GUIDELINES FOR EVALUATING AUTOMATED FINGERPRINT SYSTEMS

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AUGUST 1977

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Prepared by SEARCH Group, Incorporated, under Grant #76SS-99-6030, from the Law Enforcement Assistance Administration of the U.S. Department of Justice.

TABLE OF CONTENTS

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I. INTRODUCTION

The state-of-the-art in fingerprint identification has been propelled forward by the continual technical advancements being made in this field. Machine/manpower ratios are shifting. Labor intensive manual systems are being studied for replacement by semi-automated and fully automated classification and search systems. Today, there are several parallel developments in the fields of computer-aided technical search, automated technical search, and fingerprint image storage and retrieval.

The fingerprint identification community needs a standardized methodology which can be used to compare, evaluate and select the correct technology to satisfy a specific requirement. This report meets this need by providing a set of standardized evaluation criteria that can be utilized by funding and planning agencies as well as operational entities contemplating fingerprint system automation.

The installation of automated fingerprint classification and search systems involves enormous sums of money and very long design and implementation times. Accurate and reliable evaluation of system alternatives will increase the probability that these monies have been directed to the alternative which presents the highest payoff.

These standardized system evaluation criteria will facilitate the process of reviewing alternatives. Short and long-term dollar costs and savings will more easily be identifiable because specific system alternatives can be reviewed in terms of the payoffs of each in satisfying a certain user need. System variations can be directly compared allowing the true efficiency and effectiveness of each option to be accurately determined.

Included within the scope of this report are fully-automated as well as semi-automated systems. These criteria:

1. Provide operational agencies with the capability to accurately measure the operational performance of manual modes of classification and search;
2. Provide the capability to establish operational requirements for proposed automated or semi-automated fingerprint identification systems; and
3. Allow hardware and software alternatives to be compared in a standardized fashion to include such items as performance specifications, coding structures and system costing techniques.

The ultimate system, involving minimum human intervention and having virtually infinite throughput and expansion capability with near 100% reliability, is technically achievable. However, cost factors must be considered. Any system of this type—manual, semi-automated or fully automated—consists of a number of cost/performance trade-offs. This report provides the tools needed to acquire relevant data regarding the relative cost and performance factors in order to reach the optimum compromise for the application under consideration.

BACKGROUND

In the mid-19th century, fingerprint analysis was established as a reliable form of positive identification. When the thousands of detailed variations in ridge angles, bifurcations and endings are examined and compared on a point-by-point basis, it is found that no two prints from different fingers will display exactly the same spatial relationship. The visual comparison of these relationships is performed millions of times each day throughout the world.

In an effort to reduce the amount of comparison required to find a matching set from the thousands on file, Henry, Vucetich and others developed complex classification schemes based upon overall pattern and ridge relationships —detail that can be quickly recognized and classified. Files are subdivided into classification categories, thus reducing the number of records to be compared in the identification process. As files have grown, the basic classification schemes have become inadequate. Various modifications, or extensions, have been developed to reduce the size of the individual categories to more manageable proportions. The FBI was one of the first agencies to recognize that further extensions of the classification system based on pattern characteristics alone was not the answer, and that adding manpower to search larger and larger classification categories was approaching practical saturation limits.

IDENTIFICATION RESOURCE DISTRIBUTION

The current identification systems consist of four major, labor intensive efforts. These include:

- Classification — The process of defining into which "bin" or category the subject for identification will most probably have been filed as the result of an earlier arrest.
- Searching — Hunting through one, or more, categories in an effort to reduce the "probables" to a select few.
- Verifying — Performing a detailed comparison of minutiae detail on the select few in order to discover the one and only match.
- File Management — Adding new records to the file if no identification is made and purging old records no longer of value.

Of the four major functions, classification and searching probably consume over 90% of the resources available in the technical search/identification process. Verifying is relatively simple if the classification/search can reduce the potential candidates to a near "one or none" situation. Adding new records is equally simple. Purging is highly labor intensive and often postponed to the eventual detriment of the search effort.

The resources allocated to the classification/ search process require constant refinement to maintain the optimum cost/performance ratio. At one extreme (no subdivision of the file into male and female, for example), the classification effort is greatly simplified but at the expense of extremely long searches. Search costs are prohibitive and miss rates increase due to fatigue and boredom. At the opposite extreme, an over sophisticated manual classification system will potentially reduce the search effort but at the cost of disproportionate classification costs; search and miss rates may even increase due to the extensive cross searching resulting from overclassification. The optimum use of resources for classification and searching will depend on the size of the data base and the number of incoming fingerprints. The larger the data base, the more time will be required to search it; the more prints received, the longer the time required to classify them.

AUTOMATION DEVELOPMENT

Equipment and systems available for fingerprint automation include technology that has been developed primarily for general automation and adapted to fingerprint processing and systems that have been designed exclusively for the identification process.

The search element of the processing cycle closely resembles the selective graphic retrieval requirements of commercial and industrial applications. Therefore, it is natural that these standard systems have first been adapted to the *search* component of the identification process. Manpower thus released is able to concentrate on the classification element. These standard systems fall into four categories.

- Power File Concept — Equipment essentially moves records and reduces or eliminates walking. Some space reduction achieved.
- General Purpose Computers — Provide a high degree of selective search capability based on human-generated parameters to produce a reduced number of possibilities to be manually searched and eliminate manual search if no similar record is on file.
- Microfilm/fiche systems — Offer extensive space reduction; can be coupled with computer logic capability to display selected records for viewing and identification.
- Magnetic Tape Graphic Display Systems — Combine graphic image and digital classification data on magnetic tape. Utilizes computer search logic for selective retrieval. Improves batch process and file management functions.

All of the above systems provide a varying degree of automation to the search and retrieval side of the identification process. All rely on human classification and determination of search parameters.

By contrast, the requirements to automate the *classification* of fingerprints are unique to the identification application. Design engineers have drawn heavily on general pattern recognition techniques and standard hardware modules. However, most of the logic and software required for this process has been specially developed to scan a fingerprint pattern, extract ridge flow/minutiae data, and develop a highly sophisticated classification system. As a result, the initial systems are expensive. As systems are standardized and accepted, it is anticipated that cost levels will be significantly reduced.

Over the last decade, many private corporations and government agencies have been involved in the development of automated classification techniques. Presently, the field has been reduced to four — each

based upon a slightly different technique. Each produces a machine-unique classification for the fingerprint that cannot conveniently be used by the fingerprint technician, although all four can produce a Henry or NCIC type output as a by-product. Since the machine-generated classification is unique to each system, the search algorithms employed are also internal and unique. None of the systems are yet developed and tested to the point that a "one and only one" respondent to every file search can be reliably guaranteed. Until such time as this level of performance is established, a significant portion of the search activity may be retained. It should be noted that most systems provide for a variety of configuration options, with appropriately variable cost increments, to permit smaller agencies to select only that portion of a total system that is most cost effective and efficient for their operations.

II. OVERVIEW

Many complex variables must be taken into account by law enforcement agencies contemplating automation in the fingerprint bureau. The most cost effective solution for one agency may be totally unworkable for another.

This project developed cost/performance criteria by which an agency can measure its present manual operation against potential automation alternatives. At the outset of the project, a number of generic issues that required standardized investigation and response were identified. These included:

- How to measure a manual find rate.
- How to measure a labor rate.
- How to measure manual costs.
- How to measure automated find rates.
- How to measure automated costs.
- How to value a higher find rate.
- How to estimate file growth.
- How to project workloads.
- How to project costs.

The project does not presume that the decision problem can be reduced to a simple "truth table" with a final answer represented by a "+" or "-" value. Major decision of this type should always be considered in the context of meeting primary objectives within the limits of reasonable cost/performance capabilities. Further, the project does not intend to establish threshholds of cost or performance, but rather to identify those key elements that must be taken into consideration by the agency and to present a standard methodology for evaluating and comparing alternatives. The methodology and format of the recommended approach are as follows:

Measuring the Current System — Develops guidelines and procedures for evaluating current system cost/performance in terms of both present and future file size and activity levels.

Defining the Data Base — Emphasizes the need for good file profile definition.

Measuring Current Activity — Presents standard definitions for primary technical search functions.

Measuring Current Costs — Identifies major labor, burden and associated costs and develops a unit cost per task.

Projecting Systems Costs — Provides a method of anticipating operational cost changes as a result of changes in data base, activity and inflation factors.

