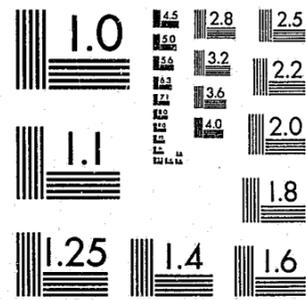


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National Institute of Justice
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4-23-82

LATENT FINGERPRINT IDENTIFICATION SYSTEM REPORT

81370^{ca}

NEW YORK STATE
DIVISION OF CRIMINAL JUSTICE
SERVICES

GRANT # 76SS-99-6036

State of New York's
LATENT FINGERPRINT
IDENTIFICATION SYSTEM
REPORT

CRIMINAL JUSTICE
RESEARCH AND DEVELOPMENT
BUREAU

NEW YORK STATE DIVISION OF
CRIMINAL JUSTICE SERVICES

U.S. Department of Justice
National Institute of Justice

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System programming was done by Mr. Michael Wierzbowski of DCJS. Throughout the project, he simplified and corrected the author's logical structures and assisted with the development of both the test programs and production system.

Lastly, many thanks to Miss Patricia Smrtic who so diligently typed the many revisions of this document.

ABSTRACT

Part 1 of this document describes the candidate ranking algorithm developed for use in the DCJS Latent Fingerprint Identification System and evaluates its use within the agency's operating environment.

The algorithm ranks candidates on the basis of fingerprint descriptors and three probability factors mentioned below. Computer disk files were created to capture data relating to:

1. The age frequency distribution of persons arrested within New York State for each of 12 penal law charge categories by sex and subdivision of the state (upstate or New York City).
2. The probability of rearrest on any of the 12 charges after an arrest on a first charge over a ten-year period from the date of first arrest.
3. The probability of a male or female at any age between 16 and 65 being arrested on any of the 12 charges.

The algorithm is a linear combination of elements of these files and a factor derived from sums of differences of latent and file print ridge counts. A sample was selected and programs written to test the ranking procedure. The test results are presented and incorporated into a cost model for the DCJS Special Services' Unit.

Part 2 analyzes the development of similar systems by other criminal justice agencies.

PART I

1.0 Executive Summary

The following conclusions have been inferred on the basis of the information presented in this document:

1. For all penal law charge categories, the candidate ranking algorithm provides substantial improvement over methods currently employed at DCJS. When properly incorporated into a production system, a long-term increase in the absolute number of identifications will occur.
2. An improvement of approximately 52% over random expected value (list position) in the sample was noted. For the charge categories of murder and arson, the improvement in list position was approximately 35%.
3. Of 37 one-finger searches with accurate ridge counts and known finger position, 14 suspect lists were less than 100 candidates; 6 additional were less than 200 and 3 less than 300. For two-finger searches, as above, 34 lists were less than 100; 3 were less than 200. For three-finger searches, all lists were less than 100 candidates to the target candidate. This data is presented graphically in FIGURE 1.
4. At current staff levels, DCJS can increase the probability of an identification by a factor of three and at the same time the number of cases processed per year to approximately 1000. Of the one-thousand cases, approximately 250 would be computer searchable. If a lower probability of identification is chosen, case volume can be increased accordingly.
5. A search on social descriptors alone will be possible under restricted conditions. With crime type, location and suspect identifying data, a candidate list can be produced that selects individuals on the basis of conformity to a model offender's arrest history, age and sex.

1.1 Recommendations

1. The system developed by R and D should be implemented. When testing in the production environment is complete, remove the pilot system.
2. In-depth exploration of modifications to the existing arrest fingerprint system and/or CCH data base to enhance throughput time.
3. Agency support for "front-end" system enhancement. This support takes the specific form of development of an image processing algorithm which will enable more accurate estimation of latent impression pattern types and ridge counts.
4. When the system is in place, solicitation of submission of latent impressions from police agencies within New York State.

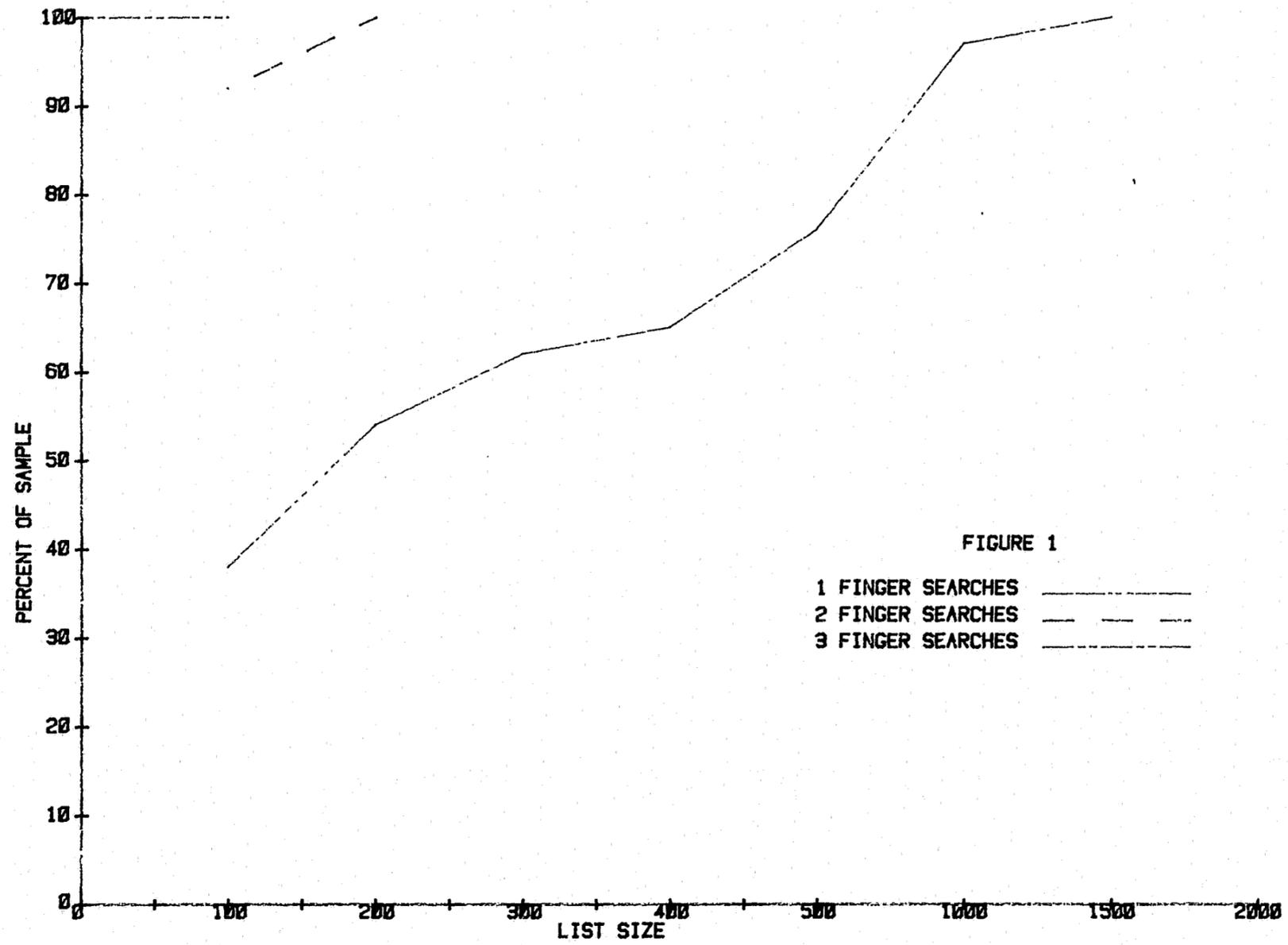


FIGURE 1

1 FINGER SEARCHES ———
 2 FINGER SEARCHES - - -
 3 FINGER SEARCHES . . .

2.0 Overview

DCJS maintains an operational unit dedicated to the identification of latent fingerprint images. Evidence is presented to the examiner and data necessary for the search is extracted. At DCJS, this takes the form of a pattern type classification, ridge count and estimation of likely finger number. (See APPENDIX 1).

Prior to the 1970's, a completely manual latent file system was maintained. In 1974 a pilot (3-county) computer assisted retrieval system was developed and implemented. Although its logic was simplistic, it provided enhanced performance and throughput over manual "single finger" files. On the basis of this performance the agency elected to develop a more powerful statewide operating system.

Latent fingerprint identification at DCJS is an instance of selecting a set of very similar records from a large computer file, and thereafter, manually verifying or rejecting each record so selected against photographs of latent impressions. Typically, input to the examiner consists of one or more fingerprint impressions and a brief narrative description of the crime. The impression may not be of sufficiently high quality to allow an accurate determination of pattern type, ridge count and a number of finger positions may appear equiprobable. If a ridge count tolerance of ± 4 is chosen, a single finger search of a high population density county can yield in excess of 40,000 candidates with previous arrests on the crime-search charge. Clearly, a more sophisticated method of candidate selection is required if the latent search is to be practical.

The R and D System differs conceptually from the pilot system in two important respects. Firstly, the system employs statistical data, described in SECTION 3 of this document, to rank candidates by their similarity to a model offender. Analysis indicates that persons first arrested on any one of the twelve-charge categories are, in general, similar to each other in terms

of age and pattern of arrest.

The R and D System, in effect, provides data about offenders for twelve-charge categories.

Secondly, the system ranks candidates on fingerprint data. The pilot system employed a ridge count tolerance and pattern type elimination independent of the number of latents input. Consequently, in multiple finger searches, much available information was ignored. By application of algorithm RH, described in APPENDIX 2, all available fingerprint data is utilized.

3.0 Search Algorithm

The search algorithm described herein is a linear combination of probabilities, discussed below, and a factor derived from fingerprint data.

3.1 Fingerprint Factor

The mechanism for ranking fingerprints on the basis of ridge count differences was developed and tested by Mr. Robert Hall, R and D Consulting Statistician, at DCJS.

Let r_{i1} and r_{if} denote ridge counts for fingers $i \in \{1, \dots, 10\}$ and file (f) or latent (l) impressions for $I \in \{1, \dots, 10\}$. Then:

$$S_1 = \sum_{i \in I} |r_{if} - r_{i1}| \quad (1)$$

In practice at DCJS: r is an integer such that $0 < r \leq 26$ and a tolerance, n , is imposed on the difference of ridge counts on each finger. Specifically, if $|r_{if} - r_{i1}| > n$, the record is rejected. For test purposes, n was set equal to 1; in production $n \leq 4$.

If the latent being searched is an arch or tented arch, $S_1 = 1 \times (\text{number of arches}) + \text{score for non-arches}$.

This ranking procedure is highly effective on ten-finger (arrest) searches and provides useful discrimination in latent searches. A performance summary is given in APPENDIX 2 of this document.

3.2 Social Factors

The following general assumptions were made:

1. Statistically, the behavior of repeat offenders within New York State, as manifested by arrest data, was quantifiable as described below.
2. Arrest history is strongly correlated with overall criminal behavior. This assumption attempted to make the intuition of the experienced latent fingerprint examiner more exact.

Factors for inclusion in the algorithm were the offender's:

- age
- sex
- arrest history
- race

For technical reasons, race could not be addressed and was relegated to an elimination factor in the production system.

3.2.1 Data Extraction and Analysis

Computer programs were written to extract data from the agency's criminal history data base. Every third record of the CCH files was examined. These files contain extensive information about persons arrested within New York State. For obtaining arrest history data including arrest charge, date and place, inquiries are made to a data base structure called the NYSEVENTSET which contains the data indicated above.

Information for age frequency distributions, as described below, was obtained from Unified Crime Reporting Files (UCR) for calendar years 1977, 1978 and 1979.

3.2.1.1 Age Frequency Distribution

New York State has traditionally been divided into ten geographic regions, consisting of groups of counties. TABLES 1 and 2 contain the correspondence between county and county code and region and county codes, respectively.

Within the UCR files, data is stored which indicates the age, sex and charge for arrestees within New York State by calendar year. The set of UCR charges was divided into twelve latent identification system charge categories. The correspondence between Penal Law Articles and Latent Charge Codes is given in TABLE 3. Raw data to produce age frequency distribution for each region, both sexes and the 12 charge classes was extracted. Graphs of selected age frequency

NEW YORK STATE COUNTY CODES

<u>County</u>	<u>Code</u>	<u>County</u>	<u>Code</u>
Albany	01	Oneida	32
Allegany	02	Onondaga	33
Broome	03	Ontario	34
Cattaraugus	04	Orange	35
Cayuga	05	Orleans	36
Chautaugua	06	Oswego	37
Chemung	07	Otsego	38
Chenango	08	Putnam	39
Clinton	09	Queens	40
Columbia	10	Rensselaer	41
Cortland	11	Richmond	42
Delaware	12	Rockland	43
Dutchess	13	St. Lawrence	44
Erie	14	Saratoga	45
Essex	15	Schenectady	46
Franklin	16	Schoharie	47
Fulton	17	Schuyler	48
Genesee	18	Seneca	49
Greene	19	Steuben	50
Hamilton	20	Suffolk	51
Herkimer	21	Sullivan	52
Jefferson	22	Tioga	53
Kings	23	Tompkins	54
Lewis	24	Ulster	55
Livingston	25	Warren	56
Madison	26	Washington	57
Monroe	27	Wayne	58
Montgomery	28	Westchester	59
Nassau	29	Wyoming	60
New York	30	Yates	61
Niagara	31	Bronx	62

TABLE 1

NEW YORK STATE AREA CODES

<u>AREA/CODE</u>	<u>COUNTY CODES</u>			
Capital District/01	01			
	41			
	46			
Hudson Valley/02	10	35		
	13	39		
	19	52		
Westchester/Rockland/03		43		
		59		
Erie/Niagara/04		14		
		31		
Southern Tier/05	02	05	50	
	03	07	53	
	04	48	54	
Western/06	05	27	49	61
	18	34	58	
	25	36	60	
Central/Mohawk Valley/07	08	21		33
	11	26		37
	12	28		38
	17	32		47
Northern/08	09	22		55
	15	24		57
	16	44		56
	20	45		
Long Island/09		29		
		51		
New York City/10	23			42
	30			62
	40			

TABLE 2

<u>SYSTEM CODE</u>	<u>PENAL LAW ARTICLE</u>	<u>DESCRIPTION</u>
01	120	Murder/Manslaughter
02	125	Assault
03	130	Sex Offenses
04	140.	Burglary/Offense against property
05	145.	Criminal Mischief
06	150.	Arson
07	155.	Larceny
08	160.	Robbery
09	165	Theft
10	220	Controlled substance
11	265	Weapons
12	All Other	-----

TABLE 3

distributions are presented in APPENDIX 3.

3.2.1.2 Sex Code Mix

Data was extracted to provide the probability of a male or female at each age from 16 through 65 and within each region being arrested on any of the latent system charge codes. Thus, if p_m and p_f are the probabilities of arrest of a male or female on any specific charge at age k within any specific region, $p_f + p_m = 1$. Graphs of selected data elements are presented in APPENDIX 4.

3.2.1.3 Arrest History Data

The arrest history data was extracted to yield the probability of an individual arrested for the first time on charge C in year Y , being rearrested during any bi-annual interval on charge C , or C_2 or ... C_{12} . Files were created for year of first arrest 1969 through 1976, ten regions, 12 first arrest charge categories and both sexes.

Graphs of the resulting probabilities versus bi-annual intervals to ten years of first arrest date, are presented in APPENDIX 5.

3.2.2 Simplification of Data Files

It was not possible to make simplifying distributional assumptions about the extracted data. Probabilities were computed from the data and plots were made of probability versus time unit. The usual non parametric statistical test, such as the χ^2 , could not be used effectively. An empirical examination of the data was made with hope of simplification.

On the basis of this examination, the following simplifications were made:

1. Adaptation of a unified 10-year arrest history. The arrest history function appeared to be time invariant in the sense that it was independent of the date of first arrest. Specifically, for application purpose, the time versus rearrest probability function is invariant under a time axis translation.

2. Consolidations of the ten regions into "upstate" and "downstate" where "downstate" consists of the five boroughs of New York City.
3. Consolidations of sex code mix into one aggregate for the time period examined.
4. Consolidation of the age frequency distribution into an aggregate derived from the data over the years used in the sample.

Format and content of the computer disk files containing the consolidated data is given in APPENDIX 6.

3.3.0 Age Factor

Let P_{ag} be the probability that an individual on file with reported age k and known sex such that $16 \leq k \leq 65$, is arrested on the search charge.

$$\text{Then: } S_2 = (1 - P_{ag}) \quad (2)$$

3.3.1 Sex Code Factor

Let P_s be the probability that an individual with an arrest history and of age k , such that $16 \leq k \leq 65$, is male or is female is arrested on the search charge.

$$\text{Then: } S_3 = (1 - P_s) \quad (3)$$

3.3.2 Arrest History Factor

Let P_{ar} be the probability that an individual with an arrest history is rearrested on the search charge - some integer number between 1 and 20 bi-annual intervals from his date of first arrest on any one of the twelve system charge categories.

$$\text{Then: } S_4 = (1 - P_{ar}) \quad (4)$$

3.4 Let $\bar{\lambda} = (\lambda_1, \lambda_2, \lambda_3, \lambda_4)$ be a four dimensional vector. The elements of this vector are real numbers. They are empirically determined weights used in the scoring procedure, as described below.

Let $\bar{S} = (S_1, S_2, S_3, S_4)$ be a 4-vector containing the score factors of equations (1) through (4).

$$\text{Then } S = \bar{\lambda} \cdot \bar{S} = \sum_{i=1}^4 \lambda_i S_i \quad (5)$$

is the aggregate score.

As incorporated into the test search programs, described below, or the production system main search, the search algorithm has the following form:

1. Read an arrest fingerprint file record. If the pattern type of the selected input finger position equals the file pattern type, continue - else read the next record.
2. Check the reported age. If within established tolerances, continue - else read the next record.
3. For file loop or whorl pattern types, check the ridge counts. If for any finger, $|r_i - r_{if}| > n$ (n , the established tolerance), read the next record - else compute equation (1).
4. Store ID number, reported age, sex code and S_1 .
5. Do 1 through 4 through detail fingerprint record exhaustion.
6. Sort the storage file by ID number eliminating the duplicates created by referencing fingerprint classification in the master file.
7. Read criminal history records by ID number from the file of 4, above.
8. Eliminate records on county code.
9. Construct an arrest history (SECTION 4.2.2.2) for the record.
10. Eliminate on charge code.
11. If race code was entered, eliminate on race code.
12. Compute S_2 from equation (2).
13. Compute S_3 from equation (3).
14. Compute S_4 from equation (4).
15. Compute S from equation (5).
16. Store S and the candidate's sex code, YOB and ID number.
17. Continue to exhaustion of the storage file.

