</u>
scene	_____	_____	_____	_____
tires	_____	_____	_____	_____
shoes	_____	_____	_____	_____
other (specify)	_____	_____	_____	_____

11. Other Services Requested*

	<u>Requestor</u>
medical examiner _____	_____
pathologist _____	_____
toxicologist _____	_____
other _____	_____

*other than crime lab and latent print identification

12. Request for lab analysis

<u>Item</u>	<u>Requestor (title/Agency)</u>
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

13. Was evidence taken to identify victim? yes ____, no ____

List: _____

14. Major cases involving victims

Were following performed? (check)

- a. protect scene: rope off _____ seal _____ guard _____ other _____
- b. photos _____, scale photos _____, sketches _____, impressions _____
- c. measurements around victim _____
- d. outline body _____
- e. collect victims' clothing _____
- f. bag victims' hand _____
- g. collect victims' hair, nail scrapings, etc. _____
- h. vacuum area _____
- i. field notes _____

FORM II - LAB INPUT/OUTPUT

Lab case no. _____ Observer _____
 Offense report no. _____ Date this report _____
 Date & time of request receipt _____^{am} First _____ Supplementary _____
 Investigator _____ Source of information _____
 Agency requesting service _____ Crime type _____

1. Purpose of request: determine if crime was committed _____?

Clues _____, reconstruction of events _____, development of suspects _____, other _____

2. Direct communication with lab (beyond request for analysis)

	at submission of request	during examination	after examination
in person conference	_____	_____	_____
telephone conversation	_____	_____	_____
copy of crime scene search report	_____	_____	_____
other (specify)	_____	_____	_____

3. Requestor state time requirement? high priority _____, time or date of report _____, none _____.

4. Physical evidence

Items collected	Submitted for Analysis	Analyzed	Identification made	Remarks*	Condition**
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

*of those items not analyzed, give reasons: 1. not enough time, 2. judgement as to relevance, 3. judgement as to importance, 4. directed by detective or prosecutor, 5. equipment limitations, 6. training limitations, 7. other (specify)

** fit/unfit for analysis (F/U), if non-usable, was this avoidable/unavoidable (A/U)

5. Screening tests performed immediately and reported by lab? yes ____, no ____

6. First report made to: _____

7. Time from request to first report: (days/hrs.) _____
 (may be verbal, telephone, form, etc.)

8. Number of requests to lab: several submitted together _____,
 items submitted at different times _____, items re-submitted _____.

9. Requests by other parties

	Report	Analysis
prosecutor	_____	_____
defense	_____	_____
other	_____	_____
none	_____	_____

FORM III - INVESTIGATION

Date of this report _____

First _____ Supplementary _____

Observer _____

Crime Type _____

Laboratory Case No. _____

Offense Report No. _____

Court Case No. _____

Date & Time Begun _____ am
pm

Date Ended _____ am
pm

Name and Title of Investigator _____

1. Screening test required to hold or release suspect? yes ___ no ___

2. Suspect in custody? yes _____ no _____

3. Search of suspect performed? yes ___ no ___

4. Standards taken? yes ___ no ___

5. Reliance on physical evidence examination by investigator (this case):

low _____ moderate _____ high _____

6. Crime lab informed of scheduling needs? yes _____ no _____

If yes, did lab meet them? yes _____ no _____

7. Number of contacts with lab by investigator and time spent on case (to date):

<u>Investigator</u>	<u>Contacts</u>	<u>Time spent on case</u>
_____	_____	_____
_____	_____	_____
_____	_____	_____

10. Report content: findings _____, analytical method _____, interpretation _____, print identification _____.

11. Court appearances: _____

12. Postponements (continuances affecting lab schedule): _____

8. Use of lab results in determining: Clues _____, reconstruction of events _____, development of suspects _____, individualization _____, others _____.

9. Outcome of investigation: unresolved _____, suspect identified but not charged _____, suspect apprehended _____, suspect charged _____, suspect released _____, exceptionally cleared _____, not a criminal offense _____.

10. Contribution to outcome of investigation by: physical evidence _____; lab analysis _____. (1. decisive, 2. significant, 3. minor, 4. none)

11. If other crimes cleared by this investigation, did physical evidence play a role? yes _____ no _____.

12. Physical evidence other than crime lab results used in case?

<u>Item</u>	<u>Source</u>	<u>Remarks*</u>
_____	_____	_____
_____	_____	_____
_____	_____	_____

* Influence on outcome of case: 1. suspect identified but not charged, 2. suspect apprehended, 3. suspect charged, 4. suspect released, 5. other crimes solved, 6. other (specify).

13. Lab results differing from expectations, by way of supporting or refuting hypothesis of case? yes _____ no _____.

14. New hypothesis result? yes _____ no _____.

15. New clues offered? yes _____ no _____.

16. Results of analysis adequate for purposes of investigator? yes _____ no _____.

17. Level of detail in lab report adequate? yes _____ no _____ 3

Prosecutor:

18. Evidence items available.

<u>Item</u>	<u>Analyzed by lab</u>	<u>Importance*</u>	<u>Use of Report**</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

* High, moderate, low, cannot determine.

**1. warrant, 2. arrest, 3. arraignment, 4. release, 5. other (specify)

19. Were results timely? yes _____, no _____.

20. Prosecutor conference with lab personnel? yes _____, no _____.

21. Lab methods used elsewhere more valuable (with respect to requirements of this case)? yes _____, no _____. If yes, specify method _____.

22. Hypothesis of case confirmed by results of lab analysis? yes _____, no _____.

23. Was laboratory evidence used to decide whether:

	<u>yes</u>	<u>no</u>
a. to conduct detective investigation, or not	_____	_____
b. to file formal charges or request complaint from prosecutor, or not	_____	_____
c. prosecutor asks for further laboratory work prior to complaint issuance, preliminary hearing, or grand jury presentation	_____	_____
d. prosecutor proceeds with trial or plea bargain	_____	_____

FORM IV - ADJUDICATION

Date of this report _____
First _____ Follow-up _____
Source _____

Laboratory Case No. _____
Offense Report No. _____
Court Case No. _____
Crime Type _____
Date of Crime _____
Date of Preliminary Hearing
or Indictment _____
Date of Arraignment _____
Date of Trial: Start _____ end _____

1. Initial charge(s): _____
2. Initial charge increased/reduced? yes _____ no _____ date _____
If yes, at what stage? pre-trial hearing _____, grand jury _____,
arraignment _____, trial _____.
3. At what stage did case end? pre-trial hearing _____, grand jury _____,
arraignment _____, between arraignment and trial _____, trial _____
4. Disposition: _____
5. Was physical evidence used in court? yes ___ no _____
6. Was physical evidence used as demonstrative evidence? yes _____, no _____.
If yes, list items: _____
7. Lab witness cross-examined? yes _____, no _____.
8. Witness called to challenge: physical evidence _____, or lab witness _____?
9. Number of stipulated items (conclusions of lab examination) _____