Measuring System Performance — Presents a method of evaluating key performance parameters — turnaround time and "miss rate".

Specifying Automation Requirements — A major phase of the evaluation process is that of soliciting necessary cost/performance data from potential system suppliers. This section presents a standarized solicitation format that will allow the agency to clearly state its needs and that will enable vendors to respond in a timely and accurate manner.

Basic Application Data — Defines the agency application needs in terms meaningful to most suppliers.

Response Data Solicited — Identifies those items that responsible vendors should be able to supply quickly and easily in response to the application requirements. Also permits the agency to more easily make an "apples to apples" comparison between systems.

Cost Data Solicited — Identifies and formats the essential items of cost information or estimates the agency must have to make knowledgeable decisions.

Analyzing System Alternative — Once the agency has collected data on both its current operational system and various technical approaches to automation, it must perform a comparative analysis. Major topics of this section include:

Evaluating Performance Criteria — Develops a method of assigning relative values to "mandatory", "nice to have" and other hard to quantify performance values.

Implementation Cost — Highlights the obvious, and less obvious, costs to be anticipated in implementing an automated system.

Operating Cost — Provides a methodology for tabulating and comparing on-going operational costs, taking into account the effects of inflation, growth and other long-range impact factors.

Calculating the "Bottom Line" — Compares the cost of manual and automated system approaches

over extended periods. Present methods of calculating cross-over points under various financial/amortization philosophies.

Other Decision Factors — Re-emphasizes the need for critical examination of automation objectives other than pure cost/performance.

As will be emphasized many times during the text to follow, the final judgments on if, when and how to automate involve far more than a simple plus or minus at the end of a balance sheet. The material supplied will help simplify the cost/performance evaluation, reserving more energy and resources for the vital efforts that must follow.

III. MEASURING THE CURRENT SYSTEM

Measuring current system cost and performance consists primarily of defining the data base and activity parameters, determining cost levels required to achieve these performance levels, and projecting costs required to maintain or improve these performance levels in spite of increasing data base size and workload demands. For manual systems, costs are primarily labor oriented with suitable burdens for overhead and services. Automated and semi-automated systems include various hardware, software, maintenance and supply costs in lieu of the manual tasks which the systems replace.

DEFINING THE DATA BASE

The cost and performance of file searching is directly related to the size and organization of the data base. Agencies with small files (e.g., 50,000 — 100,000 records) may find that a simple Henry primary/secondary breakdown is adequate for reasonable search speed

FILE DISTRIBUTION WORK SHEET

Master Criminal File				
Date of Birth, 1929 or before				
Males		225,000		
Females		25,000		
Total			250,000	
Date of Birth, 1930 or later				
Males				
Felony	350,000			
Misdemeanor	325,000			
Total Males		675,000		
Females		75,000		
Total			750,000	
Total Master Criminal File				1,000,000
Civil (non-criminal) File				
Males			1,500,000	
Females			1,300,000	
Total Civil File				2,800,000
Total Fingerprint Record File				3,800,000

Figure 1

and accuracy in all but the most popular primary sections. As files increase in size, more definitive categories are required to reduce the amount of time required to make a search. In addition to the various extensions applied to the Henry classification system, other file divisions are often established by larger agencies.

Subdividing the file into separate male and female subfiles is a common first step. In most instances, it is necessary to search only one section for an identification. (Since the female segment of the file is usually smaller than the male segment, it more readily lends itself as an interim test bed for evaluation of automated systems.)

The majority of crime is age oriented, and many agencies utilize this fact to further reduce file searching requirements. A manual system file subdivided by age may create minor cross-searching problems when borderline cases are searched. However, automated systems make extensive use of age as a discriminator and the age factor should be considered when predicting response rate from an automated system. The age distribution of both the data base and the incoming records should be thoroughly analyzed. For preliminary investigation, any age or date of birth information that is readily available may be utilized.

In some agencies, files are subdivided between major and minor crimes. Many agencies receive and retain civil, or non-criminal, fingerprint cards. Most typically, non-criminal prints are submitted by job applicants for sensitive positions and by applicants for special permits. If retained, these cards may be included in the master file or may be kept in a separate file. If the non-criminal cards are filed with the criminal cards, the larger data base will contribute to longer search times; if non-criminal prints are retained in a separate file, this will affect search efficiency.

The distribution on the basis of age and sex, etc., as well as overall size of the data base will have a major bearing on the performance of both semi-and fully-automated systems and should be taken into account when making comparative evaluations. A typical distribution worksheet has been provided as Figure 1. Since each agency will have its own physical breakdown of file organization, the worksheet should be modified to reflect actual file organization.

MEASURING CURRENT ACTIVITY

The assessment of cost and performance is task oriented, and specific tasks and associated costs must be defined to determine current and projected costs. The agency must be able to compare manual and automated system performance on a task-by-task basis — an "apples to apples" comparison. Therefore, attention should be focused on the most common tasks performed. For evaluation purposes, it is assumed that classifications, technical searches,serial (VIP) searches and updates are tasks that are common to both manual and automated systems. Figure 2 illustrates the general flow of work through a typical agency and the major tasks associated with that work flow. It is assumed that all potential identifications made as a result of a name search will be verified by a fingerprint comparison of records external to the automated system. The only exception to this assumption is when considering graphic automation, such as film or magnetic tape systems. This exception is discussed in a subsequent section.

Classification is the process of designating one or more categories of the master file to be searched. In general, the Henry classification plus necessary references will be designated. In many agencies using a computer index or computer-aided technical search, an NCIC classification will also be assigned. NCIC classification requires the determination of pattern type and ridge count/tracing information for all ten fingers and is considerably more time consuming than the Henry classification required for purely manual operations. The time, and thus the cost, to classify fingerprints is independent of file size. However, the level of technician assigned to the classification function will have a bearing on the cost of the classification function and should be considered.

Following the classification task, the master file must be searched in one or more of its various subdivisions and categories. Unlike classification, file searching is directly related to file size. Time, cost and reliability are all affected by the size and number of the individual categories that must be searched. Additionally, with the classification task, the cost of file searching is dependent upon the salary of the technician performing the search.

Assuming no identification is made during the technical search process, and assuming the record is to be added to the master file, both the index and the master file require updating. This function usually involves some level of clerical activity that should be assessed for later comparison with a similar task in an automated system environment.