4.0 Statement of the Problem

Let $\{S\}$ be a set of functions of $\bar{\lambda}$ such that $\text{Domain}(S) = \{X \mid X \text{ is a probability file element or } X \text{ is an integer such that } 0 < X \leq 10n\}$, where n is the ridge count tolerance.

Each possible λ -vector defines an $S = \bar{S} \cdot \bar{\lambda}$, i.e., a score function. At the outset, we assumed each score factor would contribute to identification of target candidates. Consequently, we set the weights equal to or greater than zero.

The range of S , denoted by $\text{range}(S)$, was, therefore, the positive reals and zero, i.e.,

$$\text{Range}(S) = \mathbb{R}^+ \cup \{0\}$$

Zero is the greatest lower bound of $\text{range}(S)$ and, in application, the best score a record can yield.

The problem was to determine a $\bar{\lambda}$ that would yield the lowest score, i.e., the highest position on score ordered candidate list for elements of a chosen sample. Consequently, the test criteria selected was the sum of candidate list positions over the sample.

Define a function T , such that:

$$T: \{\lambda_n\} \rightarrow \mathbb{I}^+ \cup \{0\}$$
$$T(\lambda_n) = \sum_{i \in \Omega} i_n \quad (6)$$

Where i is the list position and Ω is the sample.

T assigns the sum of target candidate list positions to the weight vectors. The vector that produced the lowest sum of list positions was incorporated into the production program.

Formally, the problem was to determine $\min T(\lambda_n)$, i.e., to find a λ_n such that $(\forall j \neq n) T(\lambda_n) \leq T(\lambda_j)$. (7)

4.1 The Sample

A sample of 60 arrest fingerprint cards was chosen as the source of input to the test programs. There were restrictive conditions on sample selection including:

1. The pool of candidates from which the sample was chosen was limited to recent arrestees.
2. Sample size was limited by availability of processor time and secondary storage. One test file, as described below, required 3 words per record. Based on the estimated number of retrievals, sample size was restricted to sixty target candidates.

An additional restriction was mandated by DCJS requirements.

3. DCJS operations required the algorithm function for all charge categories. It was decided, therefore, to include at least 3 sample elements per charge code. Emphasis was, however, placed on the most common crime encountered in latent fingerprint analysis, Burglary. Although Criminal Mischief was treated as a separate charge category, in practice, the two are typically coextensive.

Of the 60 target records selected, 10 could not be utilized because of sealed criminal history records. During test program executing, 3 others were lost. Data for the remaining 47 appears in APPENDIX 7.

NYSID numbers were input to the fingerprint and criminal history systems generating fingerprint file classification and criminal history documents. The candidate's fingerprint classification is presented in APPENDIX 8.

The sample chosen is clearly not random.

It cannot be considered representative of the input to any DCJS identification system in terms of distribution by county, charge code or personal characteristics of the arrestees.

4.2 Test Programs

For simplicity, the programs to determine λ_n were accomplished in four stages: The program's functional characteristics are given below.

4.2.1 TESTSRCH 1

TESTSRCH 1 accomplished a sequential search of FPMaster, the master fingerprint file. FPMaster is a hashed access file with detail records formatted as in TABLE 4.

4.2.1.1 Input

Input to the program was by punched card as follows:

1. F/P descriptors (pattern type/ridge count tolerance and finger position).
2. Associated search number. Search numbers range from 01 to 50.

4.2.1.2 Functional Description

TESTSRCH 1 performed the following functions:

1. Read every detail record of FPMaster.
2. For searches 1 through 50, eliminated records on the basis of fingerprint pattern type.
3. Eliminated on year of birth tolerance.
4. Eliminated non-criminal prints.
5. Eliminated records on the basis of ridge count tolerance taken at $n=+1$.
6. Computed selected records score using equation (1).
7. Wrote the data elements of 4.2.1.3, below, to a disk file.

FP MASTER DETAIL RECORD

The master arrest fingerprint file contains approximately 4.5 million records.

Bit format is presented below. The file can be accessed in three ways:

- sequential READ of the entire file
- by ID number
- by so-called sex pattern type (the record key)

Detail fingerprint records have the following format:

<u>ABBREVIATION</u>	<u>POSITION (WORD: START BIT:LENTGH)</u>	<u>COMMENT</u>
FPSEX	0: 47:01	M=0, F=1
FPPAT01	0: 46:03	Pattern type
FPPATn	0: 46-3(n-1):03	n=1,...,10
FPYOB	0: 16:07	Year of birth
FPRCT01	0: 09:05	Ridge count 01
FPRCT02	0: 04:05	Ridge count 02
FPRCT03	1: 47:05	Ridge count 03
⋮	⋮	⋮
FPRCT10	1: 12:05	Ridge count 10
FPFLAG1	1: 07:01	Value 0
FPFLAG2	1: 06:01	Value 0
FPFLAG3	1: 05:01	Value 0
FPMOB	1: 04:04	Month of birth
FPFLAG4	1: 00:01	Value 1
FPFLAG5	2: 47:01	Value 1
FPDOB	2: 46:05	Day of birth
FPFINIT	2: 41:05	First initial
FPMINIT	2: 36:05	Middle Initial
FPLINIT	2: 31:05	Last initial
FPCODE	2: 26:02	Record type
FPIDTYP	2: 24:01	ID number type
FPID	2: 23:23	ID number

TABLE 4

4.2.1.3 Output

TESTSRCH 1 output was a disk file containing one-word records formatted as follows:

<u>FIELD</u>	<u>START BIT:LENGTH</u>
Search number (1-50)	47:06
Match Indicator	41:02 0=finger 2 1=finger 2 and 3 2=fingers 2, 3 and 4
ID Type indicator	39:01 0=NYSID, 1=Green
ID Number (NYSID or Green)	38:23
Year of Birth	15:07
Sex Code	08:01 0=male 1=female
FP Score fingers 1, 5-10	07:05
FP Score finger 4	02:01
FP Score finger 3	01:01
FP Score finger 2	00:01

Since multiple searches employing different finger combinations were being executed it was space efficient to produce fingerprint factors at a later stage of processing, i.e., to produce separate records based on fingers being searched.

4.2.2 TESTSRCH 2

TESTSRCH 2 was employed to construct criminal histories for the candidates generated by TESTSRCH 1. Records were eliminated on county code and severity of arrest charge, i.e., only felony or misdemeanor events were considered.

4.2.2.1 Input

1. Candidate list stored in TEST 1 files
2. Data from a disk file, TESTINPUT, consisting of data elements from APPENDIX 7. Records of this file contained:

Field	Word: Start bit: length
Search Number	0: 47:06
ID#/Type	0: 41:24
County Code	0: 17:06
Crime Code	0: 11:04
Other Search Charges	0: 17:08
Crime Year	1: 47:08
Crime Month	1: 39:04

4.2.2.2 Functional Description

TESTSRCH 2 performed the following functions:

1. Accessed criminal history files by ID number.
2. Checked the county code for an event at a NYSID number. If the county code equaled the event county code, examined the record; if not, checked the next record.
3. Eliminated events not indicating a felony or misdemeanor arrest.
4. Eliminated events on the basis of selected charge codes.
5. Constructed so-called arrest histories for chosen events. These were twelve-words in length and contained 12-bit mask indicating an arrest on charge(s) 01-12, from 01 to 24 bi-annual intervals from 1969 through 1980, inclusive.
6. Wrote the records to a disk file.

4.2.2.3 Output

Output of TEST 2 was a computer disk file sorted by search number and ID

number. This file contained data from TEST 1 files and associated arrest histories.

4.2.3 TESTSRCH 3

TEST 3 correlated the records of TEST 2 with probabilities from the files of APPENDIX 3, 4 and 5. These records then contained, for each search number, fingerprint score, probability factors and candidate identifying data (sex, year of birth and ID number).

4.2.3.1 Input

Input to the program was the TEST 2 disk file TESTINPUT disk file and probability files.

4.2.3.2 Functional Description

The program performed the following functions:

1. Read each TEST 2 record.
2. Wrote the arrest history probability associated with each record to its work area. This operation may be interpreted as the programmatic equivalent of the following sentence: The candidate, with ID number X, was arrested for the first time on charge C; q-time units prior to the crime date in question. His/her probability of rearrest on the crime charge/crime date and crime place is p. The program locates "p" in the probability file.
3. Determined the sex code probability for each record's candidate's age/sex and search numbers crime code.
4. Determined the age probability for each record's candidate's age, sex, region and crime code.
5. Constructed a disk file, described below.
6. Continued to TEST 2 exhaustion.

4.2.3.3 Output

Output of TEST 3 is a disk file containing the data elements listed below:

<u>FIELD</u>	<u>WORD/BITS</u>
Word 0, Test 1	0: 47:48
Age Probability	1: 47:48
Sex Code Probability	2: 47:48
Arrest History Probability	3: 47:48

4.2.4 TESTSRCH 4

TESTSRCH 4 was the vehicle for $\bar{\lambda}$ determinations. After benchmark determination, λ vectors were input to the program by punched card. Hard copy was produced as described below.

4.2.4.1 Input

Input to the program was:

1. λ - vectors
2. TEST 3 data files

4.2.4.2 Functional Description

The program performed the following functions:

1. Read each TEST 3 record
2. Computed S_2 , S_3 and S_4
3. Computed S
4. Wrote the S_i , S and record identifiers to a disk file
5. Sorted the file by search number and S within search number
6. Counted the number of records above and below the input record
7. Computed the mean of the S_i and S above and below the input record
8. Wrote to hard copy

4.2.4.3 Output

Sample output is given in APPENDIX 9. Output consisted of:

1. Sorted candidate list with ID numbers, the score factors and total score.
2. The average value of the score factors, above and below the target candidate.

5.0 Test Procedure

Recall that the test sample was denoted by Ω and the same target candidates were searched on finger 2, fingers 2 and 3 and fingers 2 through 4. Let Ω_1 , Ω_2 , and Ω_3 , be the one, two and three-finger search samples generated from Ω . Search numbers 01 through 50 are assigned to Ω_1 , 51-100 to Ω_2 , and 101-150 to Ω_3 .

$$\text{Let } T_1 = \sum_{i \in \Omega_1} \lambda_i \quad T_2 = \sum_{i \in \Omega_2} \lambda_i \quad \text{and} \quad T_3 = \sum_{i \in \Omega_3} \lambda_i$$

Clearly: $T = T_1 + T_2 + T_3$. This is done to tabulate the search methods effectiveness on one, two and three-finger searches separately.

The following procedures were executed:

1. Set $\lambda_0 = (1,0,0,0)$ and count the number of equiprobable candidates such that $S_1=0$, by search number. Since the candidate mix agrees on fingerprint data and no other factors are considered, the expected mean list position of the target records is the list mid point. Consequently, $\frac{1}{2}T(\lambda_0)$ was taken as benchmark.
2. Initialize at some λ_1 and compute:
 - $T_1(\lambda_1), T_2(\lambda_1), T_3(\lambda_1), T(\lambda_1)$
 - $(T(\lambda_0) - T(\lambda_1))$
 - $(T(\lambda_0) - T(\lambda_1)) / \frac{1}{2}T(\lambda_0)$

The T_i 's are the sum of 1, 2 and 3-finger searches. $T(\lambda_0) - T(\lambda_1)$ is the difference between the benchmark value and the value at λ_1 . The last factor is simply the percent increase or decrease over the benchmark value.

3. λ_2 and successive vectors were generated after examination of TEST 4 output. The social factors were varied one at a time until a local minimum was found for each. The next factor was then varied in the vicinity of that minimum. The process continued until an apparent global minimum was noted.

4. Although the function was clearly periodic, this was empirically verified.

5.1 Results

The test results are given in TABLE 5. With $\lambda=(1, 12, .5, 3)$, $T=24489$.

$\frac{1}{2}T(\lambda_0)=37950$; therefore, an increase of 35.47% over expected value was obtained.

It appeared that certain search numbers biased the overall performance. The test procedures were executed with search numbers 2, 3, 4, 44, 45, 46, 47 deleted. These search numbers correspond to charge categories Murder and Arson.

In this case we computed $\frac{1}{2}T(\lambda_0)=27228$. The global minimum appeared to be at $\lambda=(1, 6, .5, 7.5)$. An improvement of 51.92% over expected value. Data for these values of T appears in TABLE 6.

In application, the actual distribution of target candidate list positions is a useful criterion for evaluation of a search algorithm's effectiveness. The distributions for $T(1, 6, .5, 7.5)$ and $T(1, 12, .5, 3)$ are given in TABLE 7.

5.2 Discussion

Abstract considerations of a search algorithm performance in themselves have small impact in the operational environment. To the latent fingerprint examiner, the "bottom line" is simply: "How many identifications can we expect (at a fixed input level) using a system based on this algorithm?" For the manager, questions of cost/benefits are germane, i.e., -"What is the mean cost total per identification (for some fixed time interval) for the system?"

5.2.1 Search System Environment

Some background material is necessary to reply to such questions. At DCJS, there is a mean discrepancy of at least magnitude 1 on ridge counts when the same rolled fingerprint impression is classified by different examiners or on impressions from the same subject at different times. The second condition appears to hold even when the same examiner classifies the impressions at different times. There is also a small but real error rate during data entry. It is, therefore,

λ	FINGER 2	FINGERS 2,3	FINGERS 2,3,4	TOTAL	CHANGE	% CHANGE
1,0,0,0	69956	5404	540	75900	-	-
1,1,1,2	28006	2606	202	30814	7136	.1880
1,1,1,4	27492	2091	196	29716	8234	.2170
1,1,1,6	26965	2010	176	29151	8799	.2319
1,1,1,12	27181	2129	186	29949	8001	.2108
1,1,1,9	27099	2113	183	29415	8545	.2252
1,1,1,7.5	27021	2099	176	29299	8721	.2280
1,1,1,6.5	26989	2048	174	29211	8739	.2303
1,1,2,2	36548	3524	234	40342	-2392	-.0630
1,1,.5,2	26185	1898	143	28226	9724	.2562
1,1,.25,2	26641	1909	156	28706	9244	.2436
1,1,.75,2	26584	1910	144	28638	9312	.2454
1,1,.5,3	25561	1949	136	27646	10304	.2715
1,1,.5,4	25873	1930	172	27975	9975	.2628
1,1,.5,6	26139	1997	201	28337	9613	.2533
1,1,.5,7.5	26337	2015	198	28550	9900	.2977
1,1,.5,3.5	25746	1939	177	27862	10880	.2658
1,1,.2,7.5	26983	2036	169	29188	8762	.2309
1,1,.4,7.5	26908	1989	161	29055	8895	.2344
1,2,.5,3	25005	1986	191	27192	10758	.2835
1,2.5,5,3	24456	1974	186	26716	11234	.2960
1,3,.5,3	24480	1859	200	26539	11411	.3007
1,3.25,.5,3	24269	1977	201	26447	11503	.3031
1,3.5,.5,3	24100	1983	224	26307	11643	.3068
1,4,.5,3	23838	1862	198	25896	72056	.3173
1,4.5,.5,3	22643	1967	208	25815	12132	.3197
1,9,.5,3	22497	1860	230	24617	13333	.3513
1,6,.5,3	22677	1901	199	24777	13173	.3471
1,12,.5,3	22296	1949	244	24489	13461	.3547
1,11,.5,3	23074	2088	258	25420	12788	.3370
1,15,.5,3	22695	2018	249	24962	12988	.3422
1,13.5,.5,3	22394	1972	238	24624	13346	.3517
1,12.5,.5,3	22314	1951	245	24510	13340	.3542
1,12,.5,7.5	22401	1963	246	24510	14390	.3567

TABLE 5

	FINGER 2	FINGERS 2,3	FINGERS 2,3,4	TOTAL	CHANGE	% CHANGE
1,0,0,0	49094	4869	493	54456	-	-
1,1,1,2	15353	1746	157	17256	9972	.3662
1,1,1,4	14632	1140	128	16067	11161	.4099
1,1,1,6	14149	1280	117	15546	11682	.4290
1,1,1,12	14467	1188	155	15810	11418	.4193
1,1,1,9	14438	1042	164	15644	11584	.4254
1,1,1,7.5	14241	1079	163	15483	11795	.4314
1,1,1,6.5	14199	1278	123	15520	11708	.4250
1,1,2,2	22183	2341	183	24707	2521	.0926
1,1,.5,2	14084	1081	146	15311	11917	.4377
1,1,.25,2	14171	1099	155	15425	11803	.4335
1,1,.75,2	14178	1109	154	15441	11787	.4329
1,1,.5,3	14059	1075	146	15280	11948	.4388
1,1,.5,4	13938	1038	139	15115	12118	.4449
1,1,.5,6	13829	1009	145	14983	12295	.4497
1,1,.5,7.5	13824	1012	135	14971	12253	.4502
1,1,.5,3.5	13937	1035	140	15112	12116	.4449
1,1,.2,7.5	14648	1103	168	15919	11309	.4153
1,1,.4,7.5	14281	1103	136	15520	11708	.4250
1,2,.5,3	13545	1018	137	14700	12528	.4601
1,2.5,5,3	13280	1020	136	14436	12792	.4698
1,3,.5,3	13081	1027	141	14248	12980	.4767
1,3.25,.5,3	12911	1028	149	14088	13190	.4826
1,3.5,.5,3	12746	1031	148	13925	13323	.4886
1,4,.5,3	12515	1039	156	13710	13718	.4965
1,4.5,.5,3	12337	1038	160	13535	13693	.5029
1,9,.5,3	12899	1097	165	14111	13117	.4817
1,6,.5,3	12448	1041	157	13645	13582	.4988
1,12,.5,3	12945	1058	163	14166	13062	.4798
1,11,.5,3	13358	1119	181	14658	12570	.4616
1,15,.5,3	13148	1039	151	14438	12890	.4734
1,13.5,.5,3	13049	1043	147	14239	12989	.4770
1,12.5,.5,3	13981	1037	145	14163	13065	.4798
1,6,.5,25	11884	1046	161	13091	14137	.5192
1,12,.5,25	12628	1218	195	14041	13187	.4843
1,9,.5,7.5	12185	1096	179	13459	13769	.5057
1,7.5,.5,25	12383	1072	170	13625	13603	.4996

TABLE 6

LIST SIZE	Ω T(1,12,.5,3)			Ω T(1,6,.5,7.5)		
	FINGER 2	FINGERS 2,3	FINGERS 2,3,4	FINGER 2	FINGERS 2,3	FINGERS 2,3,4
< 100	17	37	44	14	34	37
200	5	4		6	3	
300	4	3		3		
400	1			1		
500	3			4		
1000	7			9		
1500	3			1		
2000	1					
2500	2					
3000						
> 3000	1					
TOTAL:	44			37		

TABLE 7

unlikely that there will be exact agreement between the classification of a set of impressions on two occasions. For an arrest print system, this presents manageable difficulties if the aggregate difference is small. The algorithms employed are sufficiently insensitive to small discrepancies in ridge count to produce a high-confidence candidate list of usable size.