FORM IV - ADJUDICATION

Date of this report _____
First _____ Follow-up _____
Source _____

Prosecutor:

10. Reduced charge a result of plea-bargaining? yes _____ no _____
not applicable _____.
If yes, within courtroom _____, outside courtroom _____.
11. Physical evidence (e.g., firearms, prints, demonstrative evidence)
necessary in court? yes _____ no _____; corroborative? yes _____ no _____.
12. Purpose of presenting physical evidence.
a. To describe crime scene _____
b. To link suspect and offense: directly _____ indirectly _____.
c. To reconstruct crime _____
13. Date lab witness notified of court appearance _____
14. Number of postponements _____
15. Prosecutor confer with lab witness of manner of presentation? yes ___ no _____
16. Defense aware of analysis before trial? yes ___ no _____.
If yes, when _____. How _____
17. Guilty plea induced as a result of laboratory evidence (w/o witness
appearance)?
yes _____ no _____.

FORM IV - ADJUDICATION

Date of this report _____

First _____ Follow-up _____

Source _____

18. Role of physical evidence in pre-trial phase.

	<u>Stage Used</u>	<u>Analyzed by</u>	<u>Remarks*</u>
Preliminary hearing	_____	_____	_____
Grand jury	_____	_____	_____

*Physical evidence used in support of: 1. dropping of charge, 2. pressing of charge, 3. plea-bargaining, 4. court appearance of lab witness.

19. Did lab examination contribute to:

- a. Support or refutation of witnesses _____
- b. Establishment of proof: with _____ (without _____) other supporting _____
- c. other _____

FORM IV - ADJUDICATION

Date of this report _____

First _____ Follow-up _____

Source _____

Defense:

20. Reduced charge a result of plea-bargaining? yes _____, no _____, not applicable _____.
If yes, within courtroom _____, outside courtroom _____.

21. Purpose of presenting physical evidence.
a. To describe crime scene _____
b. To link suspect and offense: directly _____, indirectly _____.

22. Defense present physical evidence? yes _____, no _____

23. Purpose of challenging prosecutor's physical evidence.

24. Defense aware of analysis before trial? yes _____, no _____
If yes, when _____

25. Guilty plea induced as result of laboratory evidence? yes _____, no _____

FORM IV - ADJUDICATION

Date of this report _____

First _____ Follow-up _____

Source _____

Docket no. _____

Defendant's name _____

Jury Foreman:

26. What was influence of physical evidence on verdict?
decisive _____, substantial _____, contributory _____,
minor _____, none _____.

27. Did jury review physical evidence in jury room?
yes _____, no _____.

28. Did the jury understand the point made by lab witness? yes _____
somewhat _____ no _____.

29. Comments:

FORM IV - ADJUDICATION

Date of this report _____

First _____ Follow-up _____

Source _____

Judge:

The following points will be raised in a relatively unstructured interview with the presiding judge.

30. Necessity of physical evidence

31. Purpose of presenting physical evidence

32. Guilty plea induced as result of laboratory evidence

33. Influence of physical evidence on verdict

34. Was expert witness testimony well presented

35. Contribution of lab service

ANNOTATION

- I-5 The second part of the question, "If disturbed....." was not used.
- I-7 The second part of this question, "If not,....." also was not used. Much of the information on latent print search in this and the previous two volumes was recorded on a separate Form V, devoted exclusively to latent-print questions.
- I-8 Physical evidence categories are:
1. Finger and Palm Prints
 2. Physiological Material (Tissue, Blood, Hair, Fecal Matter)
 3. Physical Match Problems (Tools, Tool Marks, Foot Impressions, Broken Glass, Fabrics)
 4. Weapons (Firearms, Ammunition, Shooting Residue, incl. Clothing, Knives)
 5. Structural Materials (Safe Insulation, Glass, Wood, Paint)
 6. Transfer Materials (Dust, Soil, Plants, Fibers, Grease)
 7. Document Materials (Documents, Exemplars, Ink, Paper)
 8. Chemical Problems (Drugs, Alcohol, Toxic Materials, Petroleum)
- I-9 Physical evidence standard categories were: Fingerprints, Physiological materials and other materials.
- II-4 "Identification Made" was used to aggregate results listed in Volume I. The information obtained by the (categorical) question does not permit effectiveness conclusions and was not used for that purpose.

- II-5 Screening tests are defined in the Glossary, Section 14, Volume I.
- II-11 These questions were not used.
- II-12
- III-2 Meaning: "Was a suspect in custody at the beginning of investigation?"
- III-3 Refers to the suspect in the preceding question.
- III-4 Physical evidence standards, as listed in I-9.
- III-5 This question refers to the reliance of the investigator when assigned to the case after he knows what physical evidence was collected at the scene.
- III-7 "Time spent on Case" - estimated hours spent on case, not the time elapsed between assignment and report.
- III-9 "Suspect identified but not charged" and "exceptionally cleared" replies were merged in subsequent analysis

- III-13 through I-17 Difficulty was experienced in obtaining understanding of the sense of the questions, hence replies were few and of doubtful validity.
- IV-4 Dispositions: 1. No Bill
2. Guilty Plea, as charged
3. Guilty Plea, reduced charge
4. Guilty, Jury Trial
5. Acquittal, Jury Trial
6. Guilty, Bench Trial
7. Acquittal, Bench Trial
8. Dismissal by Judge
9. Nolle Prosequi
- IV-5 Meaning: as testimony or by stipulation
- IV-7 Question not used
- IV-1 through IV-9 These questions completed by observer from record.
- IV-10 Second part of question, "If yes ...", not used
- IV-26 to 29 Jury questionnaire; used only with court permission; defendants name used only for case identification.

Appendix B

TESTS FOR ASSOCIATION BETWEEN VARIABLES

We present here the formulae used in the analysis to establish relationships between pairs of variables listed on Forms I-IV. At the end of this section is given a derivation of the χ^2 statistic used where one of the variables may produce multiple responses for a given case.

1. Calculations

- a. Means, standard deviations, and correlation coefficients.

Let $(x_i, y_i), i=1, \dots, n$ be responses to two separate questions for n cases. The means are

$$\bar{X} = \sum_{i=1}^n x_i, \quad \bar{Y} = \sum_{j=1}^n y_j ;$$

The standard deviations are

$$s_x = \sqrt{\sum_{i=1}^n (x_i - \bar{x})^2 / n-1}, \quad s_y = \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2 / n-1}$$

and the correlation coefficient is

$$r_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y}) / n-1}{s_x s_y}$$

- b. Let two variables (questions on Forms I-IV) A and B have I and J possible mutually exclusive responses of a qualitative nature. Let $N_{ij}, i=1, \dots, I, j=1, \dots, J$ be the frequencies of joint responses over a total of n independent cases. We wish to test the independence of the two variables A and B. This was done by employing the statistic

$$X^2 = \sum_{i,j} \left(N_{ij} - \frac{N_{i.} \cdot N_{.j}}{N_{..}} \right)^2 / \frac{N_{i.} \cdot N_{.j}}{N_{..}}$$

where $N_{.j} = \sum_i N_{ij}$, $N_{i.} = \sum_j N_{ij}$, and $N_{..} = \sum_{i,j} N_{ij}$.