If purging is routinely performed by technicians

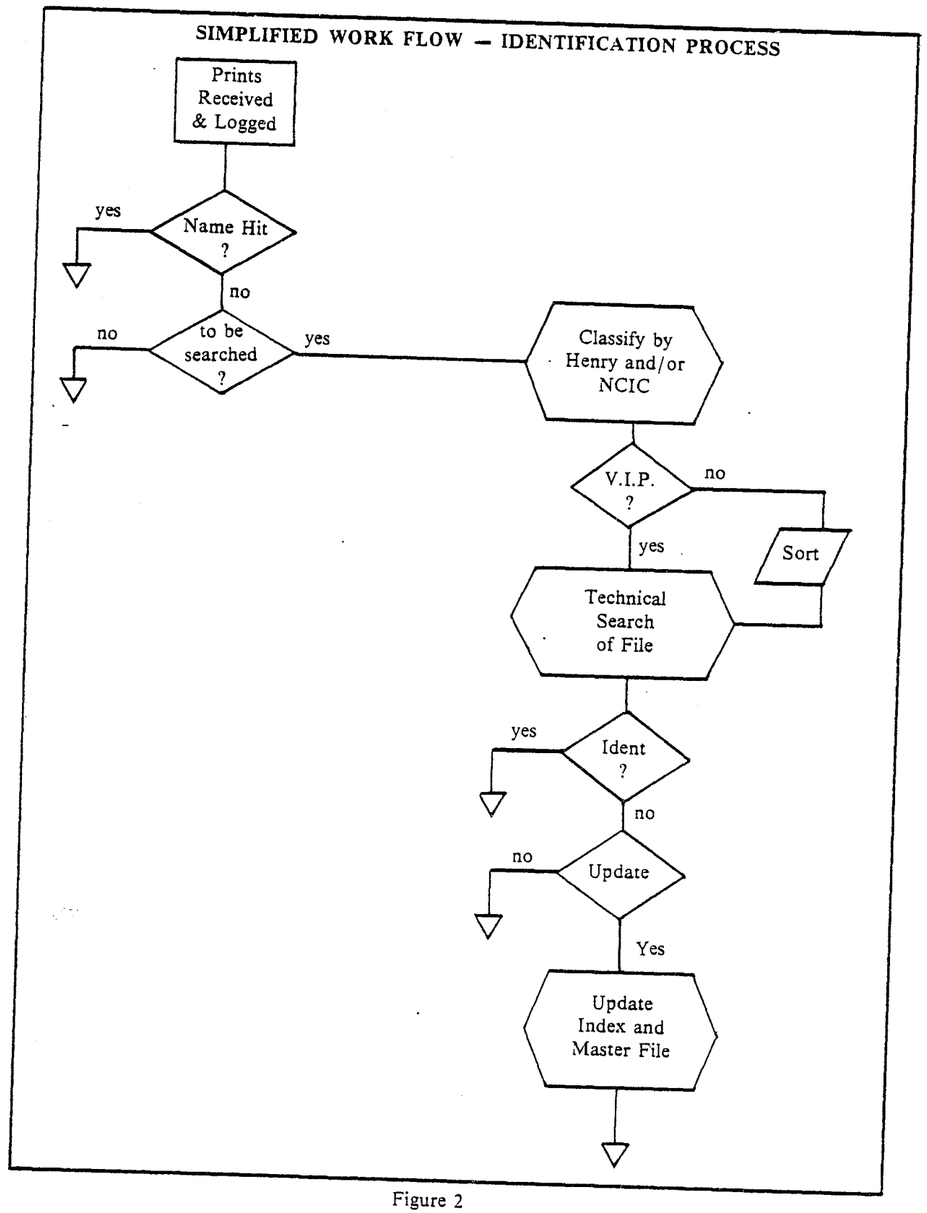

Figure 2

SEARCH DISTRIBUTION WORK SHEET
(Annual Rate)

Technical Searches Required		
Total Forms Received	250,000	
Less Name Idents Verified	100,000	
Sub-Total	150,000	
Less Inquiries Terminated	15,000	
Technical Searches Required		135,000
Technical Search Distribution		
Serial (V.I.P.) Searches	13,500	
Batch Searches	121,500	
Technical Search Distribution		135,000
Update Requirements		
Technical Searches Performed	135,000	
Less Identifications	4,000	
Sub-Total	131,000	
Less "Returned to Sender"	31,000	
New Records to be Filed		100,000

Figure 3

LABOR DISTRIBUTION WORK SHEET
(Annual Rate)

Position/Function	Classify & Sort	Search Only	V.I.P. (Serial)	Update	Total
Direct Supervision					
Grade I	.5	1.5			2
Grade II	1				1
Fingerprint Technicians					
Grade I	1	6	4		11
Grade II	5	3	1		9
Grade III	6	4			10
Clerical					
Grade I	1			3	
Grade II	1			3	
Grade III	1			2	

Figure 4

during searching, the extra time required should be assessed and factored out of the search task. If purging is performed as a clerical function, it should be so identified for later comparison with automated sytems which are normally capable of performing the task under program control. If purging has not been previously conducted, the costs of performing the task should be estimated in order to complete the evaluation.

The discussion to this point has assumed essentially a serial operation — that is, fingerprints received are classified, searched and filed in a sequential manner. In a smaller bureau, this is typically the case. However, by the time a bureau reaches the point of considering some form of automation, operational procedures to improve manual efficiency have usually been implemented. Classification and search functions may be separated and performed on a batch basis, reserving the serial function for VIP searches that must be performed quickly without regard for operational efficiency. If the batch process includes a sorting function to improve file search efficiency, this factor should be so identified. If the agency provided 24-hour service, most of the work performed is normally carried out during the prime day shift. Work performed by skeleton crews on night and weekend duty will frequently be held to different standards than work during the prime shifts. Backlog, purging and other clerical functions may be carried out as background tasks to the normal classification and search tasks. These tasks should be so identified and evaluated independently.

Developing "standard rates" for the tasks associated with the identification process is extremely valuable for analyzing both current performance of the bureau and for comparing current performance with that of automated systems under consideration. Standard rates are also useful in predicting future staff and cost levels resulting from increased file size and demand.

A standard rate for one bureau will not necessarily bear any relationship to another bureau of similar size due to the many variations in priorities, file organization, personnel turnover, intra- and inter-agency responsibilities, clerical support and a host of other variables that impact individual record turnaround time and overall bureau throughput.

Figures 3 to 6 provide typical worksheets for use in accumulating file activity data and determining standard rates. These should be used as a guide to emphasize the major items that must be identified. Worksheets should be tailored to fit individual agency requirements. All figures used on these charts are hypothetical.

MEASURING CURRENT COSTS

As with other evaluation parameters, current operating costs are subject to wide variations depending upon agency circumstances.

The purpose of this section is to identify those major cost elements that must be considered and applied with some prudence to arrive at a gross measurement of current operating costs.

The basic labor rate is that rate assigned for the particular position. Figure 7 provides a convenient worksheet for developing average rates for the various job functions. Since most positions utilize a salary range, it is suggested that the mid, or average, salary for the position be used. Provisions for various levels within the job classification have been included. Supervision to be considered is only that directly associated with the major task functions — classification, search and file management. Higher level supervision should remain constant for either manual or automated systems and should not be included at this level of evaluation. Technicians and clerical personnel are those directly associated with the major task functions, including keypunch and system operators and other non-fingerprint functions that are fully committed to technical search support.

Cash contributions in addition to direct salary can be significant. These contributions normally include full or partial payment for social security, state retirement plans, mandatory health plans, living or transportation allowance, etc. General overhead burden for facilities and services, if these amounts are significant and available should also be included. Allowances for vacation and sick pay should be excluded as these items are provided for under labor distribution. In most agencies the general labor burden will range from 15-30% of direct labor costs.

The Table (Figure 7) provides for calculating and adding the burden to arrive at a true annual cost for the various positions identified.

Having defined activity, standard rates, and burdened labor rates, it is now possible to apply the labor rates to the various tasks defined and develop the labor cost of each task. A typical worksheet is supplied as Figures 8-9.

The first step in developing labor distribution is to ascertain the number of technicians and clerical personnel assigned to each of the major tasks. In a large organization with discrete staff assigned to the classification function, as opposed to the search and/or update task, the labor distribution effort is fairly simple. The number of technicians and clerical staff in each

LABOR AVAILABILITY ASSUMPTIONS

Weeks per year	52	
Less Vacation/Sick Leave	− 6	
Active weeks available	46	
Days per average week	× 5	
	230	days
Less paid Holidays	−10	
Working days available	220	
Hours per day	× 6.5	
Hours available	1,430	hours/year
Minutes per hour	×60	
Minutes available	85,800	minutes per year

Figure 5

LABOR DISTRIBUTION WORK SHEET

BATCH PROCESSING	# Assigned	Minutes per year (000)	Unit Tasks performed (000)	Minutes per Task
Classify/Sort				
Supervision	1.5	128.7	121.5	1.1
Technician	12.	1,029.6	121.5	8.5
Clerical	3	257.4	121.5	2.1
Technical Search				
Supervision	1.5	128.7	121.5	1.1
Technician	13	1,115.4	121.5	9.2
Batch Summary				
Supervision	3	257.4	121.5	2.1
Technician	25	2,145.0	121.5	17.7
Clerical	3	257.4	121.5	2.1
SERIAL (V.I.P.) PROCESSING				
Technician	5	427.5	13.5	31.7
UPDATE				
Clerical	8	686.4	100.0	6.9

Figure 6

BURDENED LABOR RATE WORK SHEET

Position	Annual Salary Range ($000)	Mid Range Rate per Yr. ($000)	% Burden	Total Salary Costs Per Year ($000)
Direct Supervision				
Grade I	18-22	20	28	25.6
Grade II	15-18	16.5	28	21.2
Fingerprint Technicians				
Grade I	12-15	13.5	21	16.3
Grade II	10-12	11	21	13.3
Grade III	8.5-10	9.3	21	11.3
Clerical				
Grade I	8.5-10	9.3	16	10.8
Grade II	7.-8.5	7.8	16	9.0
Grade III	6.-7.	6.5	16	7.5

Figure 7

LABOR RATE DISTRIBUTION WORK SHEET

	RATE $000	Classify/Sort Number Positions	Classify/Sort $000	Search Number Positions	Search $000	V.I.P. Search Number Positions	V.I.P. Search $000	Update Number Positions	Update $000
Supervision									
Grade I	25.6	0.5	12.8	1.5	38.4				
Grade II	21.1	1.0	21.1						
Technicians									
Grade I	16.3	1	16.3	6	97.8	4	65.2		
Grade II	13.3	5	66.5	3	39.9	1	13.3		
Grade III	11.3	6	67.8	4	45.2				
Clerical									
Grade I	10.8	1	10.8					3	32.4
Grade II	9.0	1	9.0					3	27.0
Grade III	7.5	1	7.5					2.	15.0
Total			$211.8		$221.3		$78.5		$74.4

Figure 8

grade times the burdened pay rate for the grade provides the total labor cost to perform that function. Similarly, the total cost to perform the search task can be estimated if the update function is performed by separate personnel. This is usually the case, since a name index is generally updated at the same time and this function may be carried out by clerical personnel. To achieve a gross estimate of task or function costs, utilize data from the prime shift for a normal work week.