Unfortunately, the circumstances are not as favorable for latent impressions. The following factors are relevant:

1. Poor Quality Lifts

The crime scene prints are often taken from rough, moist or otherwise inhospitable surfaces. Ridge definition suffers accordingly. In such cases, a large ridge count tolerance may be desirable.

2. Print Fragments

Portions of the pattern area may be missing or unusable. If the core area is missing, a computer assisted search is not feasible. If, however, a small region about the delta is missing, a good lower bound on ridge counts can sometimes be made. The print would be searched with a tolerance between the lower bound and 26.

3. Ambiguous Pattern Type

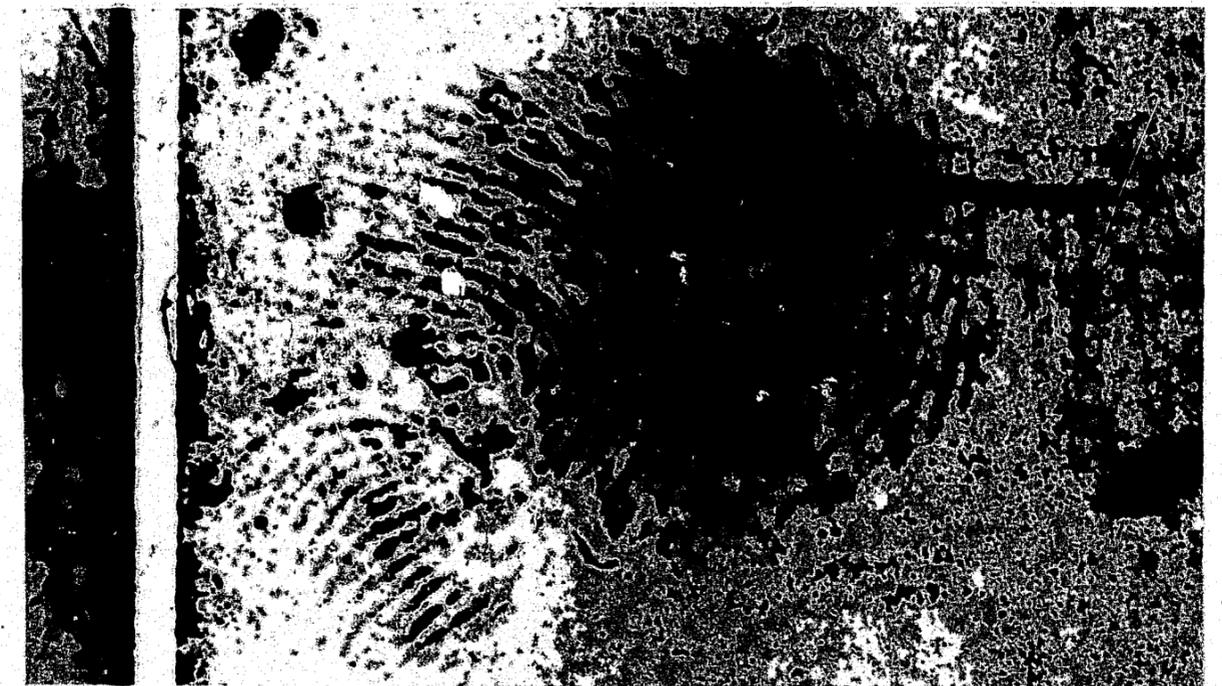
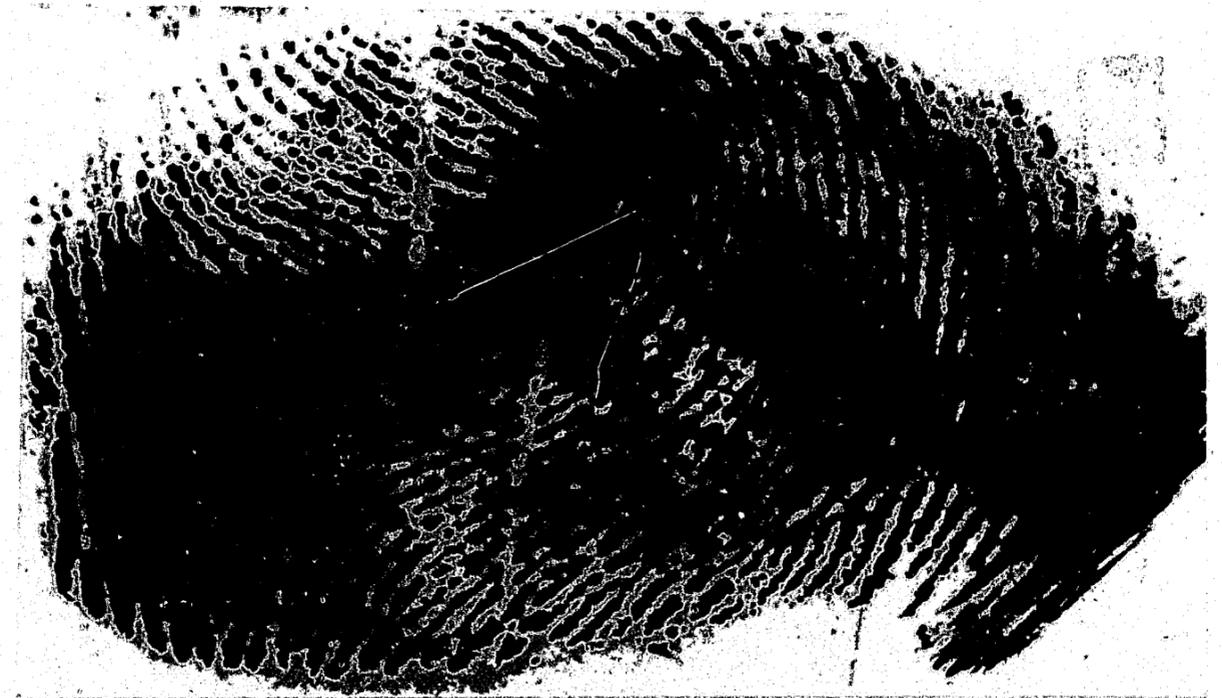
In some cases, the pattern type must be referenced, i.e., the print must be searched as two separate pattern types.

Examples of both good and poor latent impressions are presented in FIGURE 2.

Searches of some poor prints are desirable if there are sufficient minutia present to make an identification binding in court proceedings. The search algorithm, in short, should be able to search at least some poor prints.

The difficulties inherent in using a large ridge tolerance are dependent on the portions of FPMMASTER being searched. The largest single pattern type combination in the file is all ulnar loops. A ten-finger search in that portion

FIGURE 2



of the file, discriminating on pattern type alone, would output about 4% of the file. A single ulnar loop on any finger with a large ridge count tolerance would generally produce an even greater number of retrievals.

5.2.2 Rationale for λ_1

For the above reasons, λ_1 , was tentatively assigned a value of 1. Post implementation testing may dictate a greater or lesser value, as appropriate. It appears, however, that a larger value would drive target records to unreachable portions of the output list.

6.0 Evaluation Criteria

The DCJS R and D Bureau has adopted the mean total cost/identification as quantitative criteria for system evaluation. This quantity has been chosen for the following reasons:

1. It provides an estimate of what the agency "buys" for its money.
2. It produces an aggregate measure of diverse factors such as staffing level, hardware cost and other dedicated agency resources.
3. It is readily employed into formula relating it to staffing level and system performance levels (see SECTION 7).

Management is, however, also concerned with qualitative factors discussed in SECTION 7.1 of this document.

With the discussion of the difficulties inherent in the search process of SECTION 5.2 and the criteria of this section, we can now evaluate the potential use of the algorithm within a DCJS operating unit.

7.0 A Performance Model

The model presented in this section relates the total number of identifications to the cost per identification. As previously stated, R&D has adopted the mean total cost/identification as quantitative objective function. Cost factors for the Special Services' Unit are:

1. Salaries for unit staff
2. Fringe benefits
3. Cost of dedicated computer resources
4. Floor space rental
5. Dedicated equipment cost
6. Support Cost

Let X_1 denote the number of examiners;

X_2 denote the number of clerical support staff;

X_3 denote the number of clerical line supervisors;

X_4 denote the number of clerical level two supervisors;

X_5 denote hours of computer usage for system programs.

Let C_1 through C_4 denote the aggregate salaries and fringe benefits for X_1 through X_4 , respectively; C_5 denote the cost/hr for computer usage and C_0 unit support cost.

$$\text{Then: } C = C_0 + \sum_{i=1}^5 C_i X_i \quad (8)$$

Let I denote the number of identifications per unit time made on the basis of system generated retrievals. I is functionally related to the number of cases received, the system performance, the ratio of searchable to unsearchable prints and management established work conditions, discussed below.

If V cases are received per unit time, then:

$V = V_1 + V_2 + V_3$ where V_1 denotes computer searchable impression, V_2 unusable impression and V_3 denotes impressions identifiable only if a suspect

is provided by the submitting agency. For discussion of the objective function, we restrict attention to V_1 for the following reasons:

1. V_2 impressions are disposed of quickly by form letter.
2. V_3 impressions do not occupy the examiner's time, they are disposed of by senior personnel.
3. V_3 identifications are not included in system evaluations, since they are not computer generated.

In general then: $I = SV_1$ where $S \in (0,1)$ is the system performance factor.

S is empirically determined and is simply the percent of searchable prints identified per unit time.

$$\text{The mean total cost is then: } \bar{C} = C/I \quad (9)$$

Some simplifications are possible. The Special Services' Unit, by virtue of its salary grade structure has a unit head and line supervisor(s). Consequently, $X_4 = 1$. A single line supervisor can effectively discharge his or her function for a staff larger than agency resources permit in the foreseeable future. In similar fashion, a single clerical employee can support such a staff. We set $X_2 = X_3 = 1$.

Equation (8) then becomes:

$$\text{Cost} = C_0' + C_1 X_1 + C_5 X_5 \quad (8A)$$

$$\text{Where } C_0' = C_0 + C_2 + C_3 + C_4$$

Computer cost in the DCJS time sharing environment is taken at \$150/hr. The system run times are approximately:

1. 3 hrs/week for PO/LTN/FINDER
2. 3.5 hrs/day for PO/LTN/SEARCHER (estimated)
3. .5 hrs/week for front-end data entry (estimated)

Searcher can execute up to 10 (possibly 20) distinct searches per run and processing time is substantially unaffected by the number of searches within these bounds. If input is sufficient to warrant daily runs, processing cost is

constant for purpose of calculations.

The cost of secondary storage is not included since permanent system files occupy a small amount of space. Estimated cost/year for computer usage is:

$$21 \text{ hrs/week} \times \$150/\text{hr} \times 52 \text{ weeks/yr} = \$163,800$$

In practice, management controls the working environment and C in the following ways:

1. Set V by soliciting or declining submission from police agencies within New York State.
2. By establishing the number of retrievals compared per case - or
- 2A. By establishing a desired probability of identification at established confidence level for the main search program.

Consider list containing $50z$ candidates such that $z=1, 2, \dots, M$ and where M is the integer such that all target candidates appear in a candidate list containing equal to or less than $50z$ candidates.

With each incremented list size ($50, 100, \dots, 50M$) associate the probability of identifying a target candidate from a known sample.

Let $\Omega^1 = \Omega - \{x | x \text{ is a sample element corresponding to "Murder" or "Arson"}\}$ Ω^1 is a subset of the original sample, Ω .

For Ω^1 , the probability of identification of a target candidate after comparison of $50z$ candidates is given below.

LIST SIZE	PROBABILITY- P_i	LIST SIZE	PROBABILITY- P_i	LIST SIZE	PROBABILITY- P_i
50	.351	500	.703	950	.973
100	.351	550	.730	1000	.973
150	.432	600	.784	1050	.973
200	.541	650	.811	1100	.973
250	.568	700	.811	1150	.973
300	.595	750	.892	1200	.973
350	.595	800	.892	1250	.973
400	.649	850	.912	1300	.973
450	.676	900	.912	1350	.973
				1400	1

Denote this correspondence by L .

A graph of list size versus probability is given in FIGURE 3. Values were derived under idealized conditions in the following sense:

1. Exact ridge count data was input.
2. Finger positions were known.
3. Candidates were known to be on file.

The actual probability will be lower. As a first approximation, the number of retrievals compared for a value of P_i will be multiplied by a factor of 6. Experience with the implemented system will determine the actual multiplier.

Management can select a value of L . The maximum work load can then be estimated. As an example, let $P_i=.3$. Then, the number of retrievals compared per case is $50 \times 6 = 300$.

Data compiled at DCJS indicates the mean time to visually compare two impressions is 10 seconds. We can set the time for comparison of a fingerprint card to a latent impression at 2 minutes. In some cases, i.e., where the latent is of low quality, this will not hold and processing slows. It is useful, however, as a first approximation.

We assume the following:

1. Examiners work productively 6 hours per work day.
2. Three hours/day is spent comparing impressions.

An examiner can, therefore, be expected to complete 1.5 searches per work week. Management then has three alternatives:

1. To set an upper bound on V consistent with current staffing.
2. To allow a backlog that will tend to grow if V is approximately constant over time and greater than throughput capacity.
3. To set the number of examiners consistent with chosen P_i and V .

An example will illustrate the third case. Let $P_i=.3$ and set $V=275/\text{year}$. At DCJS, studies indicate an examiner will be productively employed 1350 hours/yr.

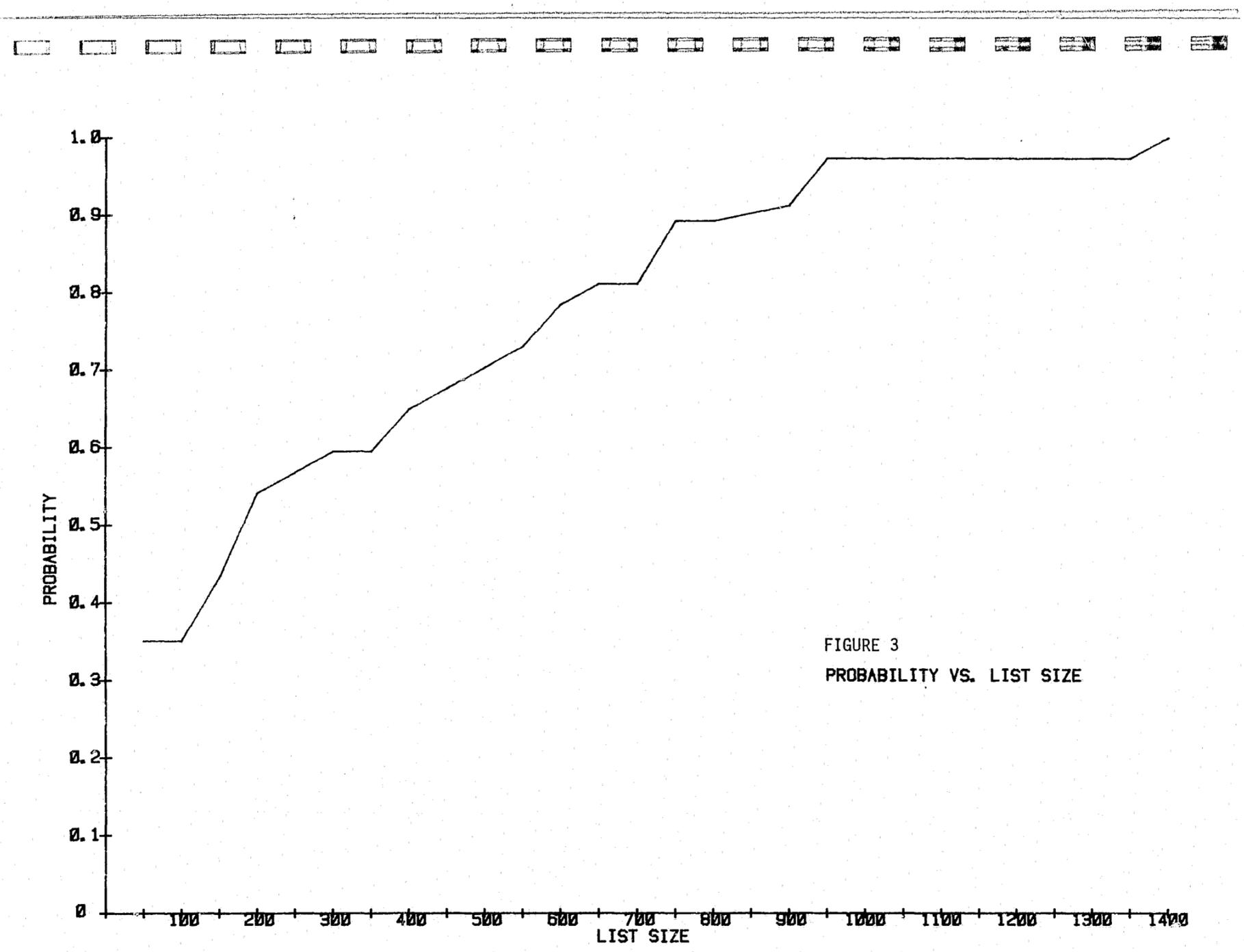


FIGURE 3
PROBABILITY VS. LIST SIZE

Of this, 675 hours will be in the comparison process. Approximately 68 searches can be completed per year per examiner. This necessitates four examiners for this value of V and P_i .

If 50% of the suspects are on file, $V=275$ and $P_i=.3$, we can expect $I=137 \times .3=42$ main search identifications/yr. Batch search identifications will contribute to the system totals. At this time, we have little hard data, but based on performance for the pilot system, we can estimate a minimum of 8 per year.

Cost calculations and data with fringe benefits at 30% of salaries follows:

1 - unit head (G-23) at \$26,371 + .3 (26,371)	= \$	34,282
1 - line supervisor (G-14) at \$16,404 + .3 (16,404)	=	21,325
4 - examiners (G-12) at \$14,681 + .3 (14,681)	=	76,341
1 - clerk (G-3) at \$9,144 + .3 (9,144)	=	11,887
TOTAL salaries and fringe benefits	=	\$ 143,835
Floor space rented (850 ft ² x \$6.61 ft ² /yr)	= \$	5,618
Associated computer cost	=	163,800
	C =	\$ 313,253

and $\bar{C} = \$7,349$ (mean total cost/identification).

Comparisons of the R and D to pilot system must be done cautiously.