If the counts are large (each cell having a count of 5 or more) this statistic has a distribution which is closely approximated by the chi-square distribution with $(I-1)(J-1)$ degrees of freedom.

- c. In the event that one of the variables, say B, may yield several responses (i.e., if they are not mutually exclusive), the above statistic was replaced by

$$X^2 = \sum_{i,j} \left(N_{ij} - \frac{N_{i.} N_{.j}}{N_{.}} \right) / \frac{N_{i.} N_{.j}}{N_{.}} \left(1 - \frac{N_{.j}}{N_{.}} \right)$$

where $N_{i.}$ and $N_{.j}$ defined as above, $N_{i.}$ = number of responses to i^{th} type of response to A, and $N_{.} = \sum_i N_{i.}$. As demonstrated in Section 2 below, this statistic has a distribution which is approximately chi-square, with $J(I-1)$ degrees of freedom.

2. Derivation of Test Statistic X^2 When One Variable has Multiple Responses

In this section we present the method used for testing independence between two variables where one of the variables may yield several responses for a given case. This occurs, for example, when one tests for independence between investigative outcome (one unique response per case) and evidence category analyzed (several possible categories for any given case). In the following, we assume factor A has I mutually exclusive levels (responses) and factor B has J distinct, but not exclusive, responses. We further assume that for a given case, each of the J levels of B may occur independently with probability p_{ij} , $j=1, \dots, J$, given that the responses are coincident with the i^{th} level of A. For this case, the probability of A taking the i^{th} level is p_i , $i=1, \dots, I$. Hence, the probability of a case giving rise to a joint response to the i^{th} level of A and the j^{th} level of B is the product $p_i p_{ij}$, $i=1, \dots, I, j=1, \dots, J$.

Assumptions

Let the outcome of the k^{th} case, $i=1, \dots, I, k=1, \dots, n$ be given by $(X_{1k}, \dots, X_{Ik}), (X_{i1k}, \dots, X_{iJk})$ where

$X_{ik} = 1$ if the i^{th} level of A is chosen $i=1, \dots, I$, and
 $= 0$ otherwise

$X_{ijk} = 1$ if level j of B is chosen, $j=1, \dots, J$
 $= 0$ otherwise

given that the i^{th} level of A has been chosen. Define the probabilities

p_i, p_{ij} by

$$P(X_{ik} = 1) = p_i, \quad i=1, \dots, I, \quad k=1, \dots, n$$

with

$$\sum_{i=1}^I p_i = 1;$$

$$P(X_{ijk} = 1 \mid X_{ik} = 1) = p_{ij},$$

$$P(X_{ijk} = 0 \mid X_{ik} = 1) = 1 - p_{ij},$$

$$P(X_{ijk} = 0 \mid X_{ik} = 0) = 1 \quad \text{for } i=1, \dots, I, \quad j=1, \dots, J, \quad k=1, \dots, n$$

Then the likelihood function of X_{ik}, X_{ijk} is

$$l = \prod_{k=1}^n \prod_{i=1}^I p_i^{X_{ik}} \prod_{j=1}^J p_{ij}^{X_{ijk}} (1 - p_{ij})^{1 - X_{ijk}}$$

Let the cell counts $\{N_i\}, \{N_{ij}\}$ be defined by

$$N_i = \sum_{k=1}^n X_{ik},$$

$$N_{ij} = \sum_{k=1}^n X_{ijk}$$

Then, the likelihood l may be written as

$$l = \prod_{i=1}^I p_i^{N_i} \prod_{j=1}^J p_{ij}^{N_{ij}} (1 - p_{ij})^{N_i - N_{ij}} \quad (0^0 = 1)$$

(Note that $N_{ij} \leq N_i, i=1, \dots, I, j=1, \dots, J$). Under this formulation, the N_i 's are multinomial with parameters $(n, \{p_i\})$, and each of the N_{ij} 's, given $N_i = n_i$, are independent binomial random variables with parameters (n_i, p_{ij}) .

Under no additional assumptions, the maximum likelihood estimates for p_i, p_{ij} are given by

$$\hat{p}_i = N_i / N, \quad \hat{p}_{ij} = \begin{cases} N_{ij} / N_i, & N_i > 0 \\ 0, & N_i = 0 \end{cases}$$

where

$$N_i = \sum_{j=1}^J N_{ij}$$

The hypothesis we wish to test is the following:

$$H_0: p_{ij} = p_j, \quad j=1, \dots, J, \\ i=1, \dots, I.$$

This states that the occurrence of the various levels of B are independent of the level of A.

Under H_0 the likelihood function becomes

$$l_0 = \prod_{i=1}^I p_i^{N_i} \prod_{j=1}^J p_j^{N_{ij}} (1 - p_j)^{N_i - N_{ij}} \\ = \prod_{i=1}^I p_i^{N_i} * \prod_{j=1}^J p_j^{N_{ij}} (1 - p_j)^{N_i - N_{ij}},$$

where
$$N_{.} = \sum_{i=1}^I N_i, \quad N_{i.} = \sum_{j=1}^J N_{ij}$$

The m.l.e.'s for $\{p_i\}, \{p_j\}$ are

$$\hat{p}_i = N_i/N., \quad \hat{p}_j = N_{.j}/N.$$

We choose as our test statistic the approximate value $-2 \log \Lambda$, where Λ is the likelihood ratio

$$\Lambda = l_0/l \text{ evaluated at the m.l.e.'s}$$

Thus,

$$\begin{aligned} -2 \log \Lambda &= -2 \log \left\{ \prod_i \left(\frac{N_i}{N.} \right)^{N_i} \prod_j \left(\frac{N_{.j}}{N.} \right)^{N_{.j}} \left(1 - \frac{N_{.j}}{N.} \right)^{N_i - N_{ij}} \right. \\ &\quad \left. \div \prod_i \left(\frac{N_i}{N.} \right)^{N_i} \prod_j \left(\frac{N_{.j}}{N.} \right)^{N_{.j}} \left(1 - \frac{N_{.j}}{N.} \right)^{N_i - N_{ij}} \right\} \\ &= -2 \log \prod_i \prod_j \left[\frac{N_{ij}}{N.} \frac{N_i}{N_{ij}} \right]^{N_{ij}} \left[\frac{\left(N_i - \frac{N_{.j} N_i}{N.} \right)}{\left(N_i - \frac{N_{.j}}{N.} \right)} \right]^{N_i - N_{ij}} \end{aligned}$$