For those agencies operating in a serial mode—classification and searching of a single record by the same technician — it will be necessary to develop standard times and rates for the individual tasks, because automated systems are best defined and compared in this manner. Standard times can be developed by temporarily altering the serial mode of operation and logging the time spent by personnel in performing the discrete tasks. However, tests of this type should be made over ext ended periods (a minimum of a week; preferably 30 days) to account for peak loading, adapting to new methods and other variations.

Unit task cost is simply the dollar cost of performaing a single unit of work — classification, searching and updating. For a manual system, which is primarily labor oriented, the unit cost is derived by dividing the total dollars spent for the task by the total number of times the task is performed.

PROJECTING SYSTEM COSTS

It is necessary to predict future cost levels of the current system as a result of increases in data base size, activity rates and inflation. While it is recognized that the longer the forecast, the less accurate the prediction, it is recommended that a ten year projection be developed. Procurement cycles for automated systems typically require up to two years; production and implementation takes one to two years; and conversion will require another one to two years.

Up to five years will have elapsed before an operating system begins to generate savings. Considering a five year payout, the ten year minimum forecasting period appears reasonable.

The increase in number of forms submitted for processing is subject to many factors and probably the most difficult to predict. Past history is normally a good indicator of increases as a result of increased population. Another major factor affecting activity growth is anticipated legislation that can have an impact on the number of fingerprints to be identified. Typical examples include new requirements for gun or medical practitioner registration. A typical worksheet is supplied as Figure 10.

Search efficiency and costs are directly related to increases in data base size. Overall increases may be determined by simply adding the number of records

UNIT TASK COST SUMMARY

Task Performed	Number Performed	Cost to Perform	Unit Cost
Batch Searches	121,500		
Classify/Sort		$211,800	1.74
Search		221,300	1.82
Total		$433,100	3.56
Serial (V.I.P.) Searches	13,500	$ 78,500	5.81
Updates	100,000	$ 74,400	.74

Figure 9

ACTIVITY RATE PROJECTION WORK SHEET

	Serial (V.I.P.) Searches (000)	Batch Search (000)	Update (000)
Current Year	13.5	121.5	100.0
+1	13.9	125.1	103.0
+2	14.3	128.9	106.0
+3	14.7	132.8	109.0
+4	15.3	136.8	113.0
+5	15.7	140.9	116.0
+6	16.1	144.6	123.0
+7	16.6	149.0	127.0
+8	17.1	153.4	130.0
+9	17.6	158.0	134.0
+10	18.1	162.7	138.0

Assumption: 3% annual increase

Figure 10

added in the previous year, subtracting the effects of purging (if any), and calculating the percent increase. However, this may generate a misleading growth factor if the current file contains a relatively high percentage of inactive records. To estimate the true growth factor, the increase in records added should be applied to that section of the file where the growth actually applies and the growth percentage applied to that subfile. A sample worksheet is supplied as Figure 11.

Inflation not only effects prime labor rates, but also the various burdens applied to labor and capital equipment investments. Assuming burdens are applied as a percentage of prime labor, then any increase in prime labor will reflect a similar increase in the dollar value of the burden without further adjustment in the burden percentage. However, if a future increase in the burden factors are anticipated, such as increases in retirement contributions or other fringe benefits, then these increases should be reflected as increased burden percentages.

Agency cost increases are due primarily to increases in labor and burden rates coupled with increases in manpower requirements. The total manpower required is determined by two factors — increase in activity, or records to be processed, and increases in the size of the data base to be searched. As the number of records to be searched increases, there will be a proportionate increase in the number of personnel required to conduct these searches. Not so obvious, however, is the effect of data base change on search costs. If the integrity of the search process is to be maintained, that is the miss rate to be held constant, then technicians must search ever larger numbers of records. Therefore, it can be assumed that search time—and cost—is directly proportional to increases in data base size. Periodic purging of the file can also have a significant effect on data base size and search costs. Figures 12, 13 and 14 illustrate a methodology for estimating unit task and overall agency costs with modest increases in file size and inflation rates.

MEASURING SYSTEM PERFORMANCE

In addition to the cost factors which have been previously discussed, the impact of data base size and activity on "turnaround time", "throughput" and "miss rate" should be considered.

Turnaround time is essentially the elapsed time from the receipt of an inquiry for processing until the response is generated. Within the technical search section of the fingerprint bureau, response time is considered as the time from a negative name index search until a technical fingerprint search has been completed. In the earlier example of Labor Distribution, Figure 6, it was indicated that the average time required to perform a serial search was 31.7 minutes. A skilled fingerprint technician may argue that he can process a single inquiry in 10 minutes or less. And so he can, if all inquiries arrive at a uniform rate and fatigue and other efficiency factors are ignored. Unfortunately, such is not the case. Requests arrive irregularly and a queue often builds up with cards waiting to be worked. Turnaround time can be reduced by adding personnel so that a technician is always waiting for inquiry, but only at the cost of increased minutes per task assignment and greater overall costs. Therefore, a reasonable trade-off between turnaround time and cost must be established and monitored.

The throughput of a system is, in essence, the inverse of the turnaround time. It is a measure of the total amount of a task that can be performed in a given unit of time. Throughput should normally be measured over longer periods of time (i.e., 30 days) to take into account such factors as peak loading, fatigue of personnel, etc. A warning signal that peak load capacity is being exceeded is the fact that significant backlogs are accruing from one period to the next. Throughput can generally be improved by adding personnel, providing that the

DATA BASE PROJECTION WORK SHEET

Year	MALE Size-Additions* (000)		FEMALE Size-Additions* (000)		Total (000)	Cumul. % Inc.
Current	675.0	90.0	75.0	10.0	750	—
+1	765.0	92.7	85.0	10.3	850	11.8
+2	857.7	95.4	95.3	10.6	953	21.3
+3	953.1	98.1	105.9	10.9	1,059	29.2
+4	1,051.2	101.7	117.2	11.3	1,168	35.8
+5	1,152.9	104.4	128.8	11.6	1,281	41.5
**Purge		(277.5)		(30.9)		
+6	978.8	110.7	109.5	12.3	1,089	31.1
+7	1,089.5	114.3	121.8	12.7	1,212	38.1
+8	1,203.8	117.0	134.5	13.0	1,339	44.0
+9	1,320.8	120.6	147.5	13.4	1,469	48.9
+10	1,441.4		160.9		1,603	53.2

*Assumes 3% activity increase results in proportional file growth.
**Assumes 50% of misdemeanor records purged at end of fifth year.

Figure 11

increased activity/backlog trands are persistent.

The two Cardinal Sins in indentification are the "false identification" and the "missed identification." Most technicians and agencies pride themselves on a low miss rate, but a true evaluation of the miss rate is difficult to make. Test programs are rarely successful due to the complexity of a meaningful evaluation and the fact that personnel who know they are being "tested" will not perform in a routine manner.

A major contributor to a high miss rate is shortening the search parameters. Ignoring referenced patterns or marginal sub-secondary classifications will invariably produce some missed identifications. If notifications of "misses" continues to exceed established standards, then a close examination of the data base/activity increases in relation to the personnel increases is in order.

SUMMARY

Key elements in the manual system must be identified and measured so that a direct comparison may be made between manual and alternative automated systems. Measuring the current system cost and performance primarily consists of:

- defining the data base and activity parameters
- determining the costs required to achieve current performance
- projecting costs required to meet increased workload demands due to increased data base size.