There are two important factors when comparing the systems:

1. The pilot system used its own smaller data base.
2. In any valid test of its performance, the average pilot system main search target candidate list position will be at the mid-point of the list. Consequently, the number of retrievals must be examiner controlled by restricting parameters such as age, ridge count, sex or race within the county or group of counties to be searched. The relationship between the number of retrievals and probability of a target candidate appearance is, therefore, not the same as that defined by L . With the reasonable assumption that target candidates are randomly distributed in

the output of the pilot system, a test made with the same parameters as in test search would yield an average of 2000 retrievals per search.

Under idealized circumstances, $P_i=.13$ would require examination of 250 candidates impressions. If the same multiplier, 6, was used to account for a larger ridge count tolerance and uncertainty of finger positions, the pilot system would require 1500 comparisons for a probability of identification of only 30% of the R & D System. Consequently, the value of \bar{C} for the pilot system will be about five times that for the new system under the same input constraints.

The calculated value of \bar{C} for the R and D System is "worse case." The "best case" at $P_i=.3$ requires only 50 retrievals. V could be increased to $6 \times 275 = 1620$, and $I=812 \times .3 = 243$ main search identifications per year. With 8 batch search identifications, \bar{C} is less than \$1500.

Also, if $P_i=.10$, as with the pilot system, there will be corresponding decrease in the upper and lower bounds of \bar{C} , assumed to be linear at this writing.

There are other factors to be included in evaluation of unit cost. The value of \bar{C} generated must be interpreted in light of:

1. Identification with suspects and other service provided by the unit are not included in cost calculations above.
2. The inclusion of computer related cost as above is suspect. DCJS pays a fixed annual fee for lease and maintenance of its computer system. Within that fixed cost, resources are allocated in compliance with an established priority system. The latent programs are executed during the evenings where usage is relatively low and, as such, do not normally tax the system in terms of adverse impact on throughput time of other programs. The execution may be viewed as no real dedicated cost to the agency.

The above has provided some insight into projected cost assuming an adequate work load, but actual cost/identification must wait for data

from the first year of operation.

7.1 Qualitative Interpretation

The formula of SECTION 7 gives a simple method of relating system performance to cost in terms of staffing levels. The "model" is, however, silent on other relevant issues including:

1. Interpretation of \bar{C} within DCJS and the criminal justice community in general.
2. Non-system related activities of the Special Services' Unit

Interpretation of \bar{C} is qualitative, i.e., is dependent on management's preception of the DCJS role in assisting line police agencies by means beyond such agency's capacity and on available agency resources. There is, essentially, a political process that incorporates the following factors:

1. Favorable public perception of DCJS in terms of clearance of visible cases.
2. Good will generated within the law enforcement community.
3. A perceived need for continuing effort to control the increase of certain types of crime, most notably Burglary, by clearance through arrest.

At the least, DCJS would maintain an individual with sufficient training to identify impressions against suspect arrest prints and to provide expert testimony in court proceedings. Such an employee would not necessarily belong to a dedicated latent identification unit. Since a relatively small percentage of employee time would be required, this may be considered a (near) zero cost solution.

It suffers from several deficiencies:

1. An impression cannot be identified without suspect.
2. The perceived needs of the law enforcement community and the public are not addressed.

The second alternative is a dedicated staff and a manual system. This

solution buys little. Neglecting computer cost, discussed above, staffing levels would be comparable. At least an order of magnitude decrease in idents could be expected and, as such, the value of \bar{C} would rise markedly.

\bar{C} then is not to be viewed as a "make-or-break" value. Given the qualitative factors, the most effective computer assisted system available within the limitations of agency support hardware and procedures will be embraced. \bar{C} is a measure of ongoing efficiency. In this context, the R and D System will provide great improvement in terms of performance and cost to benefit ratio.

8.0 Implementation

It is recommended that the new R and D Latent System be phased into production at DCJS. At the writing, portions of the system are currently in place and running parallel with the pilot system. Only the main search program is yet to be installed.

System development involved front-end determination of Functional Requirements. Thereafter, administrative, clerical and operating procedures were developed through an interactive process with Special Services' Unit staff members. The implementation process will be done within the scope of the documents resulting from this interaction.

The tasks necessary for system implementation follow:

1. Install the main search (SEARCHER) program. Data entry is through CRT. Forms have been developed to document system usage. R and D staff will provide instruction in data entry, program use and forms completion. As a result of this effort, procedures may change. Documentation will be amended as required.
2. When Special Services' staff has been trained, cases will be selected from the unidentified latent file for main search. Cases will be entered and candidate lists generated. The unit supervisor will assign the lists as time and resources permit.
3. System functional requirements will be verified. It is likely that there will be minor discrepancies between the documented keystroke entry sequence and the actual product as well as in system displayed messages. The documentation will be amended as required.
4. Searcher's on-line performance will be documented by unit staff. Revision to the estimates of SECTION 7 will be made if sufficient data is available.

5. Known target candidates will be searched with entered ridge counts differing from file counts by one through four. This will enable more accurate estimation of system performance and determination of the procedures for best utilization of system output.
6. System documentation will be given to Technical Services. With the system installed, maintenance is not an R and D responsibility. The documentation is extensive and includes program and system specifications and data file update procedures. R and D staff will remain available to provide information as required.
7. The pilot system is removed.

9.0 Enhancements

The system provides an identification capacity not previously attained at DCJS. With existing staff and funding, enhancements are possible that may further improve performance and, accordingly, reduce cost.

9.1 Image Processing

As previously discussed, a major difficulty in the latent print process at DCJS is the discrepancy between master file and latent impressions ridge counts. Suggestions for improving accuracy of the arrest system are beyond the scope of this document. It is, however, possible to improve the ridge counting and pattern classification of latent impressions by use of the digital imaging system installed at R and D.

An algorithm would be developed to enhance image contrast and "clean up" blurred portions of the impression. This project is technically feasible but would require substantial staff time.

Once done, use of the R and D equipment could be scheduled for production environment testing. If the cost/identification ratio was sufficiently improved, management could be provided the data necessary for consideration of purchase of production-oriented imaging equipment.

9.2 Soliciting Better Prints from Police Agencies

It has been noted by Special Services' staff that the quality of submissions from line agencies varies greatly. The latent print process has an unfavorable input to identification ratios and, as such, some police department administrations believe their resources are better directed elsewhere.

DCJS can enhance its identification capacity by the design and implementation of a program to advise line agencies of our capacities and provide data relevant to the evidence gathering process.

In effect, the agency can solicit computer searchable prints and provide the

data necessary to police agencies to obtain them.

9.3 Data Base Modifications

The production latent fingerprint search program is, of necessity, cumbersome. Its structure was dictated by the necessity of utilizing the DCJS master fingerprint file and the CCH data base.

The fingerprint search is done prior to examination of CCH records. In the latter process, records are eliminated on location code, race code and search charges. Substantial process and I/O time are expended in examination of these records.

Throughput time could be substantially reduced in two fashions:

1. Inclusion of an arrest county indicator in the master fingerprint file - or
2. Creation of a county index set for the CCH data base.

In the first case, the order of the search would remain unchanged (fingerprint to CCH), while in the latter the CCH file would be accessed by county code and, therefore, the arrest fingerprint file by ID number.

An in-depth discussion is beyond the scope of this document and will not be given. The area is, however, worthy of exploration.

PART II

10.0 Application of the Documentation in Other Environments

The information contained in the following sections is intended to assist potential system developers in the following areas:

1. Utilization of DCJS documentation.
2. Formulation of a development plan and suggestions for unit staffing.

10.1 Comments on Technology Transfer

On initial examination, technology transfer of a computer system is straightforward. System documentation, or in some cases source code developed in one environment, is implemented in another. In general, the environments may differ in system hardware, operating systems, data base management systems, available programming languages or, in less obvious instances, operating procedures.

The end result is that code developed on one system can seldom be run without modification on another.

Clearly, similar considerations apply to program documentation.

10.1.1 Transfer Categories

Transfer of a computer system can be broadly grouped into three categories:

10.1.1.1 Design

The system possesses a logical structure. In this context, by "logical structure" is meant:

1. Functional Goals or Requirements: The formally stated system purpose and applications can be expressed independently of both the system hardware and software environment. The acquiring agency can, of course, define their own specific objectives to supplement those provided. Fundamental changes, however, may require alterations to system design.

2. Data Requirements: The systems input data requirements are also environment independent. With the latent fingerprint system, for example, the acquiring agency must have or develop a computerized criminal history system to store data elements including offender's reported age, sex and facts concerning arrest. The specific mechanism by which the data is acquired and stored is irrelevant at this level.
3. Program Logic: Program logic can be categorized as environment dependent or environment neutral. Environment dependent logic is used to formulate the interrelations of internal data elements, file structures and sequence of operations specific to the program language.

Neutral logic is, itself, of two forms. It is a code independent description of computational methods expressed in natural language or mathematical symbolism, or a natural language description of the relation of the program's data elements.

The latent fingerprint system is based on a method of ranking persons with an arrest history on the basis of their reported physical and behavioral characteristics. The algorithm is given both as incorporated into DCJS code and in abstract form. The latter version would be employed by an acquiring agency.

10.1.1.2 Functional Components

This transfer level requires similar hardware and utilization of the same compiler/language combination. Existing system specifications can be used for file design. With small revisions, programs are also directly codable from specifications.

10.1.1.3 Turn-key Systems

At this transfer level, source code is re-compiled and executed without modification. In effect, a system is designed for a specific operating environment. In the private sector, business systems can be designed in this fashion and implemented on a specific computer system. In government, a system normally exists within a larger environment, i.e., is one of many running at an installation.

Under the conditions implicit in technology transfer, turn-key system can seldom, if ever, be realized.

10.1.2 Latent System Transfer Category

The Latent Fingerprint Identification System utilizes the resources available at DCJS. There are several system components that will probably not be found in other environments. They include:

1. Computerized Criminal History Records: The system employs the agency's extensive criminal history data in two ways:
 - Formulation of static data files: These files contain probabilities discussed in the system report, which quantify criminal behavior patterns. The data relates to events occurring within New York State. Data derived in other portions of the United States may differ to the extent that the same performance cannot be realized. In any case, the acquiring agency must conduct statistically valid tests similar to those done at DCJS.
 - Creation of "search records": The search program accesses our data base during execution. Records are formatted for use by the scoring algorithm. The information on possible candidates must be present and, therefore, files of similar content are required.
2. Fingerprint System and Files: DCJS utilizes fingerprint pattern type and ridge count (for loops and whorls) to differentiate fingerprint

impressions. Other agencies may use minutia based storage and search systems. If so, the general method employed by DCJS could be used, i.e., ranking candidates on arrest characteristics, but the fingerprint ranking procedure would have to be reformulated.

The potential system developer has been provided exhaustive documentation, exact statements of data required, and mathematical procedures employed in system development. Sufficient data is presented to initiate a sound program, but only level one transfer is attained.

10.2 Staffing a Latent Fingerprint Identification Unit

Currently available technology does not permit machine comparison of latent impressions to arrest fingerprints in the production environment. The human examiner remains central to such operation. At DCJS, the special skills and dedication of these employees has been recognized. The agency has also formalized the Latent Identification Unit's structure and procedures.

10.2.1 Role of the Latent Fingerprint Examiner

The latent fingerprint examiner has been assigned Salary Grade 12 by the New York State Department of Civil Service. Examiners engaged in processing arrest fingerprints are assigned to Salary Grade 9. In this fashion, DCJS has made the acquisition of skills necessary for specialized work financially rewarding.

Within the Civil Service System, tests are given to establish eligibility for appointment. Copies of the examiner's job duties, prepared by the Department of Civil Service, and an examination announcement are given in APPENDIX 10.

10.2.2 Unit Role and Structure

The Special Services Unit performs the following functions:

1. Within the context of administrative procedures, categorizes latent fingerprint impressions received from line police agencies.

2. Inputs data to the computerized identification system.
3. Compares arrest fingerprint cards identified by the system to latent impressions.
4. Effects identification of latent impressions against suspect prints supplied by line agencies.
5. Attempts identification of cadavers by means of agency fingerprint systems.
6. On request, the unit supervisor provides expert testimony in court proceedings.
7. The clerical and administrative procedures mandated by 1 through 6, above.

The unit consists of a unit supervisor, line supervisor, four examiners, and a single support clerk. Estimates given in the system report indicate that this staffing level is sufficient to process 1000 cases per year with a 30% chance of identifying a suspect on file. Of the 1000 cases input per year, an estimated 25% are computer searchable.

The estimates will vary in other environments as a function of the size of the master file(s) searched. Results should be outstanding if the search population is small, i.e., under 250,000. In any case, the developing agency can estimate cost to performance relationship using the model presented in PART 1 of this report.

10.3 Steps Towards a Development Plan for a Latent Identification System

The formulation of a Latent Fingerprint Identification System, based on DCJS descriptors, can be categorized into nine major components. They are:

1. Analysis of system data requirements.
2. Formulation of functional requirements, performance goals and objective function.

3. Determination of staffing requirements.
4. Analysis of hardware and software requirements.
5. Formulation of system specification.
6. Scoring algorithm formulation and testing.
7. Program documentation.
8. Program coding and testing with update of documentation.
9. Implementation and post-implementation testing.

The management and analytic skills prerequisite to the project are assumed. It is also assumed that the system is to be developed in an environment where an arrest fingerprint system exists or is under development and that criminal history data is available as discussed below.

10.3.1 Analysis of System Data Requirements

The search program requires the criminal history record containing offender's:

- sex
- race
- criminal history (charge, place and date)
- fingerprint data

There are four obvious storage requirements for this data:

1. It must be stored on random access devices such as disk.
2. It must be updated regularly, preferably in on-line fashion.
3. Storage system software must link or otherwise correlate all arrest events for an offender.

Criminal history records are also used to create static data files. This date requirement imposes another condition:

4. Criminal history data is available in sufficient quantity and duration to allow valid computation of the probability file elements.

The fingerprint data requirements are not as severe. S_1 can be formulated in terms of operation on descriptors other than ridge count. If an agency, for example, employs a minutia based system, development could proceed in the fashion evolved at DCJS. The relative weight of the factors and program operating characteristics would, however, vary considerably.

10.3.2 Functional Requirements and Objective Functions

After analysis of available data, a decision to initiate the project can be made consistent with the developer's operating and political requirements. Once made, initial functional requirements and system evaluation criteria must be formulated.

10.3.2.1 Functional Requirements

By a system's functional requirements is meant:

1. The set of operations to be performed by the system programs.
2. The human/system interface including all data entry procedures.
3. Output requirements.

At DCJS, a preliminary draft of system requirements was prepared in conjunction with Special Services shortly after project initiation. This document and its many revisions were employed to provide guidelines in preparation of system and program specifications. A copy is included in the documentation package submitted with this report.

10.3.2.2 Evaluation Criteria

It is suggested that the evaluation criteria of SECTION 6 of this report be adopted by system developers. At the outset, however, it may be difficult to assign a specific monetary value to an identification. The objective function, rather, is to be interpreted as a measure of relative performance between systems or as a measure of efficiency.

10.3.3 Staffing Requirements

Staffing requirements are contingent on diverse factors including:

1. Estimated work load, i.e., number of cases per unit time.
2. System performance in terms of identification probability per unit number of retrievals compared.
3. Non-system related function performed by unit staff.
4. Management selected confidence level.
5. The characteristics of the comparison process, i.e., comparison of actual arrest cards to latent fingerprints or one of the automated image retrieval systems currently available.

Factors 1 through 4 are discussed in SECTION 7 of this report. The method of image retrieval is not, but is critical to the latent operation. Studies done at DCJS indicate a digital image storage and retrieval system would improve the comparison time by at least an order of magnitude. The examiner's work load could be increased accordingly.

An agency dedicated to efficient latent print processing should explore the cost and benefits of the various automated systems available.

10.3.4 Hardware/Software Requirements

The developing agency must assess the impact of running a latent system on available resources. At DCJS, several hundred hours of computer time were expended in data extraction and analysis. The search programs routinely examine hundreds of thousands of fingerprint and criminal history records. The actual expenditure of computer related resources is, of course, dependent on the system's final configuration, the hardware on which it is implemented and competition with other agency systems.

10.5.5 Formulation of System Specifications

Implicit in this portion of system formulation is a task plan for development

of the component programs. Such procedures can enhance the efficiency of the development plan. For example, we recognized that the system programs to compare new arrest records to unsolved cases could be designed and implemented in a relatively short time. They were, consequently, installed first. The debugging and test process ran concurrently with the data extraction and analysis programs.

10.3.6 Scoring Algorithm Formulation

Procedures are given in SECTIONS 4 and 5 of this report.

10.3.7 - 10.3.8 Documentation and Coding

Program coding and documentation are, ideally, an interactive process. Since update of data, files and algorithm weights are periodically necessary and it is essential that documentation be thorough and reflect coding.

LIST OF APPENDICES

1. SUMMARY OF DCJS FINGERPRINT DESCRIPTORS
2. DESCRIPTION OF ALGORITHM RH
3. SELECTED GRAPHS OF AGE FREQUENCY DISTRIBUTIONS
4. SELECTED GRAPHS OF SEX CODE MIX
5. SELECTED GRAPHS OF ARREST HISTORY
6. PROBABILITY FILE CONTENTS
7. TEST SAMPLE COMPOSITION
8. TEST SAMPLE FINGERPRINT DATA
9. TEST SEARCH 4 HARD COPY
10. EXAMINER'S JOB DESCRIPTION

APPENDIX 1
SUMMARY OF DCJS FINGERPRINT DESCRIPTORS

FINGERPRINT CLASSIFICATION
TRADITIONAL HENRY-TYPE DESCRIPTORS

I. Pattern Type

The most basic descriptor is the pattern type assigned to each print. Pattern types are divided into three major groups: Arches, loops and whorls. Each of these groups is broken down into subgroups. These subgroups are:

- A. Radial and ulnar loops
- B. Central pocket loop whorl, plain whorl, double loop whorl and accidental whorl
- C. Plain arch and tented arch

The pattern type is determined by the presence and location of the core and delta(s) on the fingerprint impression. This applies to loops and whorls only as the arch group, with several exceptions in the tented arch subgroup, is characterized by the absence of the core and delta(s). The rules, employed by the DCJS operating system for locating core and delta points, are contained in the "DCJS Fingerprint Identification Manual" prepared in 1979. Copies are available upon request.

II. Ridge Count

The ridge count is the numerical value assigned to loop and whorl pattern types. To obtain the ridge count, the core and the delta(s) must be located. After these points are located, a straight line is drawn between them. The number of ridges crossed between these two points are counted and assigned to each pattern.