Setting

$$e_{ij} = \frac{N_i N_{.j}}{N.}$$

$$D_{ij} = N_{ij} - e_{ij}, \text{ we get}$$

$$\begin{aligned} -2 \log \Lambda &= 2 \sum_i \sum_j (D_{ij} + e_{ij}) \log (D_{ij} + e_{ij}) - \log e_{ij} \\ &\quad + (N_i - D_{ij} - e_{ij}) \log (N_i - D_{ij} - e_{ij}) - \log (N_i - e_{ij}) \end{aligned}$$

We obtain the approximating expression for $-2 \log \Lambda$ by expanding the above function of D_{ij} about 0, keeping in mind that $\sum_{i=1}^I \sum_{j=1}^J D_{ij} = 0$. Omitting the details, we obtain:

$$-2 \log \Lambda = \sum_{ij} \frac{\left(N_{ij} - \frac{N_i N_{.j}}{N.} \right)^2 N_i}{\frac{N_i N_{.j}}{N.} \left(N_i - \frac{N_i N_{.j}}{N.} \right)}$$

In terms of e_{ij} 's (expected values),

$$\chi^2 = \sum_{ij} \frac{(N_{ij} - e_{ij})^2}{e_{ij} (1 - \hat{p}_j)}, \quad \hat{p}_j = \frac{N_{.j}}{N.}$$

By the general result regarding likelihood ratios satisfying certain regularity conditions (see 1 for example), this statistic has an asymptotic χ^2 distribution with degrees of freedom given by $I + IJ - 1 - (I - 1) - J = J(I - 1)$.

We note the similarity between this statistic, and the one used when both factors have mutually exclusive levels. In this case, we use

$$\chi^2 = \sum_{ij} \frac{(N_{ij} - e_{ij})^2}{e_{ij}},$$

where

$$e_{ij} = \frac{N_i N_{.j}}{N..}$$

This statistic has an asymptotic χ^2 distribution with $(I - 1)(J - 1)$ degrees of freedom.

APPENDIX C
TESTS OF VARIABLE PAIRS

7
7

CONTINGENCY TABLE (CHI-SQUARE STATISTICS) FOR TESTING INDEPENDENCE OF:
 VARIABLE 32, BIT 3 OF CARD 2 - (2 LEVELS), AND VARIABLE 42, BIT 1 OF CARD 2 - (8 LEVELS)
 BY CRIME TYPE AND SITE. MARGINS GIVE POOLED STATISTICS. EACH TRIPLET GIVES: CHI**2, DEGREES OF FREEDOM,
 AND TOTAL COUNT FOR THAT CELL.

	HOMICIDE	RAPE	ROBBERY	ASSAULT	BURGLARY	LARCENY	ARSON	BOMB & EXPL.	HIT-RUN	ALL CRIMES
SITE 1	7.559 7 18	1.840 6 13	5.407 3 9	7.919 7 21	2.661 6 22	4.000 -1001 1	8.112 5 8	4.000 -1001 1	4.000 -1001 1	10.532 7 94
SITE 2	5.811 4 19	4.815 4 10	4.000 -1001 1	3.021 3 5	43.098 -1006 16	0.0 0 0	0.0 0 0	0.0 0 0	0.0 1 2	11.808 8 53
SITE 3	4.993 8 42	133.317 -1008 28	5.008 7 38	30.935 8 113	5.402 8 50	6.000 -1003 3	8.000 -1001 2	8.000 -1003 1	4.000 -1001 1	6.711 8 276
ALL SITES	11.341 8 79	5.841 8 51	3.530 8 48	30.074 8 139	6.293 8 88	5.150 -1004 4	11.357 5 10	8.000 4 2	0.889 2 4	16.205 8 425

x²
 DEGREES OF FREEDOM
 CELL COUNT

NOTES:
 1. CELLS WITH SIGNIFICANT PAIRS ARE CIRCLED
 2. ±100X MEANS THE SECOND (+) OR FIRST (-) VARIABLE HAS COUNTS IN ONLY ONE LEVEL; IT YIELDS A ONE-DIMENSIONAL TABLE WITH X DEGREES OF FREEDOM

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MAXIMUM LEVELS OF X, Y, AND X-Y, BY CRIME TYPE AND SITE.

SITE 1	1 4 14	1 2 12	1 1 11	1 4 14	1 3 13	1 5 15	1 5 25	2 5 25	1 3 13	1 4 14
SITE 2	1 4 14	1 2 12	1 8 18	2 2 22	1 3 13	0 0 0	0 0 0	0 0 0	1 3 13	1 2 13
SITE 3	1 4 14	1 1 11	1 4 14	1 4 14	1 1 11	1 3 13	1 3 13	1 2 12	1 6 16	1 4 14
ALL SITES	1 4 14	1 2 12	1 4 14	1 4 14	1 1 11	1 3 13	1 5 13	1 2 12	1 3 13	1 4 14

MAX. LEVEL, VAR. 32
 MAX. LEVEL, VAR. 42
 JOINT MAXIMA

CONDITION OF SCENE, QUESTION I-5, VARIABLE 32 VS REQUESTS FOR ANALYSIS,
 QUESTION I-12, VARIABLE 42

MEAN AND STANDARD DEVIATION OF VARIABLE 88, BIT 6 OF CARD 4, BY CRIME TYPE AND SITE

	HOMICIDE 1	RAPE 2	ROBBERY 3	ASSAULT 4	BURGLARY 5	LARCENY 6	ARSON 7	BOMB 8	HIT-RUN 9	ALL CRIMES
SITE 1	2.46	2.14	2.13	1.57	2.04	3.00	1.00	1.00	2.00	2.01
SITE 2	2.07	2.30	0.0	1.75	1.75	0.0	0.0	0.0	2.86	2.19
SITE 3	1.13	1.00	2.20	1.61	2.10	0.0	0.0	0.0	0.0	1.69
ALL	1.84	2.23	2.17	1.63	2.02	3.00	1.00	1.00	2.67	1.98

CRIMES									ALL CRIMES
1	2	3	4	5	6	7	8	9	
0.66	0.95	0.99	0.81	0.96	0.0	0.0	0.0	1.41	0.92
0.83	0.74	0.0	0.75	0.96	0.0	0.0	0.0	0.38	0.79
0.50	0.0	0.94	0.84	0.99	0.0	0.0	0.0	0.0	0.90
0.67	0.81	0.94	0.80	0.95	0.0	0.0	0.0	0.71	0.80