For manual systems, costs are primarily labor oriented. Automated systems substitute hardware and software costs for the manual costs. The assessment of cost and performance is task oriented. Therefore, specific tasks and associated costs must be defined to determine current and projected costs. The manual and automated systems should be compared on a task-by-task basis.

Developing standard rates for the various tasks associated with the identification process is extremely valuable for analyzing current performance and comparing it with the automated systems under consideration. Standard rates are also needed to predict future staff and cost levels resulting from increased file size and user demand.

The impact of increased activity and data base size on "turnaround time", "throughput", and "miss rates" *must* be carefully considered before final decisions are made.

UNIT TASK COST PROJECTIONS AS A RESULT OF DATA BASE SIZE AND LABOR RATE INCREASE

Year	*Data Base + %	**Labor Rate = %	Net Increase %	Batch Classify $	+ Search $	= Total $	V.I.P. Serial $	Update $
Current	—	—	0.0	***1.74	1.82	3.56	5.81	.74
+1	11.8	6.	17.8	2.05	2.14	4.19	6.84	.87
+2	21.3	12.	33.3	2.32	2.43	4.75	7.74	.98
+3	29.2	19.	48.2	2.58	2.70	5.28	8.61	1.10
+4	35.8	26.	51.8	2.64	2.76	5.40	8.82	1.12
+5	41.5	34.	75.5	3.05	3.19	6.24	10.20	1.30
+6	31.1	42.	73.1	3.01	3.15	6.16	10.06	1.28
+7	38.1	50.	88.1	3.27	3.42	6.69	10.93	1.39
+8	44.0	59.	103.0	3.53	3.69	7.22	11.79	1.50
+9	48.9	69.	117.9	3.79	3.97	7.76	12.66	1.61
+10	53.2	90.	143.2	4.23	4.43	8.66	14.13	1.80

*Data Base Increase, Ref. Figure 3.11
**Labor Rate Increase, compounded at 6% per year.
***Current unit task costs, Ref. Figure 3.9

Figure 12

PROJECTING TOTAL TASK COSTS

Batch Processing

Year	*Qty. (000)	Classify **Unit Rate $	Classify Net Cost $	Search **Unit Rate $	Search Net Cost $	Process Total $
Current	121.5	1.74	211.4	1.82	221.1	432.5
+1	125.1	2.05	256.5	2.14	267.7	524.2
+2	128.9	2.32	299.0	2.43	313.2	612.2
+3	132.8	2.58	342.6	2.70	358.6	701.2
+4	136.8	2.64	361.2	2.76	377.6	738.8
+5	140.9	3.05	429.7	3.19	449.5	879.2
+6	144.6	3.01	435.2	3.15	455.5	890.7
+7	149.0	3.27	487.2	3.42	509.6	996.8
+8	153.4	3.53	541.5	3.69	566.0	1,107.5
+9	158.0	3.79	598.8	3.97	627.3	1,226.1
+10	162.7	4.23	688.2	4.43	720.8	1,409.1

*Activity Rate Projection, Ref. Figure 10
**Labor Rate Projection, Ref. Figure 12

Figure 13

PROJECTING TASK COSTS

Serial (V.I.P.) Search, Update, and Total Costs

	Serial (V.I.P.) Search			Update			***Total
	*Qty. (000)	**Unit Rate $	Net Cost ($000)	*Qty. (000)	**Unit Rate $	Net Cost ($000)	Agency Cost ($000)
Current	13.5	5.81	78.4	100	.74	74.0	584.9
+1	13.9	6.84	95.1	103	.87	89.6	708.9
+2	14.3	7.74	110.7	106	.98	103.9	826.8
+3	14.7	8.61	126.6	109	1.10	119.9	947.7
+4	15.3	8.82	134.9	113	1.12	126.6	1,000.3
+5	15.7	10.20	160.1	116	1.30	150.8	1,190.1
+6	16.1	10.06	162.0	123	1.28	157.4	1,210.1
+7	16.6	10.93	181.4	127	1.39	176.5	1.354.7
+8	17.1	11.79	201.6	130	1.50	195.0	1,504.1
+9	17.6	12.66	222.8	134	1.61	215.7	1,664.6
+10	18.1	14.13	255.8	138	1.80	248.4	1,913.3

*Activity Rate Projection, Ref. Figure 10
**Labor Rate Projection, Ref. Figure 12
***Includes Batch Processing, Ref. Figure 13

Figure 14

IV. SPECIFYING AUTOMATION REQUIREMENTS

Once a clear sense of the characteristics and costs of the existing system has been established and potential future impacts upon the system have been projected, the agency can turn to specification of system requirements and the solicitation of technical responses from system vendors. In specifying system requirements, the focus should be upon specific objectives rather than upon supposed means of accomplishing those objectives. Further, the agency should differentiate between those system objectives that are mandatory ("musts") and those which are simply desirable ("wants").

BASIC APPLICATION DATA

In order to develop a reasonably accurate estimate of cost and performance, the prospective supplier requires a definitive statement of data base and processing activity, and a statement of objectives or improvements anticipated. Much of the data collected in Measuring the Current System can be utilized. Specific data to be included are the following.

A description of both current and projected file size and distribution should be provided. The description should include any pertinent distribution factors such as active/inactive segments of the file, age breakdowns, criminal/civil, male/female, and other data that may be useful in developing the optimum system.

The current and projected activity rates for the various major work functions should be clearly defined. These include the task oriented work functions—classify, search, serial (V.I.P.) searching, update, purge, etc. Activity rates should be clearly identified with the major file subdivisions that currently exist. For example, if 95% of the technical search inquiries are directed to the active male criminal segment (17.8% of the total civil and criminal file), this should be clearly stated.

A realistic approach to specifying the turnaround and throughput requirements for the various tasks is essential to soliciting cost-effective system estimates. Minimum acceptable times for V.I.P. processing, batch search processing, and updating will have a significant impact on system cost estimates.

Well prepared flow diagrams of the major work cycles will greatly assist the vendor in supplying accurate estimates of system costs. The flow diagrams should be representative of the current operational work flow. Maximum benefit from the system under consideration may well be derived from minor alterations to the current operation. Flow diagrams should reflect major points of interaction with other departments within the agency and with other external agencies. Flow diagrams should be in such form that key activities and rates can be easily identified.

A major element in specifying the application is a definition of fingerprint card forms and formats. While most agencies have converted to a standardized 8 x 8 form with fingerprints in the center, many older, but still active, records follow a wide variety of layout configurations. For instance, layout on one side of the form may be of little consequence to a microfilm system, but double-sided forms can have a major impact. The location of fingerprints on the form will also have impact on most scanning systems. Therefore, it is recommended that the request for estimate include copies of the different fingerprint forms and formats that must be considered.

Whether the system under consideration is for graphic image storage only, or for a fully automated scanning system which classifies fingerprints, fingerprint quality will affect system reliability. Fingerprint quality standards will inevitably be the subject of considerable discussion in a final system specification. However, in the preliminary stages of investigation, representative samples ranging from minimum to excellent quality should be supplied to potential vendors as examples in the preliminary estimates.

The use of Henry and/or NCIC fingerprint codes as part of both the current and projected requirements should be clearly indicated. The availability of such data may also be of significance in estimating automated system costs. If coded data is currently available in a computer format for use in file conversion, details should be noted in the estimate request.

If the system will require either operational or system hardware interfaces with intra-departmental and interagency activites, the interface points and relative activity at these points must be clearly identified. The operational flow diagrams should reflect all interface requirements.

TECHNICAL RESPONSE DATA SOLICITED

This section describes the type of technical description responses that are required from prospective equipment vendors to make a comparative analysis between manual and automated system performance. Technical responses should reflect the application requirements as provided by the agency and should be task oriented—classification, search and update. Specific response items include the following.

A description of the basic system concept to be applied in automating the application should be included. The concept should provide, in terms understandable to a layman, a description of the methodology employed for such functions as scanning, minutiae detection, etc., and should refer to experience gained in using the concept in other installations. It should also describe future trends or plans for the concept.

Assuming the automated system concept differs from current searching methodology, "hit rate" and "miss rate" using the methodology should be stated or estimated for evaluation. Experience in other operating environments should be cited. If such experience is not available, as in the case of a new development, methods for testing reliability should be recommended. Automated sytems require some degree of preventive maintenance. Unscheduled maintenance as a result of "key element" failure will also effect systems to a varying degree. The vendor response should include the following major references:

- Up-time (or down-time) and how measured.
- Alternate path degradation.
- Mean time between failure/mean time to repair (MTBF/MTTR).
- Back-up system capability.