APPENDIX 2
DESCRIPTION OF ALGORITHM RH

A2-1

S_1 , the fingerprint score factor of the latent search algorithm, was adapted from one developed by R and D statistician, Robert Hall. Mr. Hall's research had a two-fold purpose.

1. To reduce the number of misses on 10-finger searches and
2. To reduce or eliminate dependence on information provided by arrestees such as date of birth and initials.

The algorithm is based on the mathematical concept of a metric or distance function. Given a pattern type combination, the 10 ridge counts, if available, are considered to be points in a 10-dimensional space. The input data provides one "point" and the elements of FPMaster within the input pattern type a set of points to be compared. In terms of the metric used, the closer the points, the more likely a match.

There are several complicating factors:

1. Arches and tented arches have no ridge counts. When these pattern types are present, their contribution to the total distance must be comparable to that for loops and whorls.
2. If the search card or a FPMaster record or both have ridge count data missing, an empirically determined value must be substituted.

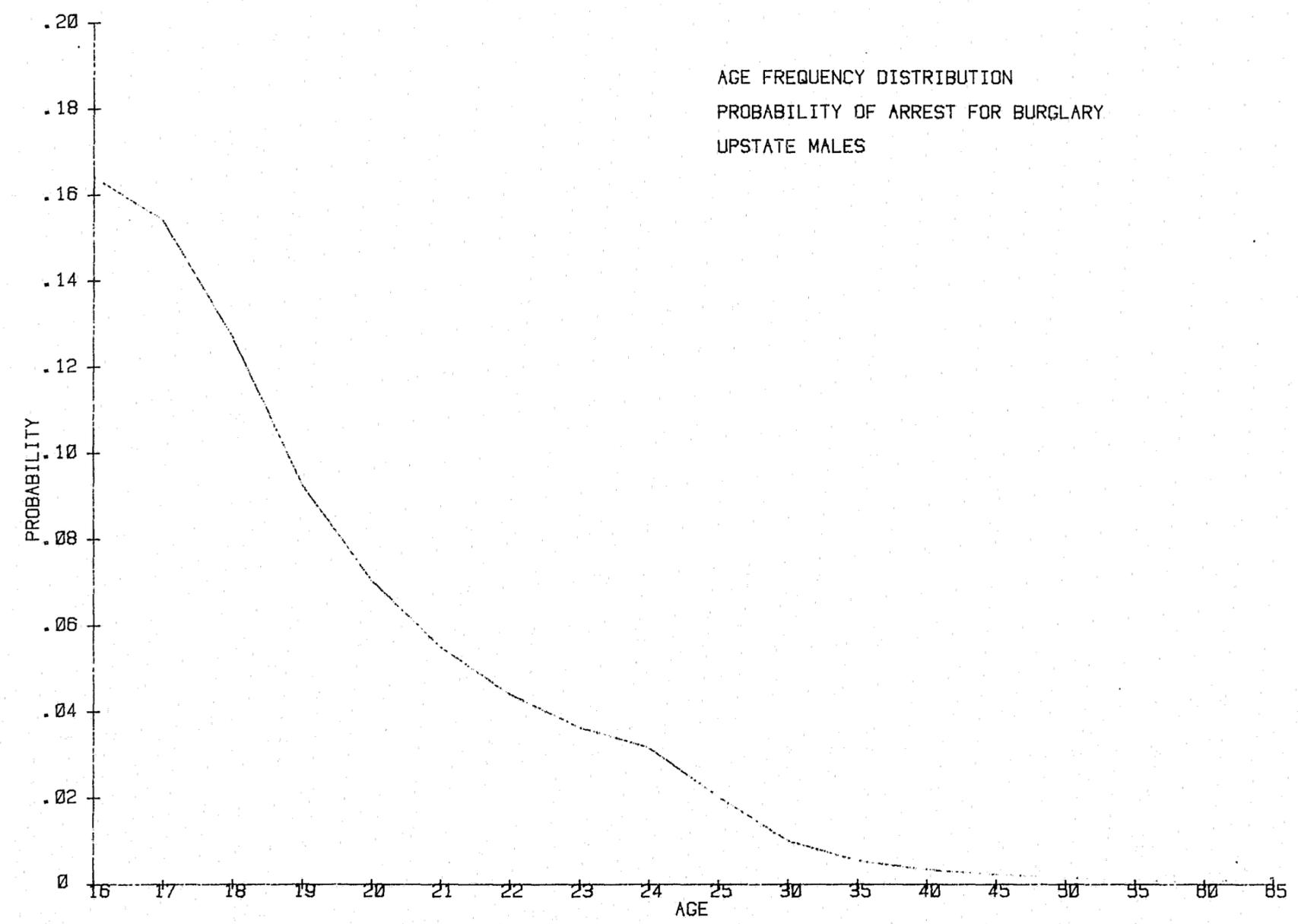
The weighted sum of ridge count differences is a simple distance function that satisfies the desired characteristics. Testing was done and, although time and physical resources prohibited accounting for all conditions that occur, yielded excellent results.