MEAN AND STANDARD DEVIATION OF VARIABLE 90, BIT 3 OF CARD 4, BY CRIME TYPE AND SITE

	HOMICIDE 1	RAPE 2	ROBBERY 3	ASSAULT 4	BURGLARY 5	LARCENY 6	ARSON 7	BOMB 8	HIT-RUN 9	ALL CRIMES
SITE 1	7.00	2.50	3.25	2.81	1.46	1.00	1.50	1.00	2.00	2.89
SITE 2	1.64	1.46	0.0	1.58	4.25	0.0	0.0	0.0	2.29	1.74
SITE 3	1.94	1.00	2.67	1.30	2.40	0.0	0.0	0.0	0.0	1.94
ALL	3.37	1.73	2.87	1.93	1.97	1.00	1.50	1.00	2.22	2.25

2.63	1.87	3.26	2.40	0.76	0.0	0.71	0.0	1.41	2.09
0.74	0.61	0.0	0.67	3.30	0.0	0.0	0.0	1.38	1.17
2.17	0.0	2.00	0.70	1.84	0.0	0.0	0.0	0.0	1.73
3.16	1.17	2.49	1.69	1.66	0.0	0.71	0.0	1.30	2.00

JOINT COUNTS AND CORRELATION COEFFICIENTS FOR VARIABLE 88, BIT 6, CARD 4, AND VARIABLE 90, BIT 3, CARD 4

	1	2	3	4	5	6	7	8	9	90
SITE 1	13	14	6	21	26	3	2	1	2	90
SITE 2	14	37	0	12	4	0	0	0	7	74
SITE 3	16	1	15	23	10	0	0	0	0	65
ALL	43	52	23	56	40	3	2	1	9	229

0.27	0.09	0.60	0.10	0.30	0.0	0.0	0.0	-1.00	0.19
-0.20	0.12	0.0	0.68	0.97	0.0	0.0	0.0	-0.23	0.16
0.67	0.0	0.41	0.44	0.64	0.0	0.0	0.0	0.0	0.51
0.51	0.02	0.48	0.06	0.39	0.0	0.0	0.0	-0.32	0.24

NOTE: HIGH CORRELATIONS ARE CIRCLED

RELIANCE ON PHYSICAL EVIDENCE, QUESTION III-5, VARIABLE 88 VS NUMBER OF CONTACTS W. INVESTIGATOR, QUESTION III-7, VARIABLE 90

APPENDIX D
CRIME-SPECIFIC REPRESENTATION OF LINKS
BETWEEN SIGNIFICANT SYSTEM VARIABLES

This Appendix presents crime specific models of the interrelations between variables discussed in Section 4. The general model required that each link be established at several sites and over several crime categories. The crime specific charts show links of three types:

- a. Significance at 2 or more sites and over all sites.
- b. Significance at 1 site and over all sites, or at 2 sites.
- c. Significance only over all three sites.

The first link (a) can be interpreted as one existing in general, in a relatively strong fashion. Links of type (b) are somewhat less general, suggestive of site (or observer) variation. Links of type (c) indicate a clear site (observer) variation. Due to small data counts, only results for homicide, rape, robbery, assault, and burglary are presented.

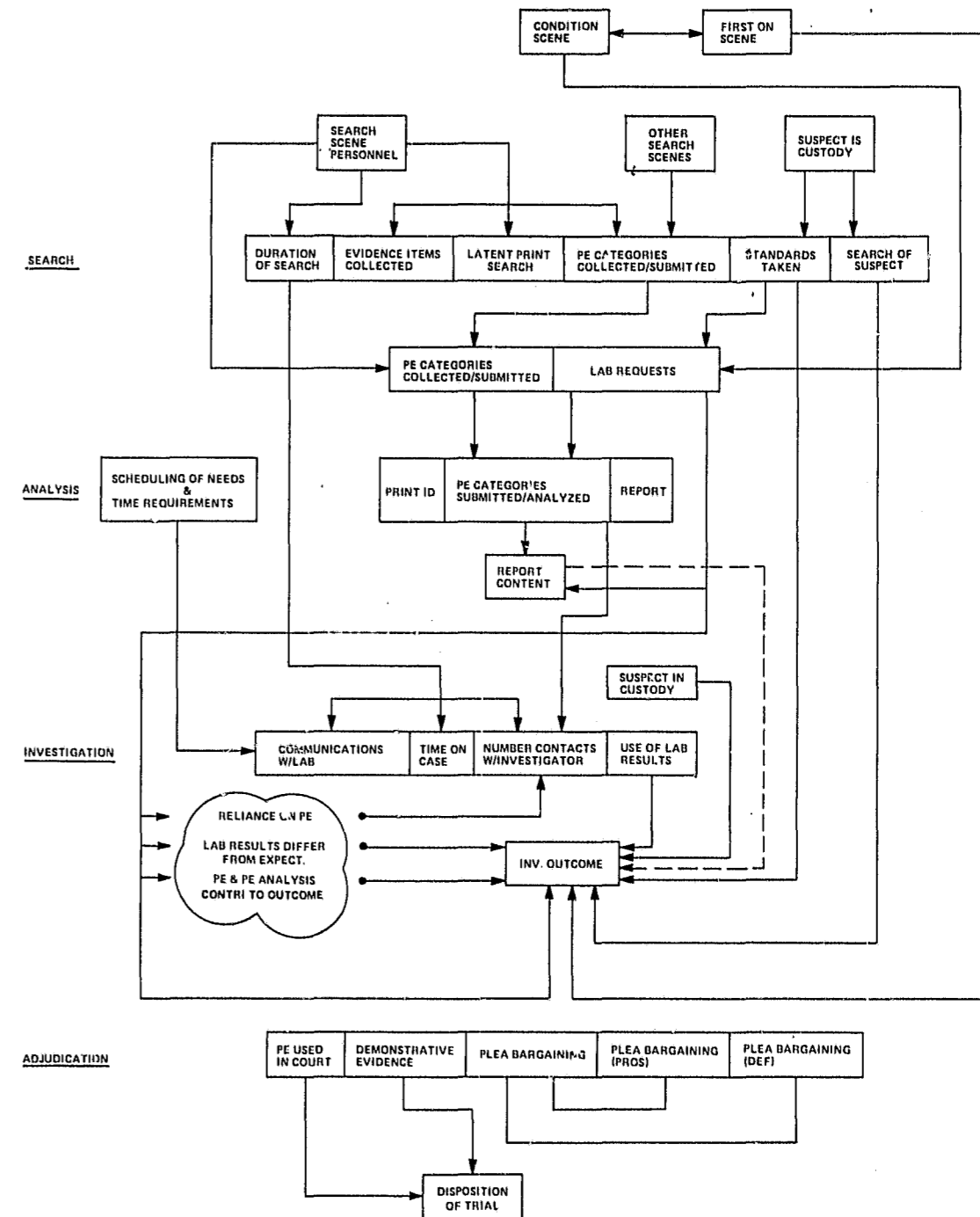


Figure 8 LINKS BETWEEN CRIMINAL JUSTICE SYSTEM VARIABLES
(a) PRIMARY LINKS (GENERAL)