The vendor should supply easily understandable flow diagrams reflecting the major task elements and relevant interface points. The flow diagrams should be of such a form that personnel and equipment required to perform the operation, as well as related timing factors, can be easily identified.

System timing estimates should be included and related both to major task functions and the flow diagrams. Personnel estimates and/or assumptions should be included. Internal system timing functions are relatively unimportant, at this stage.

Emphasis should be placed on timing specifications at the man/machine interface. Timing estimates should include both current and projected data base/activity requirements.

From the vendor point of view, the system input requirements and assumptions should be described and should include a response to the sample forms supplied and intended use or modification of the coded data available. Any assuptions regarding operator/technician capabilities and speeds should be identified.

An Output Statement should describe the output to be provided by the proposed system. Samples of output forms, such as CRT displays, facsimile reproductions, respondent listings, etc., should be included if available. Assumptions regarding technician/operator capabilities and speeds should also be included.

Operating personnel at various levels should be specified and quantified. If special training and/or attributes are required, these should be identified. If the vendor offers training, he should include provisions for the training in the estimate.

The vendor should be encouraged to offer alternate equipment configurations and to define the cost/performance impact of the various options. Typical of the alternatives are:

- On-line vs. off-line storage of data.
- Real time vs. batch processing modes of operation.
- Manual vs. fully automated input.
- On-site vs. on-call maintenance.

Assuming a major conversion effort is required, the vendor should recommend a conversion implementation program that will create minimum disturbance to the current operation. The conversion program recommendations should make provisions for the following major items:

- Pre-conversion file conditioning such as purging, reclassification, etc.
- File conversion sequencing and impact on current operation.
- Parallel manual/automated operation during the conversion period.
- Interim testing of partially converted or selected files.
- Concurrent conversion of new input during the conversion period.
- Special or temporary personnel required during the conversion period.

The vendor should clearly specify "off the shelf" vs. new development efforts required to produce the proposed system. If a significant item requires new development, then testing programs should be included in the estimates.

COST DATA SOLICITED

The primary purpose in soliciting the preliminary estimate is to allow the agency to analyze current and projected operating costs and to arrive at a decision to

expend resources on further investigation. Recognizing the fact that the preliminary vendor estimates can be no more accurate than the data supplied, estimate requests should provide some latitude. In general, cost data accumulated that is accurate within a range of plus or minus 20% should be acceptable at this level of evaluation. Following are the minimum items that should be included in a responsible system estimate. Vendors should provide estimates of hardware and software required to satisfy the application requirement and optional implementation if these produce a better cost benefit profile.

If the vendor supplies hardware on a lease or lease/purchase basis, he should be asked to supply estimates in this form. This is especially true in the case of input/output terminals and storage devices when quantity requirements are highly dependent upon anticipated temporary requirements. Lease programs may also provide for a better cash flow justification.

Maintenance rates for on-site/on-call maintenance are essential ingredients in predicting ongoing costs. Warranty provisions on parts and estimated parts usage requirements must be considered in the final cost analysis.

System operating materials and supplies for both the conversion and ongoing system operation must be estimated. Typical are such items as film, tape, disks, paper and EAM cards. Extensive processing costs, if applicable, should also be included.

Depending upon the complexity of the system, site preparation may be a significant cost item to be considered. While site preparation is primarily a user responsibility, the vendor should specify detailed site requirements and provide any supportive data that may be useful in a final cost analysis. Typical site requirements may include the following:

- Building Modifications — Floor space requirements for both the system and maintenance/parts accommodation should be identified and evaluated in terms of space currently available. Equipment floor loading and physical size may require major modifications to building and facilities.
- Environmental Considerations — Many automated systems require some measure of control over temperature and humidity. The vendor should specify requirements of his system for comparison against existing facilities.
- Power Requirements — The power availability in the planned facility should be compared with the automated system requirements. Backup (motor driven supplies) may be required if power outages are likely in the local area.
- Facilities Modifications — Ascertain if false floor or special lighting requirements are needed for the automated system. If these facilities are not already available, they may contribute significantly to the ultimate implementation cost.

It may be safely assumed that all current personnel will require some degree of training in automated system operation. The agency may find that providing maintenance with agency personnel may be an attractive alternate to full-time maintenance support from the vendor. The vendor should specify the degree of training required, and he should also provide cost estimates for these services. If the vendor relies on his suppliers (such as a scanning system that utilizes standard minicomputers), then this fact should be identified and typical training rates provided.

SUMMARY

When considering the purchase of automated equipment, primary emphasis should be placed on the statement of the objectives rather than how to meet those objectives.

To provide a reasonably accurate estimate of cost and performance, the supplier needs a definitive statement of:

- current operating parameters
- projections of data base size
- anticipated processing activity
- objective or improvements anticipated.

Response from vendors should reflect the application requirements as provided by the agency and should be task oriented—classification, search, and update. The vendor should be encouraged to offer alternate equipment configurations and to define the cost and performance impact of the various options. The vendor should also recommend a conversion implementation program that will create minimum disturbance to the current operation.

V. ANALYZING SYSTEM CAPABILITIES AND COSTS

well within the stated requirements. A poor rating is used to infer that the system's ability to meet the minimum requirements may be marginal or that alternate approaches are questionable. A "DNC", or Does Not Comply, indicates that the system under consideration does not meet the agencies' mandatory minimum requirements.

The assessment of these ratings, as with most management decisions, must be tempered with prudent judgment. An Excellent rating in turn-around time may be of great value to an agency which is constantly struggling to improve response time, while it may be of little value to an agency which is quite satisfied with its current response. Similarly, a higher find rate (lower miss rate) may be of far more value to one agency than to another.

IMPLEMENTATION COSTS

System cost analysis can best be performed by considering cost factors in two segments—implementation (one time) costs and ongoing operating costs. This section identifies those costs typically incurred from the negotiation of a contract until the system is fully operational—the implementation period. Typical work sheets are shown as Figure 16. These work sheets can be modified as required to satisfy the particular application. Key factors to be considered include the following:

Basic System Costs/Options — This section assumes a purchase contract wherein the total system cost is included for payment following acceptance testing. If lease or lease/purchase plans are provided, this section may be disregarded.

External Interface — Includes costs of modifying interface relationships required to satisfy new system requirements. Typical costs are software changes to existing computerized criminal history (CCH) operation, forms redesign and introduction, etc.

Site Preparation — Assumes some level of site preparation is required for installation of the sytem.

Implementation Manpower — During the sytem implementation phase, significant manpower may be

System concepts range from simple graphic storage and retrieval, computer-assisted technical search processes to improve search performance, to highly sophisticated scanner systems that can be utilized either to improve the classification effort or to totally automate the classification/search procedure. The first step in analyzing system capabilities and costs is to determine which automation concept presents a viable approach for the agency.

If cost reduction is the primary objective, considering an automated system in which maintenance costs alone are comparable to or exceed current operating costs does not appear reasonable. Similarly, if the agency has a long range commitment to computer assisted technical searching, then examining a scanning system that is not compatible would not appear to be feasible. This does not mean to imply that two or more concepts should not be considered, but it does imply that different comparison approaches may be required.

Having determined the system concept(s) that appear to offer viable solutions, the second level of comparison and analysis involves the selection of a particular system that best meets the needs of the agency. Making the decision between two or more system concepts involves comparison of both cost and performance standards. Cost comparisons are primarily objective, based upon comparisons of the relative costs to performs the major tasks. The evaluation of performance, on the other hand, becomes primarily subjective when performance capabilities extend beyond the basic mandatory requirements. The values of increased find rates, latent search capabilities, multiple installations, and reduced turnaround times are difficult to quantify but should be considered in the final evaluation formula.