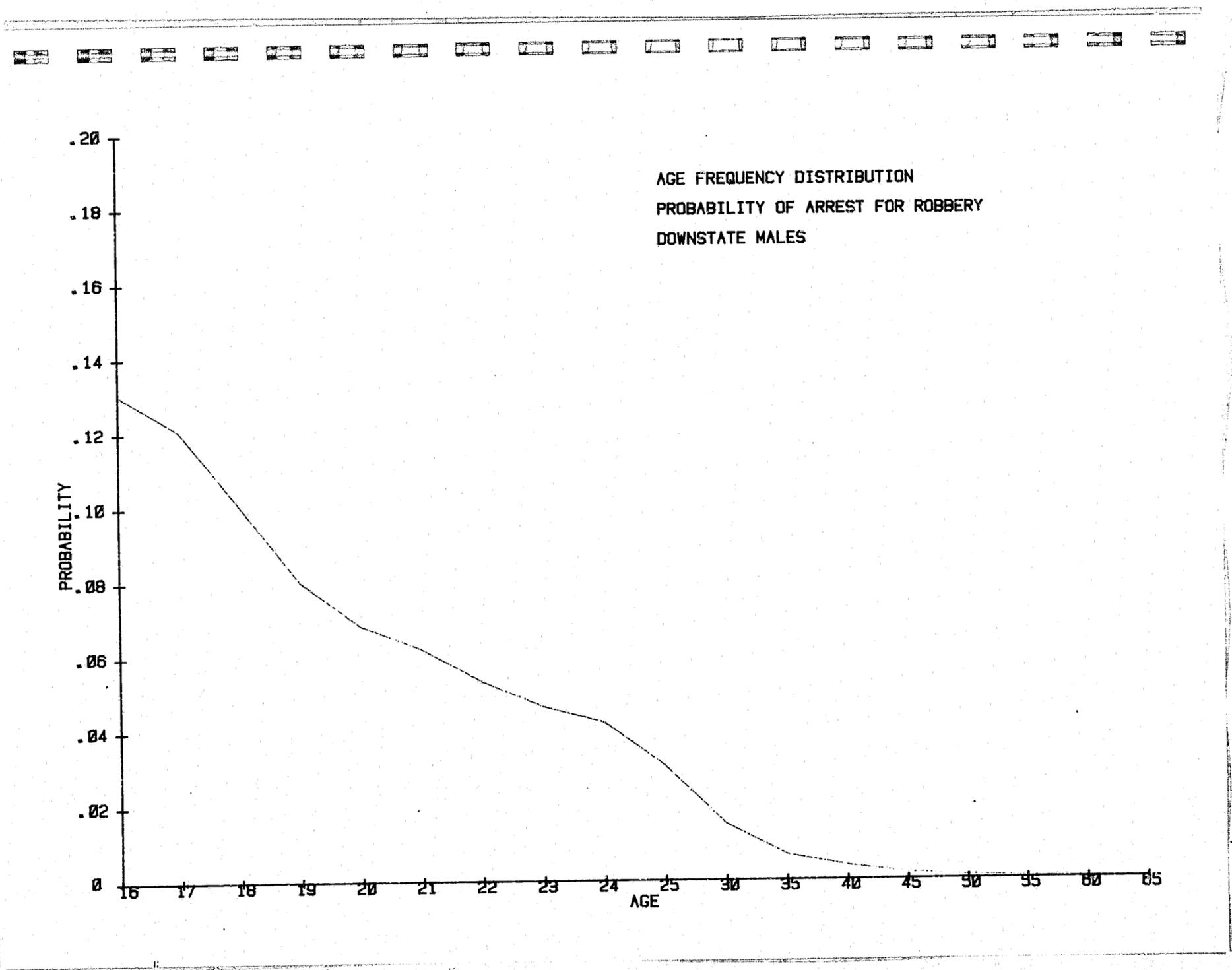
APPENDIX 3

SELECTED GRAPHS OF AGE FREQUENCY DISTRIBUTIONS



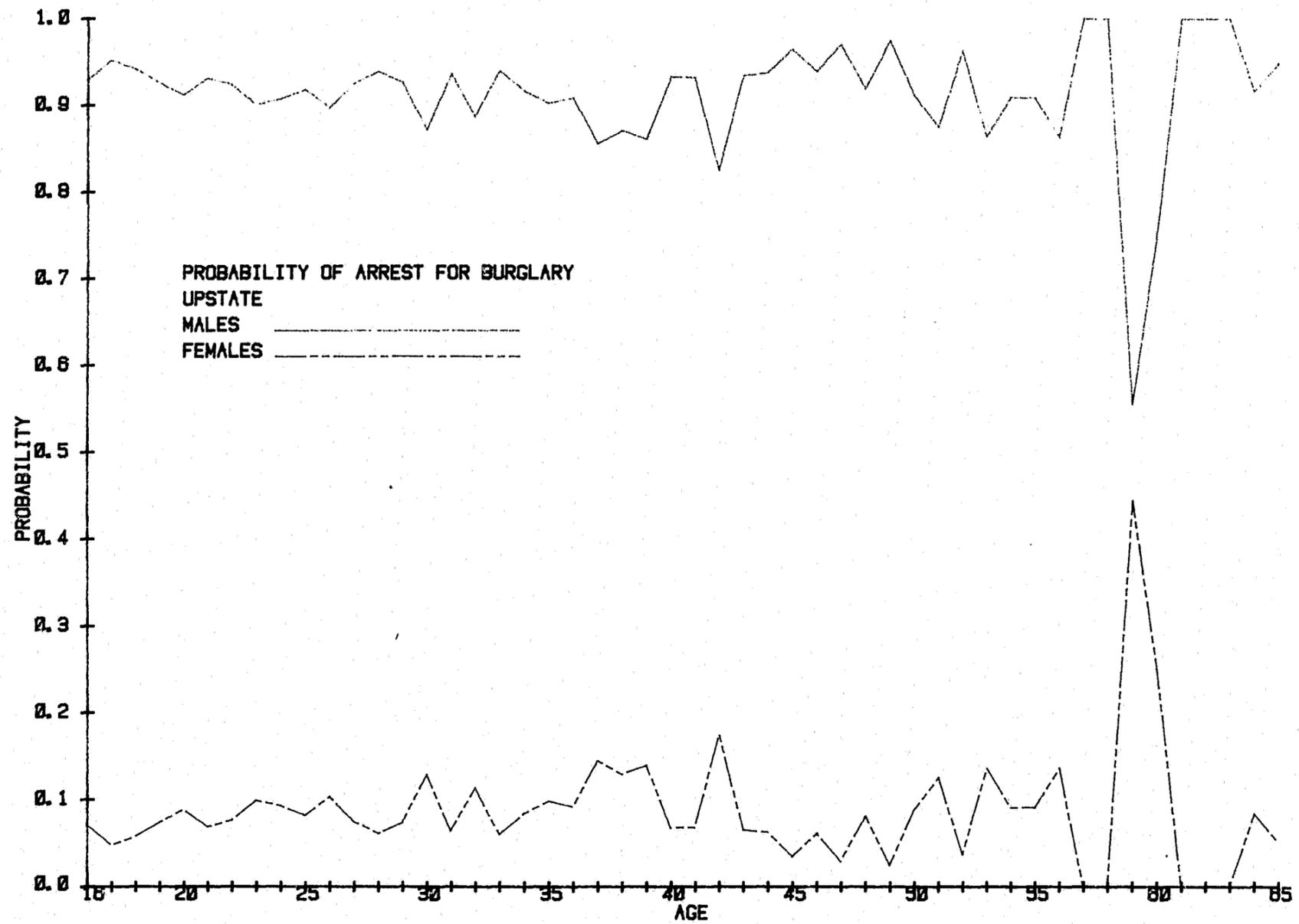
AGE FREQUENCY DISTRIBUTION
PROBABILITY OF ARREST FOR BURGLARY
UPSTATE MALES

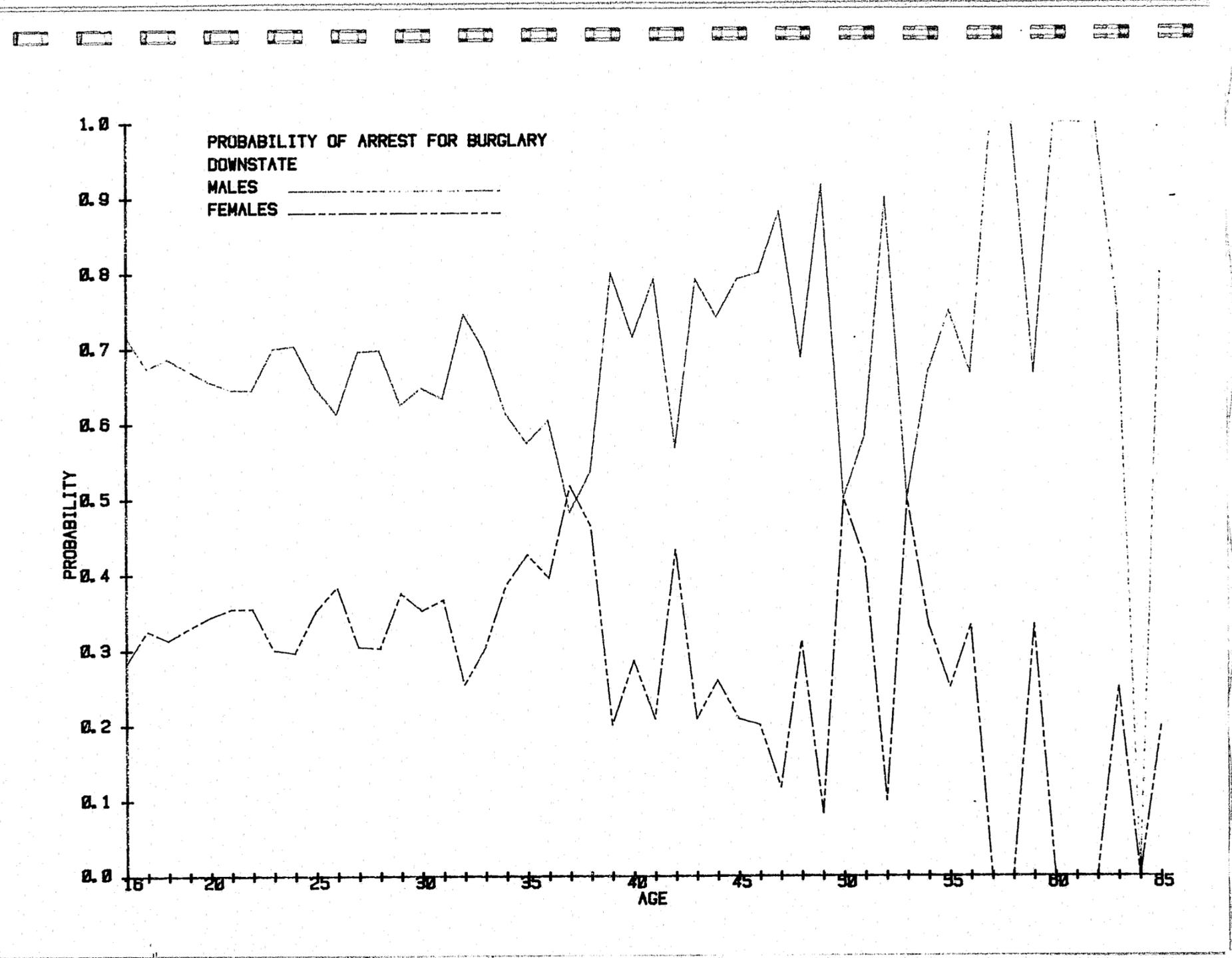




APPENDIX 4

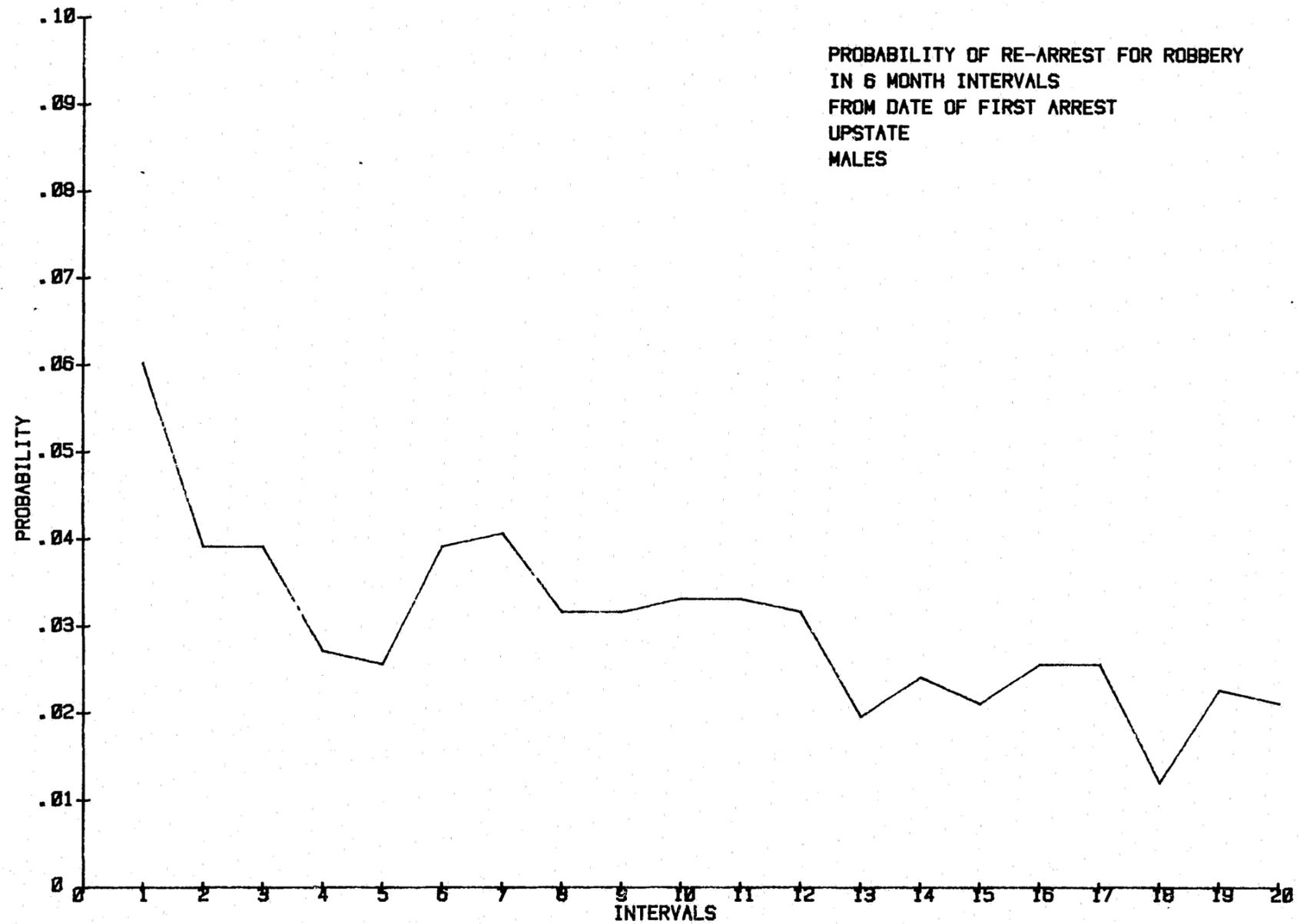
SELECTED GRAPHS OF SEX CODE MIX

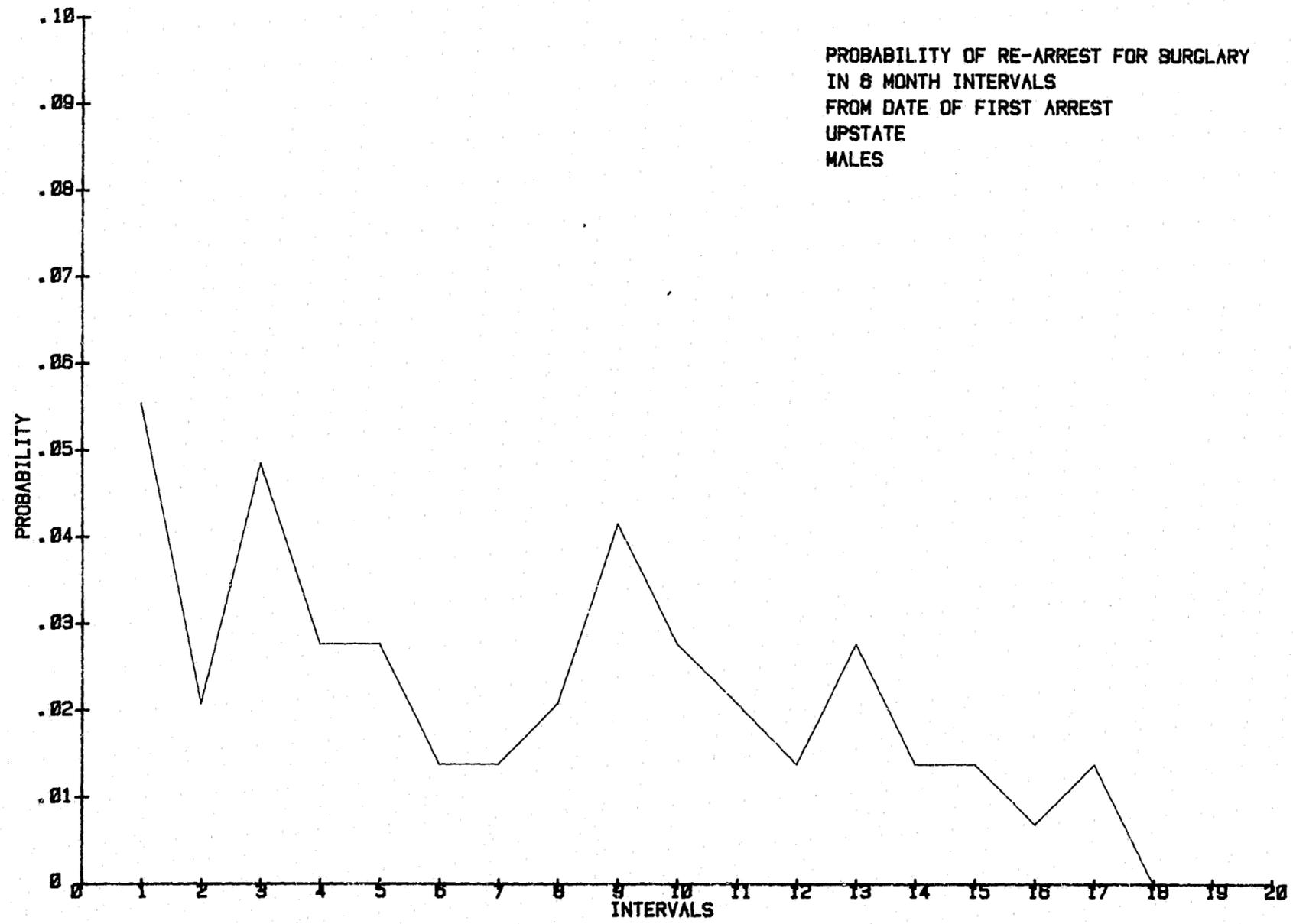




APPENDIX 5

SELECTED GRAPHS OF ARREST HISTORY





APPENDIX 6
PROBABILITY FILE CONTENTS

A6-1

PO/LTN/PROBAG

PROBAG contains age frequency distributions for both sexes, 2 regions and the 12 latent charge codes.

File Specifications

Number of Records: 48

Record Length: 50 words

Format: Record 0: Males, charge code 01, upstate

Record 1: Males, charge code 01, downstate

.
Record 23: Males, charge code 01, downstate

.
Record 24: Females, charge code 01, upstate

.
Record 47: Females, charge code 12, downstate

Record Content: Real numbers in (0,1)

Word 0: Age 16

Word 1: Age 17

Word n: Age (n + 16)

A6-6

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0742	0.0983	0.1030	0.0941	0.0907	0.0835	0.0686	0.0619	0.0538	0.0330
0.0330	0.0330	0.0330	0.0330	0.0122	0.0122	0.0122	0.0122	0.0122	0.0042
0.0042	0.0042	0.0042	0.0042	0.0026	0.0026	0.0026	0.0026	0.0026	0.0013
0.0013	0.0013	0.0013	0.0013	0.0006	0.0006	0.0006	0.0006	0.0006	0.0003
0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000
0.0351	0.0466	0.0571	0.0579	0.0589	0.0645	0.0733	0.0702	0.0666	0.0464
0.0464	0.0464	0.0464	0.0464	0.0206	0.0206	0.0206	0.0206	0.0206	0.0103
0.0103	0.0103	0.0103	0.0103	0.0058	0.0058	0.0058	0.0058	0.0058	0.0035
0.0035	0.0035	0.0035	0.0035	0.0012	0.0012	0.0012	0.0012	0.0012	0.0008
0.0008	0.0008	0.0008	0.0008	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
0.0508	0.0482	0.0609	0.0584	0.0660	0.0635	0.0558	0.0533	0.0406	0.0350
0.0350	0.0350	0.0350	0.0350	0.0228	0.0228	0.0228	0.0228	0.0228	0.0137
0.0137	0.0137	0.0137	0.0137	0.0137	0.0137	0.0137	0.0137	0.0137	0.0086
0.0086	0.0086	0.0086	0.0086	0.0025	0.0025	0.0025	0.0025	0.0025	0.0020
0.0020	0.0020	0.0020	0.0020	0.0010	0.0010	0.0010	0.0010	0.0010	0.0005
0.0390	0.0390	0.0437	0.0516	0.0519	0.0489	0.0500	0.0519	0.0456	0.0398
0.0398	0.0398	0.0398	0.0398	0.0264	0.0264	0.0264	0.0264	0.0264	0.0184
0.0184	0.0184	0.0184	0.0184	0.0132	0.0132	0.0132	0.0132	0.0132	0.0084
0.0084	0.0084	0.0084	0.0084	0.0047	0.0047	0.0047	0.0047	0.0047	0.0025
0.0025	0.0025	0.0025	0.0025	0.0014	0.0014	0.0014	0.0014	0.0014	0.0004
0.0400	0.0556	0.0624	0.0789	0.0712	0.0721	0.0799	0.0595	0.0556	0.0392
0.0392	0.0392	0.0392	0.0392	0.0193	0.0193	0.0193	0.0193	0.0193	0.0113
0.0113	0.0113	0.0113	0.0113	0.0078	0.0078	0.0078	0.0078	0.0078	0.0031
0.0031	0.0031	0.0031	0.0031	0.0027	0.0027	0.0027	0.0027	0.0027	0.0008
0.0008	0.0008	0.0008	0.0008	0.0004	0.0004	0.0004	0.0004	0.0004	0.0000
0.0230	0.0353	0.0590	0.0606	0.0514	0.0621	0.0629	0.0729	0.0613	0.0529
0.0529	0.0529	0.0529	0.0529	0.0261	0.0261	0.0261	0.0261	0.0261	0.0110
0.0110	0.0110	0.0110	0.0110	0.0044	0.0044	0.0044	0.0044	0.0044	0.0046
0.0046	0.0046	0.0046	0.0046	0.0018	0.0018	0.0018	0.0018	0.0018	0.0008
0.0008	0.0008	0.0008	0.0008	0.0003	0.0003	0.0003	0.0003	0.0003	0.0000

A6-7

PO/LTN/PROBSX

PROBSX data elements are probabilities of a candidate at each age from 16 through 65 years, of either sex and upstate or in New York City being arrested on any of the twelve latent system charge classes. "Downstate" is county codes 23, 30, 62, 40 and 42. "Upstate" consists of the other 57 state county codes as specified in TABLE 1. System charge codes are defined in TABLE 3.

File Specifications

Number of Records: 48
 Record Length: 50 words
 Record Layout:
 Record 0: Males, charge code 01, upstate
 Record 1: Males, charge code 01, downstate

 Record 23: Males, charge code 12, downstate
 Record 24: Females, charge code 01, upstate

 Record 47: Females, charge code 12, downstate
 Record Content: Real numbers in (0,1)
 Within a Record: Word 0 is the probability of arrest for age 16; word 1 for age 17; word n for age (16+n).

A6-10

0.8751	0.8738	0.8612	0.8622	0.8411	0.8414	0.8270	0.8247	0.8035
0.8347	0.8238	0.8320	0.8413	0.8526	0.8539	0.8352	0.8348	0.8554
0.8310	0.8413	0.8113	0.8561	0.8667	0.8708	0.8522	0.8442	0.8594
0.8538	0.8824	0.6571	0.8799	0.5294	0.9206	0.6250	0.8667	0.6981
0.9241	0.9155	0.9098	0.9068	0.8994	0.9053	0.8803	0.8690	0.8835
0.8770	0.8689	0.8723	0.8754	0.8854	0.8876	0.8314	0.8569	0.8865
0.8450	0.8047	0.8628	0.8338	0.8542	0.8532	0.8314	0.8433	0.8461
0.8720	0.8044	0.8338	0.8750	0.8444	0.9130	0.8019	0.9204	0.8464
0.8676	0.8525	0.8333	0.8364	0.8444	0.9130	0.4040	0.9204	0.8464
0.7637	0.7840	0.7459	0.7598	0.7747	0.7881	0.7716	0.7778	0.7355
0.8025	0.8084	0.8891	0.8423	0.8879	0.8710	0.8906	0.8537	0.9869
0.9087	0.8598	0.8429	0.9121	0.9239	0.8351	0.8300	0.8571	0.9599
0.9031	0.9750	0.8462	1.0000	0.8839	1.0000	1.0000	0.8571	0.7500
0.9091	0.8000	1.0000	1.0000	0.8839	1.0000	1.0000	0.8571	0.7500
0.3314	0.0333	0.0200	0.0045	0.0281	0.0281	0.0471	0.0476	0.0147
0.0100	0.0332	0.0200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0100	0.0332	0.0200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0100	0.0332	0.0200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.1341	0.1250	0.0580	0.0893	0.0250	0.0250	0.1591	0.1379	0.2000
0.0625	0.2000	0.0714	0.3333	0.0000	0.0000	0.4000	0.3333	0.5000
0.5000	0.2000	0.0000	0.4000	0.5000	0.5000	1.0000	0.3333	0.5000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0448	0.0617	0.1169	0.0685	0.0972	0.1154	0.0769	0.1400	0.1290
0.2963	0.1304	0.1304	0.3182	0.4000	0.4000	0.1111	0.2838	0.2500
0.3350	0.4118	0.3333	0.2000	0.0000	0.3333	0.0000	0.1667	0.1538
0.3371	0.2979	0.3333	0.2000	0.0000	0.3333	0.0000	0.1667	0.1538
0.1101	0.1132	0.0964	0.0909	0.1052	0.1106	0.1099	0.1145	0.1403
0.1489	0.1424	0.1761	0.1443	0.1735	0.1327	0.1522	0.1815	0.1881
0.1581	0.2069	0.1944	0.2103	0.0931	0.1842	0.1891	0.2103	0.1735
0.1849	0.1259	0.1964	0.1146	0.0931	0.1842	0.1891	0.2103	0.1735
0.1163	0.1064	0.0976	0.3158	0.3214	0.6647	0.0741	0.1709	0.1031
0.0565	0.0422	0.0818	0.0549	0.0764	0.0578	0.0727	0.0857	0.0702
0.1159	0.1774	0.1034	0.0459	0.2308	0.2455	0.2000	0.1333	0.2000
0.2143	0.2143	0.2857	0.0000	0.3333	0.3333	0.3333	0.3333	0.3333
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0482	0.0404	0.0424	0.0440	0.0620	0.0579	0.0691	0.0808	0.0713
0.1512	0.0902	0.1005	0.0959	0.1322	0.1260	0.1679	0.0945	0.1111
0.1875	0.1475	0.1552	0.1311	0.1208	0.1176	0.1667	0.1569	0.2222
0.1867	0.1429	0.0468	0.1250	0.1250	0.2500	0.2308	0.2727	0.1818
0.1111	0.0000	0.1111	0.0000	0.0000	0.5000	0.3333	0.1429	0.0000
0.0711	0.0479	0.0578	0.0741	0.0885	0.0690	0.0763	0.0993	0.0821
0.1033	0.0752	0.0613	0.0739	0.1285	0.0641	0.1133	0.0602	0.0929
0.0910	0.1447	0.1294	0.1395	0.0678	0.0682	0.1754	0.0625	0.0909
0.0612	0.0294	0.0811	0.0250	0.0878	0.1250	0.0370	0.0909	0.0513
0.1364	0.0000	0.0000	0.4444	0.2500	0.0000	0.0000	0.0000	0.0000

A6-11

0.2819	0.3260	0.3134	0.3296	0.3442	0.3547	0.3551	0.3004	0.2963	0.3520
0.3873	0.3041	0.3023	0.3750	0.3523	0.3667	0.2540	0.3030	0.3860	0.4259
0.3953	0.5172	0.4634	0.2000	0.2857	0.2083	0.4324	0.2083	0.2593	0.2083
0.2000	0.1176	0.3125	0.0833	0.5000	0.4167	0.1000	0.5000	0.3333	0.2000
0.3333	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.2500	0.0000	0.2000
0.0402	0.0391	0.0609	0.0621	0.0438	0.0497	0.0259	0.0617	0.0512	0.0474
0.0299	0.0172	0.0057	0.0069	0.0077	0.0403	0.0385	0.0098	0.0000	0.0000
0.0000	0.0333	0.0152	0.0000	0.0000	0.0444	0.0000	0.0000	0.0213	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.1183	0.1667	0.2535	0.1098	0.1698	0.1509	0.2051	0.2000	0.1667	0.4500
0.2778	0.2657	0.1600	0.2000	0.2941	0.2000	0.3158	0.3333	0.5455	0.3529
0.3750	0.1000	0.3630	0.1000	0.3385	0.3333	0.0000	0.0000	0.0000	0.4286
0.0000	0.0000	0.5000	0.2000	0.3333	0.0000	0.2000	0.0000	0.0000	0.0000
0.5000	0.0000	0.0000	0.5000	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000
0.2749	0.2610	0.2731	0.3075	0.3224	0.3584	0.3670	0.4073	0.4071	0.4518
0.4563	0.4409	0.4686	0.4825	0.4984	0.5016	0.5107	0.5085	0.4957	0.5139
0.5643	0.5013	0.5239	0.5230	0.5704	0.5466	0.5132	0.5186	0.5441	0.5239
0.5556	0.4118	0.5455	0.5096	0.5053	0.5314	0.5439	0.4694	0.4933	0.5000
0.4750	0.5204	0.4340	0.5000	0.3857	0.5973	0.5313	0.4545	0.3636	0.2967
0.0697	0.0557	0.0490	0.0833	0.0881	0.1022	0.0921	0.1291	0.1167	0.1553
0.1347	0.1233	0.1575	0.2000	0.1441	0.1522	0.1370	0.2353	0.2090	0.2826
0.1846	0.2041	0.1277	0.1591	0.1212	0.1951	0.2308	0.2162	0.1351	0.2000
0.1364	0.2000	0.2105	0.2000	0.1250	0.4000	0.4345	0.0000	0.1250	0.2000
0.1429	0.0000	0.1250	0.0000	0.0000	0.6660	0.0000	0.0000	0.0000	0.1111
0.0612	0.0599	0.0641	0.1197	0.0954	0.0664	0.1261	0.0928	0.1273	0.1406
0.1478	0.1504	0.2000	0.2083	0.1084	0.2093	0.2468	0.1538	0.1522	0.2273
0.3077	0.0714	0.1724	0.1379	0.1389	0.0769	0.1667	0.0388	0.0714	0.0000
0.1333	0.2143	0.2000	0.2500	0.0000	0.0000	0.1250	0.1538	0.3333	0.0000
0.2000	0.0000	0.5000	0.1667	0.0000	0.1429	0.0000	0.0000	0.0000	0.1333
0.1034	0.1148	0.1209	0.1131	0.1296	0.1202	0.1425	0.1550	0.1490	0.1530
0.1428	0.1488	0.1462	0.1462	0.1676	0.1527	0.2070	0.1951	0.1724	0.1782
0.1800	0.1550	0.1730	0.1755	0.1793	0.1802	0.1662	0.1425	0.1536	0.1860
0.1659	0.1711	0.1169	0.1688	0.1677	0.1644	0.2061	0.1538	0.1803	0.1667
0.1881	0.1735	0.1154	0.2000	0.1818	0.1250	0.1515	0.0750	0.1143	0.0857
0.1352	0.1345	0.1327	0.1308	0.1306	0.1391	0.1182	0.1312	0.1568	0.1242
0.1449	0.1517	0.1455	0.1552	0.1301	0.1618	0.1189	0.1548	0.0853	0.1622
0.1571	0.1512	0.1286	0.1277	0.0909	0.2500	0.0930	0.0556	0.1143	0.2692
0.1333	0.0000	0.1176	0.0588	0.0000	0.0000	0.1000	0.1875	0.0000	0.2500
0.5455	0.6667	0.0000	0.2000	1.0000	0.0000	0.0000	0.0000	0.0000	0.1538
0.1005	0.1019	0.0930	0.1038	0.1328	0.1533	0.1440	0.1353	0.1725	0.2252
0.1694	0.1975	0.2258	0.1872	0.1771	0.1728	0.1417	0.2296	0.1584	0.2500
0.1529	0.2535	0.2388	0.1887	0.3125	0.1316	0.1321	0.1724	0.2333	0.1316
0.2407	0.1944	0.1944	0.1818	0.3158	0.0800	0.0952	0.2500	0.0667	0.0455
0.1000	0.1818	0.0625	0.0000	0.0000	0.0000	0.0000	0.2000	0.0000	0.1852
0.1932	0.1805	0.1990	0.2055	0.2378	0.2343	0.2797	0.2761	0.2604	0.2893
0.2879	0.3075	0.2503	0.2807	0.2409	0.2823	0.2568	0.2959	0.3054	0.2924
0.3011	0.3012	0.3182	0.3154	0.3140	0.3286	0.3333	0.3135	0.3413	0.3188
0.3440	0.2642	0.2824	0.3415	0.4444	0.2917	0.2759	0.2917	0.3051	0.2766
0.3947	0.1111	0.2955	0.4815	0.5909	0.1364	0.4545	0.1364	0.3846	0.3750
0.0441	0.0582	0.0628	0.0632	0.0677	0.0760	0.0870	0.1048	0.0951	0.1097
0.1245	0.0612	0.0761	0.1274	0.1104	0.1290	0.1575	0.1667	0.2045	0.1463
0.1267	0.0938	0.1549	0.1786	0.1600	0.1935	0.0769	0.1282	0.1500	0.1370