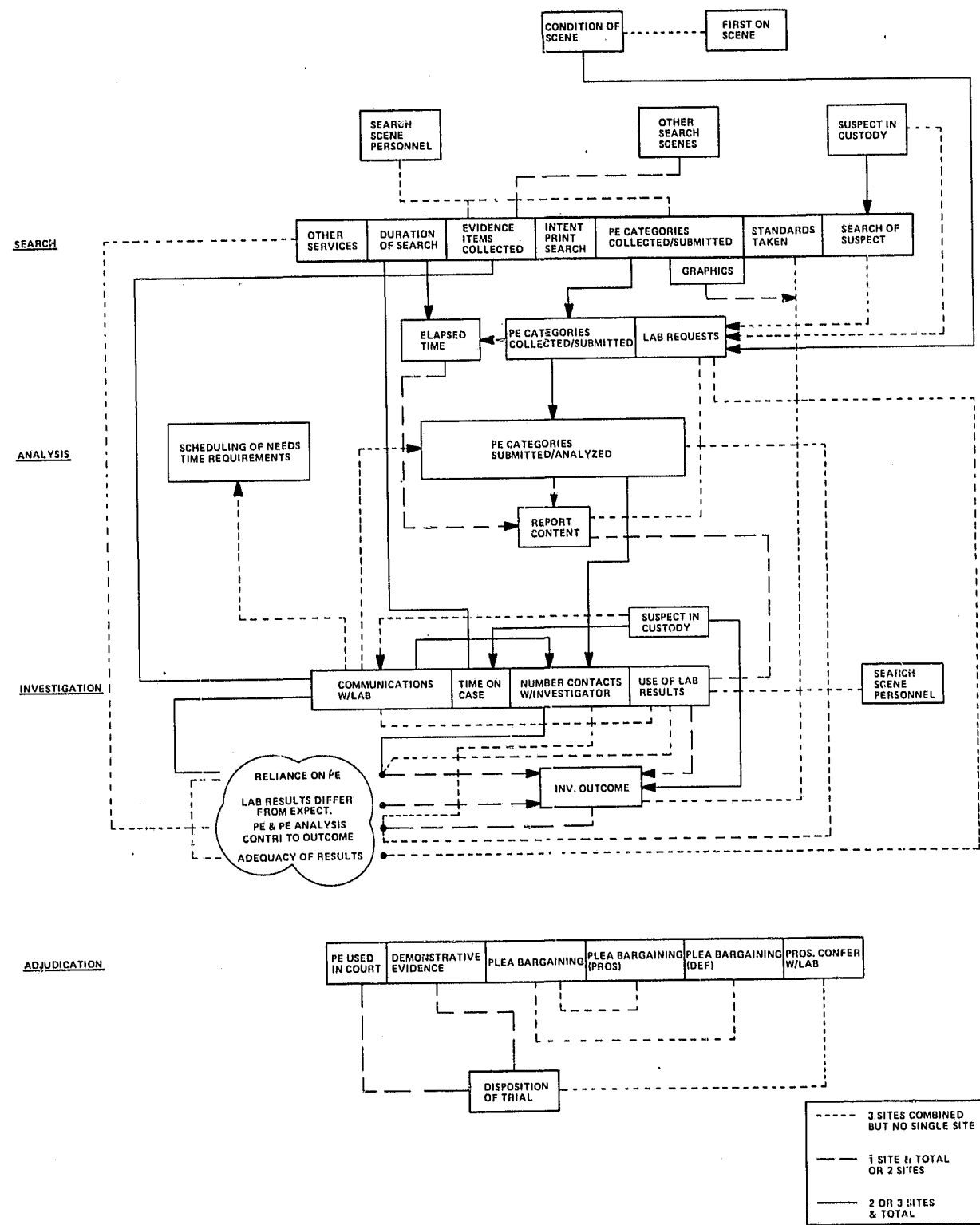


Figure 8 LINKS BETWEEN CRIMINAL JUSTICE SYSTEM VARIABLES
(b) PRIMARY LINKS (HOMICIDE)