EVALUATING PERFORMANCE

Probably the most difficult task in system evaluation is comparing the performance of various systems and suppliers. A typical work sheet for use in comparing relative systems and approaches is supplied in Figure 15. The ratings "Excellent", "Good", "Poor", and "DNC" (Does Not Comply) should be related to the mandatory requirements suggested by the agency. An Excellent rating is implicit of a performance characteristic that significantly exceeds the mandatory requirement. A rating of Good implies that the rated system performs

PERFORMANCE EVALUATION WORK SHEET

	Exc.	Good	Poor	DNC
1. File Dimensions				
Does the system meet the minimum application requirements?	☐	☐	☐	☐
Is it easily expandable for future requirements?	☐	☐	☐	☐
Is it adaptable for new applications?	☐	☐	☐	☐
Is it adaptable for new file organizations?	☐	☐	☐	☐
Can it effectively take advantage of purging?	☐	☐	☐	☐
2. File Activity				
Does it provide minimum throughput for current activity?	☐	☐	☐	☐
Does it provide for minimum throughput for projected activity?	☐	☐	☐	☐
Does it provide for minimum turn around time for current activity?	☐	☐	☐	☐
Does it provide for minimum turn around time for projected activity?	☐	☐	☐	☐
Does it have flexibility to meet peak load demands?	☐	☐	☐	☐
Does it meet the minimum update timing required?	☐	☐	☐	☐
3. Reliability				
Does it meet maximum miss rate specified?	☐	☐	☐	☐
Can miss rate performance be demonstrated?	☐	☐	☐	☐
Have provisions for degraded performance been included?	☐	☐	☐	☐
Does the system meet the "down time" requirements?	☐	☐	☐	☐
Are provisions available for system backup?	☐	☐	☐	☐
Are provisions available for file backup?	☐	☐	☐	☐
4. Maintenance				
Does the system comply with the maximum MTBF? MTTR specified?	☐	☐	☐	☐
Does it comply with maximum service call response time specified?	☐	☐	☐	☐
Does it comply with spare parts support specified?	☐	☐	☐	☐
Does it provide for user maintenace?	☐	☐	☐	☐
5. Input Requirements				
Did the vendor accept the stated document formats?	☐	☐	☐	☐
Did he accept the specified document quality?	☐	☐	☐	☐
Are present coding formats and media acceptable?	☐	☐	☐	☐

Figure 15

PERFORMANCE EVALUATION WORK SHEET (Continued)

	Exc.	Good	Poor	DNC
6. Output Capability				
Can the system provide all output data required?	☐	☐	☐	☐
Is it in a useable form and format?	☐	☐	☐	☐
Does graphic output meet minimum standards?	☐	☐	☐	☐
What is fingerprint technician attitude toward output media and format?	☐	☐	☐	☐
7. Interface Requirements				
Will the system accept computer generated input as presently available?	☐	☐	☐	☐
Does the system provide data output in a format compatible with current DP operations?	☐	☐	☐	☐
Is NCIC coding available as an output?	☐	☐	☐	☐
Is FBI standard minutiae classification available?	☐	☐	☐	☐
8. Installation Criteria				
Can the system utilize current facilities?	☐	☐	☐	☐
Power?	☐	☐	☐	☐
Environment?	☐	☐	☐	☐
Lighting?	☐	☐	☐	☐
Does it fit in present space available?	☐	☐	☐	☐
Has vendor specified necessary installation data?	☐	☐	☐	☐
Will he provide installation support?	☐	☐	☐	☐
9. Training				
Is extensive training required?	☐	☐	☐	☐
Does vendor offer required training?	☐	☐	☐	☐
Is training "on-site" (Agency facility)?	☐	☐	☐	☐
10. Contractural Considerations				
Are lease/purchase options offered?	☐	☐	☐	☐
Will delivery/conversion requirements be met?	☐	☐	☐	☐
Does vendor generally accept standard agency contract format?	☐	☐	☐	☐
Will vendor meet long term support commitments?	☐	☐	☐	☐
11. Vendor Credentials				
Has vendor installed many systems?	☐	☐	☐	☐
Has vendor supplied installation references?	☐	☐	☐	☐
Is a "user group" available?	☐	☐	☐	☐
Does the system represent a major segment of the vendor's business?	☐	☐	☐	☐
Do vendor personnel give a good background/insight to the application?	☐	☐	☐	☐

Figure 15

DATA WORK SHEET
IMPLEMENTATION COSTS

VENDOR _____ CONFIGURATION OPTION _____

I. Basic System Costs

Hardware/Software ..... $ _____
External Interface Hardware ..... $ _____
External Software ..... $ _____
Other "One-Time" Costs ..... $ _____

II. Site Preparation Costs

Building Modifications ..... $ _____
Electrical Modifications ..... $ _____
Environmental Modifications (Temp., Humidity, etc.) ..... $ _____
Facilities Modifications (False floor, lighting) ..... $ _____

III. Project Support Team

Systems Analysts ..... $ _____
Programmers ..... $ _____
Other ..... $ _____

IV. Travel Expenses

Transportation ..... _____ trips @ $ _____
Per Diem ..... _____ days @ $ _____

V. Consulting Services

_____ weeks/months @ $ _____

VI. Training

Vendor Charges ..... $ _____
Personnel:
Supervision ..... _____ man-weeks @ $ _____
Technician ..... _____ man-weeks @ $ _____
Clerical ..... _____ man-weeks @ $ _____

Figure 16

DATA WORK SHEET (Continued)

VII. **Conversion Costs**

Purge (if implemented)

Records to be purged ..... _____

Cost per record purged ..... $ _____

Total Purge Costs ..... $ _____

Records to be converted

Current File Size _____ records

Additions ..... _____ records

Sub-Total ..... _____

Less records purged ..... $ _____

Total to be converted ..... $ _____ records

VIII. **Manpower Costs**

Keypunch (if required)

_____ records/man-year @ $ _____ /man-year

Total Keypunch costs ..... $ _____

Refiling (or other disposition)

_____ records/man-year @ $ _____ /man-year

Refiling Costs ..... $ _____

System Operators (Camera Station, Document Handler, etc.)

_____ records/man-year @ $ _____ /man-year

Total operator cost ..... $ _____

Other Temporary Labor ..... $ _____

Total Conversion Manpower ..... $ _____

IX. **Media Costs (Materials)**

Media Cost per 1,000 Records ..... $ _____

_____ 000 Records Converted

Conversion Media Costs ..... $ _____

X. **Maintenance Costs**

On-call Maintenance ..... $ _____ /year

On-site Maintenance ..... $ _____ /year

XI. **Parts Cost** ..... $ _____ /year

Figure 16

expended depending upon the complexity of the system to be installed. Specific categories that should be considered are the following:

Project Team — Full-time personnel assigned during the implementation phase for the purpose of system planning and analysis, progress monitoring and general program management functions.

Conversion Team — Personnel required for both pre-conversion file conditioning and conversion processing. Temporary help for purging or special test purging or special test programs should also be included.

Travel Expense — If significant travel and per diem are required for interim or final testing programs, these expense items should be considered.

Consulting Fees — The use of temporary consultants for specific tasks may be desirable. Include as appropriate.

Conversion Materials — Includes cards, tapes, film and other media and supplies necessary to effect conversion prior to full system operation.

Training — If specialized training for technicians and other operating personnel is required, these costs must be taken into account. Recruiting costs for new personnel (programmers, system operators, etc.) may also be included.

OPERATING (On-Going) COSTS

The operating, or on-going, costs are all operating costs chargeable to the operating system following the conversion and acceptance testing effort. Typical work sheets are provided as Figure 17 and may be used as a guide in estimating the task oriented costs in the automated environment. Typical costs include the following:

Equipment Costs — Assuming a lease, or lease/purchase, arrangement has been negotiated, the annual lease payments and buy out option should be included. If incremental additions of equipment have been added for future expansion, or other future hardware/software expansions are anticipated, these costs should be accounted for. If the basic system purchase price is to be amortized over a finite period of time, system amortization rates should be included as an on-going system cost instead of as an implementation item.

Maintenance and Parts — Includes all maintenance and parts cost estimates as provided by the vendor. If Maintenance Contracts are available on long term basis (i.e. 3+ years), utilize vendor estimates. Otherwise, apply inflation factors for future years as appropriate. Unless vendor is willing to supply maintenance at no charge during the conversion period, the cost of maintenance and parts (less warranty provision) during the conversion should be included.

Operating Personnel — Includes both operating and direct supervision with appropriate allowances for shift differentials. Overhead burden and inflation factors should be applied as illustrated.

Support Personnel — Includes personnel directly associated with system support, but not directly involved in the identification process. Typical support personnel are systems analysts, programmers, and agency-employed systems maintenance personnel.

Operating Materials — Includes all operating materials and supplies required to support the automated system operation. Typical items are film, processing costs, tape, disks, EAM Cards, paper and other expendables.