CONTINUED

1 OF 2

A6-12

0.1852	0.0417	0.0741	0.0769	0.0909	0.0000	0.0769	0.1429	0.1667	0.0000
0.2000	0.2500	0.0000	0.3333	0.0000	0.0000	0.2500	0.1667	0.0000	0.0526
0.0705	0.0664	0.0088	0.0520	0.0761	0.0828	0.1080	0.1073	0.1290	0.0885
0.1247	0.0776	0.0949	0.1343	0.0833	0.1087	0.1121	0.1008	0.0930	0.0856
0.0709	0.0200	0.0536	0.0938	0.1788	0.1000	0.0435	0.1938	0.1429	0.1111
0.0000	0.1000	0.1111	0.0000	0.0000	0.2222	0.5000	0.1667	0.0000	0.0000
0.0000	0.5000	0.5000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0506	0.0506	0.0667	0.0630	0.0627	0.0801	0.0798	0.0942	0.0860	0.0875
0.0814	0.0677	0.0750	0.0807	0.0716	0.0675	0.0725	0.0672	0.0772	0.0667
0.1307	0.0704	0.0588	0.1161	0.1053	0.0926	0.1099	0.1356	0.1667	0.1017
0.1970	0.0426	0.0233	0.0517	0.2222	0.1212	0.0323	0.0000	0.0435	0.0000
0.0667	0.1818	0.3750	0.2222	0.1000	0.2500	0.5000	0.1667	0.0000	0.0526
0.1076	0.1241	0.1253	0.1525	0.1459	0.1518	0.1600	0.1422	0.1518	0.1564
0.1354	0.1299	0.1317	0.1415	0.1444	0.1848	0.1174	0.1484	0.1574	0.1661
0.1439	0.1441	0.1860	0.1119	0.1429	0.1782	0.1939	0.1842	0.2118	0.1481
0.2800	0.1200	0.2500	0.2750	0.4000	0.2500	0.1579	0.2308	0.0769	0.1250
0.0714	0.1667	0.0000	0.0625	0.3529	0.2667	0.0000	0.3333	0.1250	0.0714
0.1249	0.1218	0.1388	0.1373	0.1589	0.1586	0.1730	0.1753	0.1682	0.1965
0.1611	0.1702	0.1680	0.1507	0.1474	0.1461	0.1328	0.1833	0.1643	0.1406
0.1753	0.1844	0.1795	0.1404	0.1931	0.2202	0.1848	0.1958	0.2234	0.1832
0.1690	0.2529	0.1887	0.1839	0.2593	0.2000	0.1667	0.2800	0.1765	0.2857
0.3462	0.1176	0.3429	0.5000	0.4706	0.0714	0.3750	0.1333	0.4000	0.3019
0.0759	0.0645	0.0902	0.0932	0.1006	0.0947	0.1197	0.1310	0.1232	0.1135
0.1230	0.1311	0.1207	0.1246	0.1458	0.1524	0.1686	0.1617	0.1431	0.1439
0.1530	0.0953	0.1372	0.1662	0.1415	0.1468	0.1271	0.0979	0.1067	0.1598
0.1280	0.1156	0.1242	0.1250	0.1009	0.1495	0.1981	0.2143	0.0800	0.1467
0.1324	0.1475	0.1667	0.1656	0.1556	0.0870	0.0952	0.0714	0.8476	0.0626
0.2363	0.2160	0.2541	0.2402	0.2253	0.2119	0.2284	0.2222	0.2073	0.2645
0.1975	0.1916	0.1309	0.1577	0.1205	0.1290	0.1094	0.1222	0.0816	0.1301
0.1913	0.1402	0.1171	0.0879	0.0741	0.1649	0.2000	0.1463	0.0154	0.0847
0.0789	0.0250	0.1538	0.0000	0.1667	0.1154	0.1250	0.2000	0.1429	0.0500
0.0909	0.2000	0.0000	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.2500

A6-13

PO/LTN/PROBAR

PROBAR contains arrest histories. These are vectors whose elements are the probability of an individual first arrested on any of the 12-system charges being rearrested or any of the 12-system charges on any of 20 bi-annual intervals from the date of first arrest. Separate data is stored for the two sexes and upstate/downstate regions.

File Specifications

Number of Records: 48
 Record Length: 240 words
 Record Format: Record 0: Male, charge code 01, upstate
 Record 1: Male, charge code 01, downstate

 Record 23: Male, charge code 12, downstate
 Record 24: Female, charge code 01, upstate

 Record 47: Female, charge code 12, downstate
 Record Contents: Real numbers within (0,1)
 Word 0: First interval, subsequent charge code 01

 Word 11: First interval, subsequent charge code 12

 Word 239: Twentieth interval, subsequent charge code 12
 File Contents: Real numbers in (0,1)

APPENDIX 7
TEST SAMPLE COMPOSITION

A7-1

TEST SAMPLE

SEARCH #	NYSID #	COUNTY CODE	LATENT CHARGE	SEX	YOB	NO. OF PRIOR ARRESTS
01	Lost during programming					
02	4435029	23	Murder	M	1935	2
03	4442726	30	Murder	M	1954	4
04	4444237	30	Murder	M	1962	2
05	4420168	23	Weapons	M	1963	2
06	Lost during programming					
07	" "	"				
08	4424319	23	Weapons	M	1963	2
09	4425035	23	Weapons	M	1961	2
10	4421428	23	Assault	M	1962	3
11	4424155	40	Assault	M	1911	2
12	4424163	40	Assault	M	1963	2
13	4425269	33	Assault	M	1962	3
14	4426141	59	Assault	M	1962	8
15	4423363	23	Drugs	M	1953	3
16	4425788	30	Drugs	F	1962	1
17	4427431	23	Drugs	M	1959	2
18	4431209	30	Drugs	M	1944	8
19	4431322	40	Drugs	M	1962	4
20	3830321	30	Forgery	F	1942	1
21	3845752	55	Forgery	M	1951	4
22	4225519	53	Forgery	M	1958	4
23	4422334	51	Forgery	F	1951	2
24	4424212	40	Forgery	M	1959	3
25	4420447	23	Robbery	M	1963	3

TEST SAMPLE

SEARCH #	NYSID #	COUNTY CODE	LATENT CHARGE	SEX	YOB	NO. OF PRIOR ARRESTS
26	4420567	23	Robbery	M	1960	2
27	4424940	62	Robbery	M	1960	5
28	4420972	40	Larceny	M	1962	2
29	4420981	23	Larceny	M	1958	3
30	4421438	30	Larceny	M	1947	11
31	4422114	23	Larceny	M	1961	1
32	4436548	62	Rape/Sodomy	M	1962	2
33	4439645	62	Rape	M	1960	3
34	4440324	23	Rape	M	1963	1
35	4441310	55	Rape	M	1949	6
36	4421375	30	Burglary	M	1962	2
37	4422249	35	Burglary	M	1963	2
38	4422515	23	Burglary	M	1963	4
39	4423966	57	Burglary	M	1963	4
40	4423007	33	Mischief	M	1961	3
41	4427426	40	Mischief	M	1962	3
42	4429452	23	Mischief	M	1955	5
43	4430587	40	Mischief	M	1962	1
44	4072321	30	Arson	M	1952	5
45	4075158	23	Arson	M	1957	9
46	4428570	23	Arson	M	1963	4
47	4420977	30	Arson	F	1959	6
48	4421438	30	Auto Theft.	M	1940	11
49	4424823	30	Auto Theft.	M	1962	8
50	4427019	14	Auto Theft.	M	1960	3

DATE 01-05-81 STATE OF NEW YORK
 TIME 0913 DIVISION OF CRIMINAL JUSTICE SERVICES
 FAX NO CONFIDENTIAL TO: DCJS - PHASE III

TRAN NO 81207
 PAGE 1
 DOB 01-21-62
 RAC BLACK
 SEX MALE
 HGT 5-03
 SOC
 FBI

81207
 01-05-81 81207 D INQUIRY ONLY
 0913 BBBB70168888
 01 99003R 0 2 BIA 4 CRT 15COPMP01604PORMPIE
 WUU N11 HUU MOU JU CO IQ OO LJO MOO DD6 NONE
 M1 FO
 63 10 1108801444 10 0 NO DIAGNOSTICS
 4284816M 01 COMPUTER OK = 85 G
 45999919 IN-HOUSE PRINTER

NAME INQUIRY ONLY INYSID

NAMES USED BY SUBJECT

01 10 01 05 01 00
 04 03 01 03 01 00
 06 01 00

<<<<<< CRIMINAL HISTORY >>>>>>

ARREST DATE INFORMATION	ARREST CHARGES	DISPOSITION AND CORRECTIONS DATA
ARR DT/PL 05-06-78 KINGS COUNTY	ATTEMPTED BURGLARY-3 110.7140.20 PL CLASS E FEL NCIC 2299	DISPOSITION - - 06-06-78 CRIM CRT KINGS OKT
CRM DT/PL 05-05-78 KINGS COUNTY	POSSESSION OF BURGLAR TOOLS 14J.35 PL CLASS A MISD NCIC 2206	CONVICTED UPON PLEA OF GUILTY THE FOLLOWING CHARGE(S): DISORDERLY CONDUCT 240.20 PL CLASS VIOL SENT: 25750 FINE PAID
ARR #/AGY NYCPD PCT U9J	CRIMINAL MISCHIEF - 4 145.00 PL CLASS A MISD NCIC 2999	IN FULL SATISFACTION OF: POSS BURG TOOLS 140.35 PL CLASS A MISD CRIM MISCHIEF-4 145.00 PL CLASS A MISD CRIM TRESPASS-3 140.11 PL CLASS B MISD
CRT CON#		08-29-78 CRIM CRT KINGS RETURN ON WARRANT
FAX NO		08-23-78 CRIM CRT KINGS RETURN ON WARRANT
		08-23-78 CRIM CRT KINGS BENCH WARRANT ISSUED
		08-09-78 CRIM CRT KINGS RETURN ON WARRANT
		08-09-78 CRIM CRT KINGS BENCH WARRANT ISSUED
		07-11-78 CRIM CRT KINGS BENCH WARRANT ISSUED

060678 01
 923001K PL 14020000FA3 060678 230000AZ
 01 00 00 00 01 02 01 00
 07 00 00 00 01 10 2 MT-0281
 923001K 02
 0000 0 PL 1403500AM00 05 PL 24020000V00
 0100904 03
 PL 1450000AM04 905
 02 PL 1403500AM00
 03 PL 1450000A 04
 04 PL 14010008M03
 230000AZ
 060678 02 022 MT-0248
 230000AZ
 060678 03 022 MT-0242
 230000AZ
 060678 04 020 MT-0242
 230000AZ
 060678 05 022 MT-0227
 230000AZ
 060678 06 020 MT-0227
 230000AZ
 060678 07 020 MT-0198

ARR DT/PL 05-17-78 ATTEMPTED GRAND LARCENY-3
 (CONT. NEXT PAGE) = - DISPOSITION - =

061778 101

APPENDIX 8
TEST SAMPLE FINGERPRINT DATA

06/23/81 T-I 08:18 T-O 08:18 SMP2078
U 44350298 M 04/07/35 I H
T00,W04,U12,W16,W15,A00,W10,U11,W18,W14.
U 44350298 M 04/07/35 I H
A00,W04,U12,W16,W15,A00,W10,U11,W18,W14.
06/23/81 T-I 08:19 T-O 08:19 SMP2078
U 4442726P M 01/02/54 VES
U18,W15,U12,W20,W19,T00,W15,W20,W19,U18.
U 4442726P M 01/02/54 VES
U18,W15,U12,W20,W19,A00,W15,W20,W19,U18.
U 4442726P M 01/02/54 VES
U18,W15,U12,W20,U19,T00,W15,W20,W19,U18.
U 4442726P M 01/02/54 VES
U18,W15,U12,W20,U19,A00,W15,W20,W19,U18.
06/23/81 T-I 08:19 T-O 08:19 SMP2078
U 4444237R M 01/19/62 P C
U21,U05,T00,U04,U06,U18,R03,U02,U04,U13.
U 4444237R M 01/19/62 P C
U21,U05,T00,U04,U06,U18,R03,T00,U04,U13.
06/23/81 T-I 08:19 T-O 08:19 SMP2078
U 4420168H M 03/13/63 JJD
W21,W14,W18,W20,W21,W21,W12,W16,W19,U16.
U 4420168H M 03/13/63 JJD
W21,W14,W18,W20,W21,W21,W12,W16,U19,U16.
06/23/81 T-I 08:19 T-O 08:19 SMP2078
U 4424319L M 03/07/63 W R
U15,U13,U15,U13,U17,U13,U06,U02,U14,U15.
06/23/81 T-I 08:19 T-O 08:19 SMP2078
U 4425035Z M 04/09/61 W P
U13,U12,W13,W16,U15,U15,U12,U14,W16,U13.
06/23/81 T-I 08:19 T-O 08:19 SMP2078
U 4421428D M 05/11/62 DAM
U19,W15,U21,W20,W18,U21,U11,U18,W19,U20.
06/23/81 T-I 08:20 T-O 08:20 SMP2078
U 4424155Z M 09/12/11 J M
U11,A00,T00,A00,U05,U12,A00,A00,A00,U04.
U 4424155Z M 09/12/11 J M
U11,A00,A00,A00,U05,U12,A00,A00,A00,U04.
WORKING ON LONG SEARCH: TT24820 08:20:44 GETCT: 00300
06/23/81 T-I 08:20 T-O 08:21 SMP2078
U 4424163Z M 02/09/63 A R
W19,W16,W11,W23,W14,W10,W12,U16,W20,U12.
06/23/81 T-I 08:20 T-O 08:21 SMP2078
U 44252698 M 01/11/62 JJH
W22,W12,U17,W20,U15,W22,W13,U17,W20,U17.
06/23/81 T-I 08:20 T-O 08:21 SMP2078
U 4426141K M 08/10/62 W G
W21,U13,U15,W23,U15,W11,U11,U18,W18,U15.
06/23/81 T-I 08:20 T-O 08:21 SMP2078
U 4423363Z M 08/13/53 C P
U20,R14,U08,U20,U15,U15,W17,U11,U14,U15.
06/23/81 T-I 08:20 T-O 08:21 SMP2078
U 4425788Y F 10/03/62 M L
U11,U10,U09,U14,U11,W06,W10,U10,W13,U12.
U 4425788Y F 10/03/62 M L
U11,U10,U09,U14,U11,W06,U10,U10,W13,U12.

06/23/81 T-I 08:20 T-D 08:21 SMP2078
U 4427431H M 00/00/59 R A
W16,W09,W10,W14,U14,W09,W09,W14,W19,U16.
U 4427431H M 00/00/59 R A
W00,W09,W10,W14,U14,W09,W09,W14,W19,U16.
06/23/81 T-I 08:21 T-D 08:21 SMP2078
U 4431209R M 07/17/44 M R
W25,W18,U10,W20,W15,W23,W17,W19,W20,U08.
06/23/81 T-I 08:21 T-D 08:21 SMP2078
U 4431322P M 01/22/62 J B
W21,W14,U13,W15,U16,W20,W11,U13,W16,W14.
U 4431322P M 01/22/62 J B
W21,W14,U13,W15,U16,W20,W11,U13,W16,U14.
06/23/81 T-I 08:21 T-D 08:21 SMP2078
U 3830321P F 08/28/42 A S
U19,U14,U13,U16,U15,U15,U14,U11,U15,U00.
U 3830321P F 08/28/42 A S
U19,U14,U13,U16,U15,U15,U14,U11,U15,U00.
06/23/81 T-I 08:21 T-D 08:21 SMP2078
U 3845752L M 01/27/51 GDB
W20,W17,W19,W22,W19,U16,W17,W21,W23,W21.
U 3845752L M 01/27/51 GDB
W20,W17,W19,W22,W19,U16,W17,W21,W23,U21.
06/23/81 T-I 08:21 T-D 08:21 SMP2078
U 4225519Z M 09/06/58 D C
U14,U03,U07,U16,U09,W05,U02,W03,U19,U10.
06/23/81 T-I 08:21 T-D 08:21 SMP2078
U 4422334M F 05/03/51 C S
W24,W18,U19,W22,U18,W22,W16,U14,W22,W18.
06/23/81 T-I 08:22 T-D 08:22 SMP2078
U 4424212L M 10/26/59 K F
W11,W13,W14,W17,W15,U10,U14,U13,W15,W14.
06/23/81 T-I 08:22 T-D 08:22 SMP2078
U 4420447P M 01/17/63 S W
W13,W14,U13,W23,U20,W13,W11,W12,W21,U19.
06/23/81 T-I 08:22 T-D 08:22 SMP2078
U 4420547K M 05/24/60 I M
W12,A00,U03,W09,W16,W14,A00,T00,U03,U09.
U 4420547K M 05/24/60 I M
W12,A00,U03,W09,W16,W14,A00,U03,U03,U09.
06/23/81 T-I 08:22 T-D 08:22 SMP2078
U 4424940N M 10/27/60 A T
W20,U13,U14,W21,U15,W20,U08,U17,W22,U18.
06/23/81 T-I 08:22 T-D 08:22 SMP2078
U 4420972R M 02/28/62 JAP
U12,R10,U09,U17,W00,U08,T00,U07,U11,U14.
U 4420972R M 02/28/62 JAP
U12,R10,U09,U17,W11,U08,T00,U07,U11,U14.
U 4420972R M 02/28/62 JAP
U12,R10,U09,U17,W00,U08,A00,U07,U11,U14.
U 4420972R M 02/28/62 JAP
U12,R10,U09,U17,W11,U08,A00,U07,U11,U14.
U 4420972R M 02/28/62 JAP
U12,R10,U09,U17,U00,U08,T00,U07,U11,U14.
U 4420972R M 02/28/62 JAP
U12,R10,U09,U17,U11,U08,T00,U07,U11,U14.
U 4420972R M 02/28/62 JAP
U12,R10,U09,U17,U00,U08,A00,U07,U11,U14.
U 4420972R M 02/28/62 JAP
U12,R10,U09,U17,U11,U08,A00,U07,U11,U14.