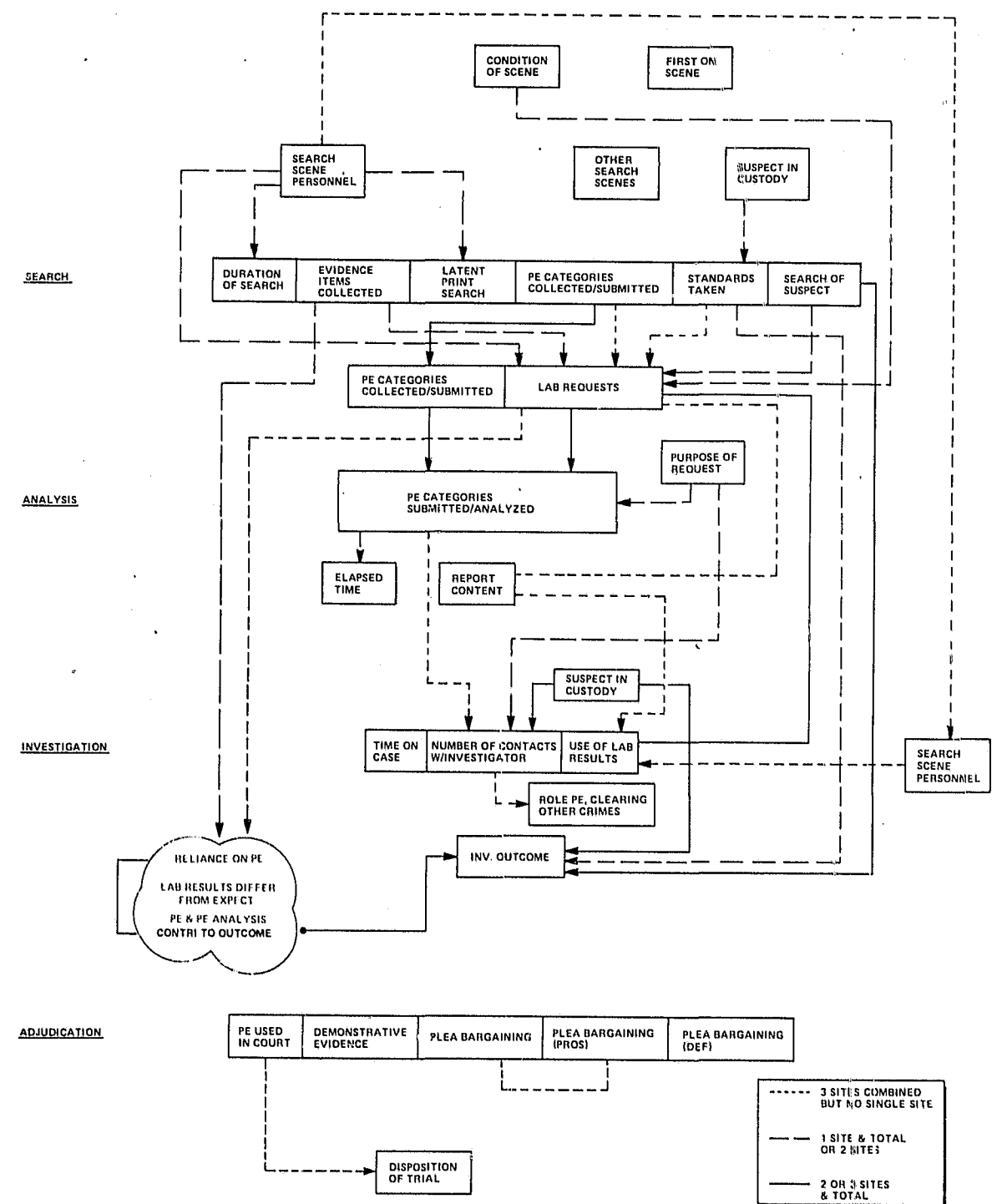


Figure 8 LINKS BETWEEN CRIMINAL JUSTICE SYSTEM VARIABLES
(c) PRIMARY LINKS (RAPE)

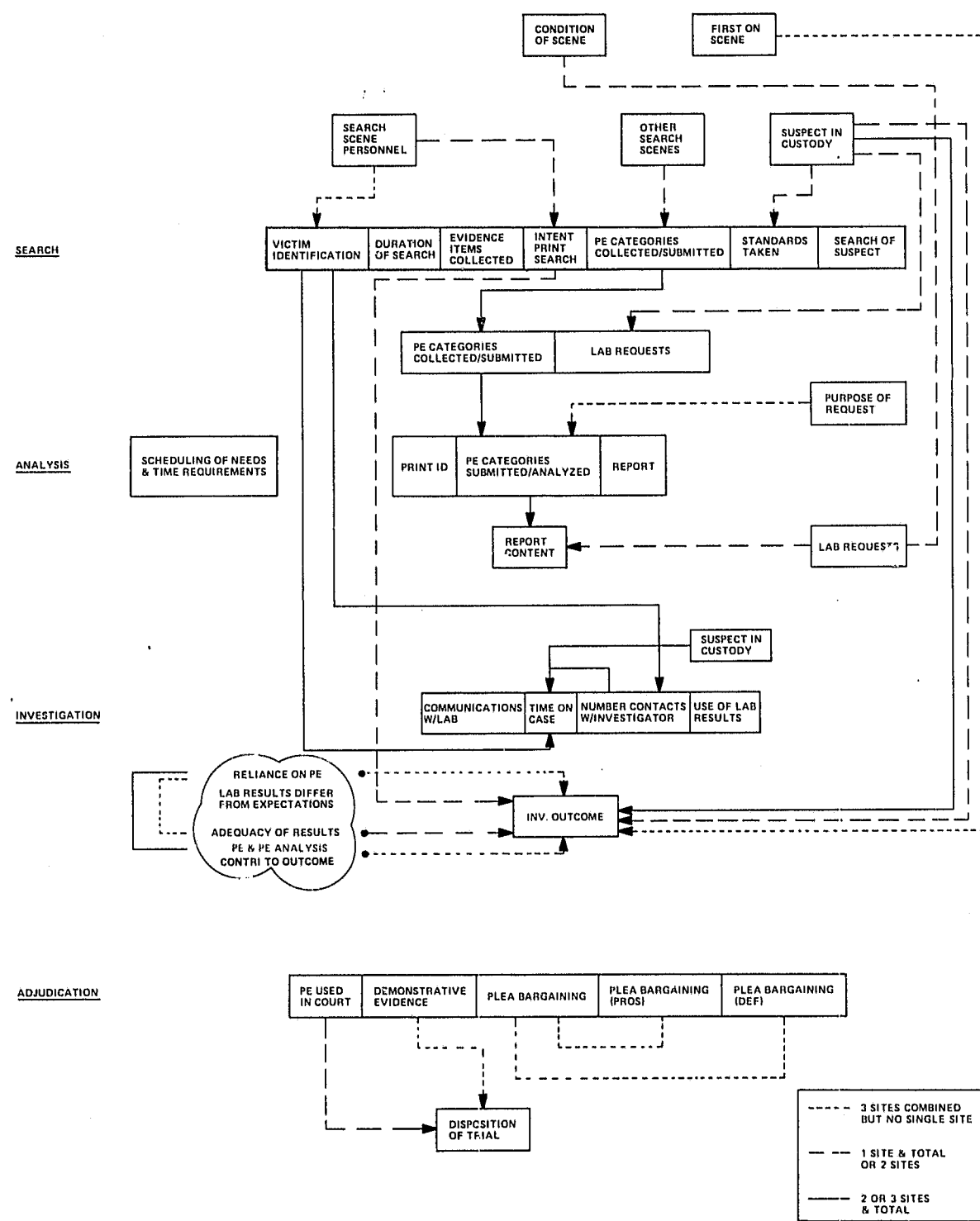


Figure 8 LINKS BETWEEN CRIMINAL JUSTICE SYSTEM VARIABLES
(d) PRIMARY LINKS (ROBBERY)