06/23/81 T-I 08:22 T-D 08:22 SMP2078
U 4420981P M 10/16/58 R G
U18,W19,U13,W17,U09,U23,W17,U21,W18,U17.
06/23/81 T-I 08:22 T-D 08:22 SMP2078
U 4421438M M 03/08/47 J L
U14,U18,U12,U16,U13,W15,U12,U18,U17,U17.
06/23/81 T-I 08:23 T-D 08:23 SMP2078
U 4422114Y M 09/13/61 R F
W24,W13,W13,W20,U15,U24,W16,W16,W21,U15.
06/23/81 T-I 08:23 T-D 08:23 SMP2078
U 4436548J M 01/04/62 C J
W12,A00,A00,A00,U06,W10,A00,U03,U06,U04.
06/23/81 T-I 08:23 T-D 08:23 SMP2078
U 4439645Y M 11/16/60 L R
U19,W12,W08,U13,U15,W21,U16,U17,U15,U18.
06/23/81 T-I 08:23 T-D 08:23 SMP2078
U 4440324R M 07/07/63 V G
W19,W02,U09,W18,U13,W15,R02,U06,U18,U14.
U 4440324R M 07/07/63 V G
W19,W02,U09,W18,U13,W15,T00,U06,U18,U14.
06/23/81 T-I 08:23 T-D 08:23 SMP2078
U 4441310N M 01/10/49 R C
W24,U15,U06,U09,U13,U09,U12,U11,U10,U10.
U 4441310N M 01/10/49 R C
W24,T00,U06,U09,U13,U09,U12,U11,U10,U10.
06/23/81 T-I 08:23 T-D 08:23 SMP2078
U 4421375K M 00/00/62 J S
W23,R03,U09,W10,U06,U20,U12,U05,U04,U04.
U 4421375K M 00/00/62 J S
W23,T00,U09,W10,U06,U20,U12,U05,U04,U04.
06/23/81 T-I 08:24 T-D 08:24 SMP2078
U 4422249R M 02/28/63 T C
W17,T00,U06,U10,U07,U17,U10,U07,U11,U06.
06/23/81 T-I 08:24 T-D 08:24 SMP2078
U 4422515N M 03/22/63 JGM
W19,W08,U10,U16,U11,W18,R02,U09,U16,U10.
U 4422515N M 03/22/63 JGM
W19,W08,U10,U16,U11,W18,T00,U09,U16,U10.
06/23/81 T-I 08:24 T-D 08:24 SMP2078
U 4423966J M 02/26/63 R V
U05,A00,A00,U10,U02,A00,R04,A00,U08,A00.
U 4423966J M 02/26/63 R V
U05,A00,A00,U10,U02,A00,R04,A00,U08,T00.
U 4423966J M 02/26/63 R V
U05,A00,A00,U10,U02,T00,R04,A00,U08,A00.
U 4423966J M 02/26/63 R V
U05,A00,A00,U10,U02,T00,R04,A00,U08,T00.
06/23/81 T-I 08:24 T-D 08:24 SMP2078
U 4423007P M 05/03/61 DTF
W23,R17,W16,W18,W20,W23,W12,U16,W23,U18.
U 4423007P M 05/03/61 DTF
W23,R17,W16,W18,W20,W23,W12,U16,U23,U18.
06/23/81 T-I 08:24 T-D 08:24 SMP2078
U 4427426M M 09/07/62 D S
U11,U09,U08,W19,U12,U08,U09,U09,W16,U10.
06/23/81 T-I 08:24 T-D 08:24 SMP2078
U 4427452J M 07/12/55 FDP
W24,W13,U14,W17,W17,W20,W17,U15,W16,W15.

APPENDIX 9
TEST SEARCH 4 HARD COPY

06/23/81 T-I 08:25 T-O 08:25 SMP2078
U 4430587Y M 07/15/62 A R
W18,R15,U13,W16,U17,W17,W13,U11,U17,U17.
06/23/81 T-I 08:25 T-O 08:25 SMP2078
U 4072321Z M 09/12/52 MB
U12,U06,U09,U12,U00,U15,U05,U03,U05,U09.
U 4072321Z M 09/12/52 B M
U12,U06,U09,U12,U00,U15,U05,U03,U05,U09.
U 4072321Z M 09/12/52 MB
U12,U06,U09,U12,U06,U15,U05,U03,U05,U09.
U 4072321Z M 09/12/52 B M
U12,U06,U09,U12,U10,U15,U05,U03,U05,U09.
06/23/81 T-I 08:25 T-O 08:25 SMP2078
U 40751580 M 10/21/58 SVD
U26,T00,U03,W15,U08,U23,R03,U15,U17,U10.
U 40751580 M 10/21/58 SVD
U26,T00,U03,U15,U08,U23,R03,U15,U17,U10.
06/23/81 T-I 08:25 T-O 08:25 SMP2078
U 4428570H M 04/14/63 D O
U24,U10,U15,U16,U19,U18,R17,U17,U18,U18.
06/23/81 T-I 08:25 T-O 08:25 SMP2078
U 4420977H F 09/03/54 ARB
U12,U02,U02,U12,U12,U03,U02,U04,U11,U14.
U 4420977H F 09/03/54 ARB
U12,U02,U02,U12,U12,U03,U02,T00,U11,U14.
U 4420977H F 09/03/54 ARB
U12,U02,U02,U12,U12,U03,T00,U04,U11,U14.
U 4420977H F 09/03/54 ARB
U12,U02,U02,U12,U12,U03,T00,T00,U11,U14.
06/23/81 T-I 08:25 T-O 08:25 SMP2078
U 4421438M M 03/08/47 J L
U14,U12,U12,U16,U13,W15,U12,U12,U17,U17.
06/23/81 T-I 08:26 T-O 08:26 SMP2078
U 4424823M M 12/09/62 R B
W17,T00,T00,U13,W12,W17,U07,U14,U13,U12.
U 4424823M M 12/09/62 R B
W17,T00,U01,U13,W12,W17,U07,U14,U13,U12.
U 4424823M M 12/09/62 R B
W17,R02,U01,U13,W12,W17,U07,U14,U13,U12.
U 4424823M M 12/09/62 R B
W17,R02,T00,U13,W12,W17,U07,U14,U13,U12.
06/23/81 T-I 08:26 T-O 08:26 SMP2078
U 4427019J M 06/16/60 C H
W15,W11,W12,W19,U16,U12,W12,U14,U15,U15.

	OF 362 RECORDS BEFORE HIT AVERAGES	0.489	11.191	0.080	5.038	16.797
	OF 1556 RECORDS AFTER HIT AVERAGES	0.713	11.459	0.138	7.366	19.677
SEARCH NO =	51					
OF	0 RECORDS BEFORE HIT AVERAGES	0.000	0.000	0.000	0.000	0.000
OF	0 RECORDS AFTER HIT AVERAGES	0.000	0.000	0.000	0.000	0.000
SEARCH NO =	52					
OF	6 RECORDS BEFORE HIT AVERAGES	0.000	11.850	0.092	7.491	19.432
OF	145 RECORDS AFTER HIT AVERAGES	1.372	11.895	0.136	7.491	20.894
SEARCH NO =	53					
OF	82 RECORDS BEFORE HIT AVERAGES	0.000	11.447	0.061	7.485	18.993
OF	1879 RECORDS AFTER HIT AVERAGES	1.399	11.537	0.140	7.490	20.566
SEARCH NO =	54					
OF	8 RECORDS BEFORE HIT AVERAGES	0.000	11.223	0.046	7.486	18.756
OF	289 RECORDS AFTER HIT AVERAGES	0.772	11.377	0.117	7.491	19.756
SEARCH NO =	55					
OF	12 RECORDS BEFORE HIT AVERAGES	0.000	10.881	0.056	7.327	18.265
OF	597 RECORDS AFTER HIT AVERAGES	1.357	11.256	0.103	7.342	20.058
SEARCH NO =	56					
OF	0 RECORDS BEFORE HIT AVERAGES	0.000	0.000	0.000	0.000	0.000
OF	0 RECORDS AFTER HIT AVERAGES	0.000	0.000	0.000	0.000	0.000
SEARCH NO =	57					
OF	0 RECORDS BEFORE HIT AVERAGES	0.000	0.000	0.000	0.000	0.000
OF	0 RECORDS AFTER HIT AVERAGES	0.000	0.000	0.000	0.000	0.000
SEARCH NO =	58					
OF	14 RECORDS BEFORE HIT AVERAGES	0.000	10.711	0.068	7.491	18.270
OF	935 RECORDS AFTER HIT AVERAGES	1.361	11.223	0.135	7.485	20.204
SEARCH NO =	59					
OF	1 RECORDS BEFORE HIT AVERAGES	0.000	11.000	0.127	7.488	18.615
OF	141 RECORDS AFTER HIT AVERAGES	1.234	11.296	0.139	7.482	20.130
SEARCH NO =	60					
OF	1 RECORDS BEFORE HIT AVERAGES	0.000	0.000	0.000	0.000	0.000
OF	61 RECORDS AFTER HIT AVERAGES	1.410	11.400	0.116	7.418	20.343
SEARCH NO =	61					
OF	7 RECORDS BEFORE HIT AVERAGES	0.000	11.953	0.286	7.361	19.599
OF	5 RECORDS AFTER HIT AVERAGES	0.000	11.942	0.500	7.443	19.884
SEARCH NO =	62					
OF	1 RECORDS BEFORE HIT AVERAGES	0.000	0.000	0.000	0.000	0.000
OF	63 RECORDS AFTER HIT AVERAGES	1.500	11.379	0.076	7.405	20.359
SEARCH NO =	63					
OF	8 RECORDS BEFORE HIT AVERAGES	1.125	11.339	0.017	4.930	17.411
OF	92 RECORDS AFTER HIT AVERAGES	1.402	11.333	0.078	7.347	20.160
SEARCH NO =	64					
OF	25 RECORDS BEFORE HIT AVERAGES	0.739	11.296	0.016	5.140	17.192
OF	337 RECORDS AFTER HIT AVERAGES	1.294	11.328	0.139	7.368	20.128
SEARCH NO =	65					
OF	5 RECORDS BEFORE HIT AVERAGES	0.000	11.470	0.050	7.144	18.665
OF	238 RECORDS AFTER HIT AVERAGES	1.416	11.598	0.090	7.305	20.409

APPENDIX 10
EXAMINER'S JOB DESCRIPTION

LATENT FINGERPRINT EXAMINER
NEW YORK STATE DEPARTMENT OF CIVIL SERVICE

CLASSIFICATION STANDARD

NATURE OF WORK

Latent Fingerprint Examiners classify, search, and identify fingerprints lifted from the scenes of crimes and from unidentified bodies.

These positions are found only in the Special Services Unit of the Bureau of Identification and Information Services within the Division of Criminal Justice Services.

CLASSIFICATION CRITERIA AND DISTINGUISHING CHARACTERISTICS

Positions in this class are characterized by their responsibility for classifying and coding latent fingerprints and identifying the perpetrator of a crime by comparisons of latent prints to fingerprint cards on file in the Division. Typically, the latent fingerprints are incomplete and of poor quality. Incumbents usually work from photographs of prints taken in situ, which may show distortion from the surface from which the prints are lifted. These conditions complicate the identification of prints. Occasionally, incumbents will classify full prints that are difficult to analyze because of dermatological or occupational disfiguration, dust evidence to lift prints, and identify corpses from lifted prints.

TYPICAL ACTIVITIES, TASKS AND ASSIGNMENTS

Classifies latent fingerprints according to latent print codes or other descriptors.

- Codes and references latent fingerprints according to latent print codes or other descriptors.
- Identifies the fingerprint pattern from the photographs of fingerprint evidence received.
- Determines from which finger(s) the print is taken or whether the print is from the palm.
- Searches for possible patterns and eliminates prints or patterns that are improbable - based on knowledge of statistical nature of print patterns for particular fingers.
- Evaluates possible distortion of prints based on the nature of surface from which the print is lifted.
- Identifies proper fingers and right or left hand according to their relationship to themselves and the objects on which the prints are found.

Enters search argument through computer input devices.

- Determines if prints can be searched by the quality and amount of detail obtained from the prints.
- Selects parameters for the search and enters these into the computer for search.
- Changes parameters, as necessary, if search prints generated provide an insufficient or excessive field of suspects.

Reviews prints generated to make identifications, using a magnifying eyepiece, to check latent print photographs against print cards.

- Compares prints of suspects generated by the initial computer search against the latent print.
- Checks new fingerprint cards received against open latent fingerprint cases.
- When possible identification of a latent print is made, notes points of comparability and refers to supervisors for verification.
- If suspects are identified for particular crimes, checks latent files for unsolved cases in the same geographic area.

Classifies or verifies full sets of fingerprints in cases where dermatological or occupational conditions have distorted prints or resulted in poor prints.

Compares prints of unidentified corpses against the master print file to make identifications of the deceased.

Talks to police officers to explain details needed by the section and to obtain information that might be useful in selecting a field of suspects, such as possible suspects, physical descriptions of suspects, and similar crimes committed in the area.

RELATIONSHIPS WITH OTHERS

Latent Fingerprint Examiners orally communicate primarily with their supervisors and other staff in the Special Services Unit. Incumbents also have telephone and personal contact with other members of the bureau in processing identifications and fingerprints.

Incumbents have infrequent face-to-face or telephone contact with police officers to explain work or obtain additional information.

NATURE OF SUPERVISION

Latent Fingerprint Examiners are not supervisory positions, but may assist in on-the-job training of new Latent Fingerprint Examiners.

Positions in this class are supervised by Identification Specialists who

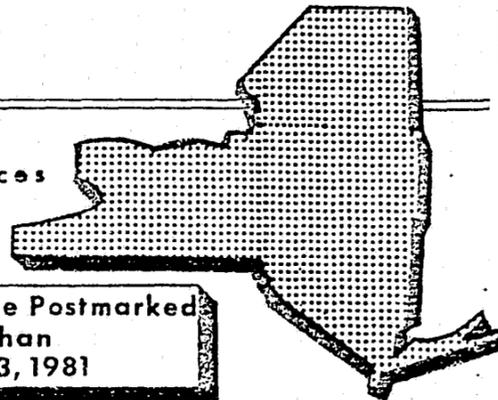
make assignments, provide training, and verify positive identifications. Incumbents work with considerable independence in evaluating prints, making tentative identifications, and rejecting non-matches.

JOB REQUIREMENTS

- Good knowledge of the principles of the American Fingerprint Classification System and related search systems.
- Good knowledge of the policies, procedures, and guidelines used in the identification process.
- Good knowledge of latent print codes.
- Working knowledge of federal, state, and agency procedures and manuals relating to latent print identification.
- Working knowledge of parameters used for searching the computerized fingerprint file and the effect of variable parameters on print field and identification.
- Working knowledge of procedures for entering computer searches.
- Good knowledge of print patterns and probabilities of prints having been obtained from particular fingers.
- Basic knowledge of print development techniques.
- Good knowledge of the effects of surface distortion on latent fingerprints.
- Ability to undertake prolonged and intensive examination of fingerprints.
- Ability to memorize and remember the characteristics of individual fingerprints.
- Ability to discern the relationship between minute points of identification in the latent print and inked impression.
- Ability to stay mentally alert and concentrate for long periods of time.
- Skill in accurately determining matches and non-matches of prints.
- Skill in identifying and classifying partial and distorted fingerprints.

New York State Department of Civil Service Announces

Competitive Promotion Examination



Written Test To Be Held

APRIL 4, 1981

Applications Must Be Postmarked

No Later Than
FEBRUARY 23, 1981

NO. 37-212 LATENT FINGERPRINT EXAMINER G-12

THIS EXAMINATION IS OPEN TO ALL QUALIFIED EMPLOYEES OF
THE DIVISION OF CRIMINAL JUSTICE SERVICES, EXECUTIVE DEPARTMENT.

At present there are four vacancies in Albany.

QUALIFYING EXPERIENCE:

FOR TAKING THE TEST: On or before the date of the written test, candidates must have had one year of permanent competitive service as a Senior Identification Clerk G-9.

Candidates permanently appointed to a qualifying title on or before April 17, 1980, and who have served continuously in this title since that date, shall be deemed to meet the Qualifying Experience For Taking The Test.

FOR APPOINTMENT FROM THE ELIGIBLE LIST: two years of the Qualifying Experience For Taking The Test.

SUBJECT OF EXAMINATION: *Written test* designed to test for the knowledge, skills and/or abilities in such areas as:

1. Understanding and interpreting written material
2. Effecting identification through the comparison of friction ridges
3. The American Fingerprint Classification System and the identification operations administered by the NYS Division of Criminal Justice System

Points will be added to an eligible score as follows:

Seniority For Each Year 0.2

Duty descriptions are available in your Personnel Office.

You May Obtain Announcements And Promotion Application Cards, XD-5,
From Your Agency Personnel Office

S-5/T-4-GFJ-bk

SEE REVERSE SIDE

Issued: 1-16-81

NO. 37-212 LATENT FINGERPRINT EXAMINER

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