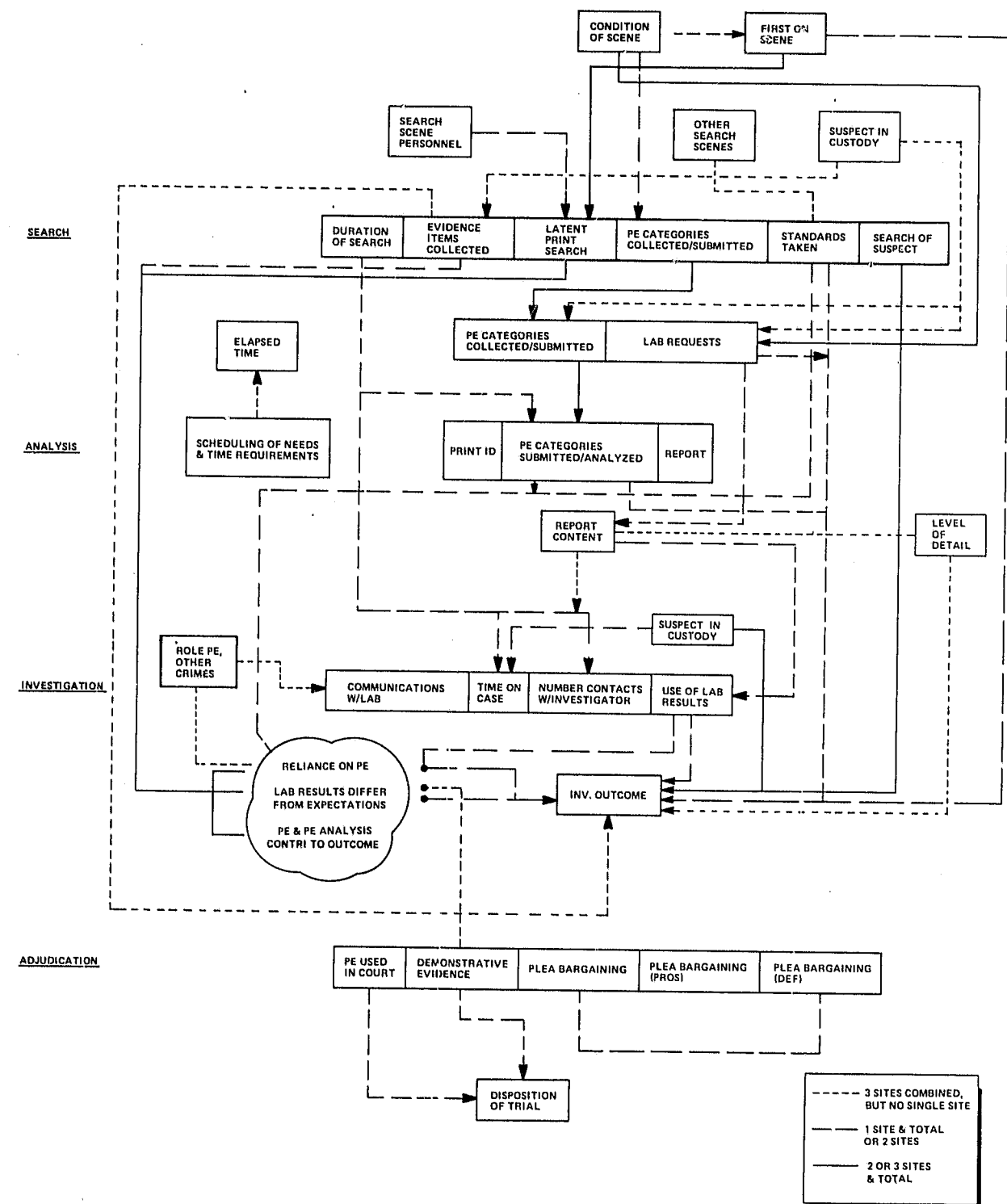


Figure 8 LINKS BETWEEN CRIMINAL JUSTICE SYSTEM VARIABLES
(e) PRIMARY LINKS (ASSAULT)

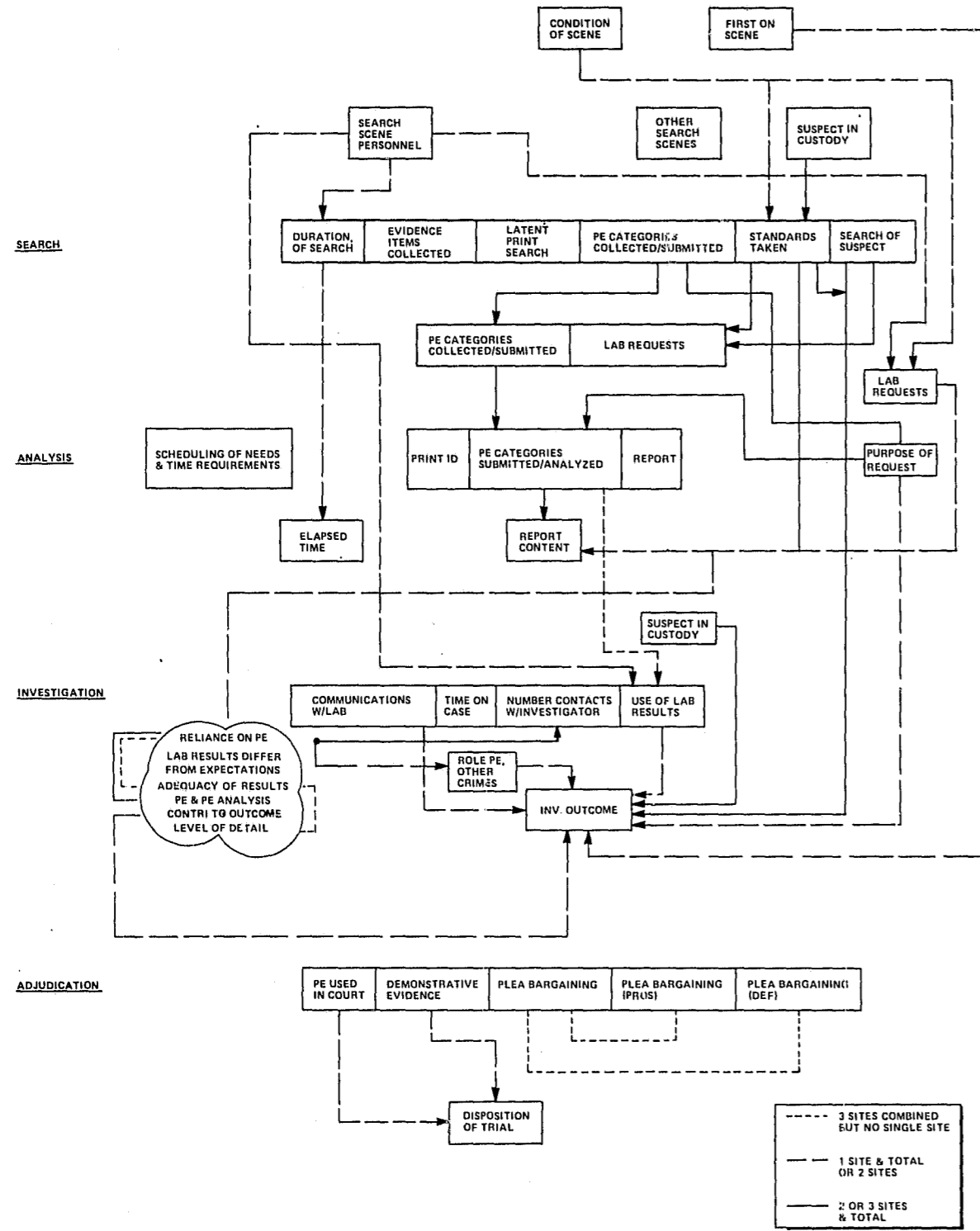


Figure 8 LINKS BETWEEN CRIMINAL JUSTICE SYSTEM VARIABLES
 (f) PRIMARY LINKS (BURGLARY)

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END