Interface Costs — If significant external support and interface costs are anticipated as a result of automated system installation, these should be included and burdened as appropriate. Typical costs include modem lease rates, external CPU time required to support the automated system, etc.

CALCULATING THE "BOTTOM LINE"

Assuming the performance capabilities of the system under consideration meet the criteria of the agency, then implementation and on-going costs of the automated approach must be compared against the projected costs of the current method of operation. Automated system costs must be evaluated in two discrete segments—the cost to implement the system, and the cost to operate the following implementation.

As indicated earlier, implementation costs include not only the basic cost of the hardware/software, but also the conversion and other support costs required to bring the automated system up to full operating status. Previous work sheets illustrated the type of data to be collected in order to analyze implementation costs. Fig. 18 illustrates a method of displaying these costs for analysis and comparison with the manual system projections, the examples provided are purely hypothetical and do not relate to any particular system or concept. They are, however, typical and provide a means of identifying those key items that must be considered. In the example shown, it is assumed that two years are required to produce and install the sytem in question and to convert the file for total operation. Several points in the example are worthy of notation.

DATA WORK SHEET
ON-GOING COSTS

I. Equipment Costs

Lease Rate ..... $ _____/year

Buy out option .....$_____ year applied

Equipment additions ....$_____ year applied_____

Inflation factors to be applied..... _____ %

II. Maintenance Costs

On site maintenance..... $ _____/year

On call maintenance ..... $ _____/year

Inflation factor to be applied ..... _____ %

III. Parts Cost

Parts cost (per vendor estimate) ..... $ _____ year

Inflation factor to be applied ..... _____ %

IV. Operating Personnel

Supervision ..#_____ @ $_____ average burdened rate

Technicians ..#_____ @ $_____ average burdened rate

Clerical .....#_____ @ $_____ average burdened rate

Increases applied:

Salary Inflation ..... _____ %

Growth/activity increase ..... _____ %

Total..... _____ %

V. Support Personnel

Systems Analysts #_____ @ $_____ average burdened rate

Programmers....#_____ @ $_____ averaged burdened rate

Inflation Factor:..... _____ %

VI. Materials (Media) Costs

Unit Record Cost ..... $ _____

VII. Interface & Support Charges

Annual Rate ..... $ _____

Inflation Factor:..... _____ %

Figure 17

(a) The system cost has been displayed on the assumption it is a straight purchase. (If the system is leased, these costs are to be transferred to Fig. 19 which follows.)

(b) The conversion costs include a modest estimate for purging. Total conversion costs nearly equate to system costs and require a closer examination in the final analysis.

(c) The "bottom line" total is approximately 2.5 times the investment in the basic system, highlighting the need for detailed studies before final commitments are made.

Assuming that the system under consideration can be installed and the files converted in two years, on-going costs can be compared for the third, and subsequent, years when the system is in full operation. If longer

PROJECTING AUTOMATED SYSTEM IMPLEMENTATION

	Year 1 ($000)	Year 2 ($000)
I. Basic System Costs		
Progress Payment	100.	
Final System Payment		500.
Interface Costs		
Software mods to CCH		50.
D.P. Support	50.	
Site Preparation		
Building	25.	
Electrical	15.	
Environment	12.5	
False Floor	2.5	
III. Project Team		
1 programmer/1 analyst	50.	
1 programmer/2 analysts		60.
IV. Travel and per diem	9.	
V. Consulting Services	15.	15.
VI. Training	6.	32.
VII. Conversion		
Purging	45.	
Conversion manpower	80.	315.
Conversion media		60.
VIII. Maintenance		27.
IX. Parts Cost		4.5
Totals	410.	1,063.5
		1,473.5

Figure 18

PROJECTING AUTOMATED SYSTEM ON-GOING COSTS

Year	+3 ($000)	+4 ($000)	+5 ($000)	+6 ($000)	+7 ($000)	+8 ($000)	+9 ($000)	+10 ($000)
Equipment								
Lease								
Buy out								
Additions				75.0				
Maintenance	36.0	38.2	40.4	42.9	45.4	48.2	51.1	54.1
Parts	6.0	6.4	6.7	7.1	7.6	8.0	8.5	9.0
Operating Personnel								
Supervision	60.0	65.4	71.3	77.7	84.7	92.3	100.6	109.7
Technical	192.0	209.3	228.1	248.6	271.0	295.4	322.0	351.0
Clerical	40.0	43.6	47.5	51.8	56.5	61.5	67.1	73.1
Support Personnel	18.0	19.1	20.2	21.4	45.4	48.2	51.1	54.1
Materials	10.0	10.6	11.2	11.9	12.6	13.4	14.2	15.0
Interface	—	—	—	—	—	—	—	—
Total	362.0	392.6	425.4	536.4	523.4	567.0	614.6	666.0

Figure 19

installation/conversion times are anticipated, then cost projections should be modified as appropriate. Significant items to be noted in Figure 19 include the following:

(a) Except for an equipment addition allowance in the sixth year, all equipment costs are accounted for in the initial period. A lease or lease/purchase contract would minimize initial investment, but at the cost of higher operating expenses.

(b) The example illustrated is still highly labor intensive. Labor accounts for approximately 2/3 of the on-going operational costs indicating a possibility of closer examination of the labor estimates and projections in a final system analysis.

Many approaches to economic comparison of current and automated concepts are available and valid. Factors such as the availability of funds, cost and availability of labor, the feasibility of lease versus purchase plans, and other long range considerations must be taken into account in the final decision analysis.

It is hoped that the preceding tables and examples have highlighted the major items that must be examined and the degree of importance they play in overall economic comparisons.

Having collected the "raw material" for this economic comparison, all that remains is to project the current and automated estimates and to determine the point in time that the economic payoff will occur. Fig. 20 illustrates a method of providing for the cost display. Key elements from this display include the following:

(a) Manual and automated costs are from previously projected estimates and calculations.

(b) Net change represents the increase/decrease (+/–) of cash outlay as a result of system implementation. The high costs during the first two years reflect both conversion and equipment purchase.

(c) The cumulative column reflects the net result of system implementation on cash flow. In the example cited, savings will start to accrue in the sixth year after contract (fourth year of full operation), and the cumulative cost reduction within ten years is substantial.

The data thus presented is by no means conclusive. However, it does indicate the possibility of significant cost reductions through system implementation and, in the example cited, would warrant further investigation and detailed studies to confirm the estimates and/or assumptions that were made.

OTHER DECISION FACTORS

As indicated in the Introduction, and repeatedly emphasized in other sections, prudent management consideration must be given to the analysis developed in order to arrive at a "go-no-go" decision. The material developed is to be based on preliminary estimates and must be followed by detailed study and data verification. The primary purpose of this level of analysis is to determine the best automation direction to be heading before extensive funds and resources are allocated to the detailed studies required. In addition to the basic cost and performance criteria presented, many other questions must be addressed during the course of the project. Typical are the following:

Risk Factors — Is the automation approach established and proven, or is it primarily developmental? Have other agencies gone this route? If so, what is their experience? If the approach is developmental, what support is behind the developmental effort? Federal funding? Private funding? What are the chances of success/failure? What recourse is available if the system does not perform to expectations?

Funding Factors — Is funding realistically available for the project selected? What is the competition for funding? Can funding be committed for the period of time required to effect full operation?

Automation Objectives — Have long range objectives been assessed? Does the approach selected meet these long term objectives? Are the objectives primarily cost? Performance? A combination of the two?

Technology trends — Is the system under consideration at the end of its technical life? Is it a well established technology that has a high probability of lasting for the projected future? Is it a technology potentially leading up a "blind alley"? As future technology is developed, can the system be adapted to the new technology?

Capability Extensions — Can the system be expanded to meet forecast requirements? Can the system be adapted to other applications?

Supplier Credentials — Is the system concept manufactured by several manufacturers? Or is it a sole source situation? Is the manufacturer likely to continue the support of the system? Is the system concept in general application, or is it tailored specifically for fingerprint use? What is the supplier history in areas of software, maintenance and parts support?

The previously described Figure 14 illustrates the type of questions that should be considered in evaluating the vendor and system performance capabilities.

SUMMARY

Making the decision between two or more system concepts involves comparison of both cost and performance standards. Performance must be directly related to meeting the agencies' priorities and objectives.

System cost analysis can best be performed by considering cost factors in two segments — implementation (one time) costs and ongoing operating costs. In addition to basic cost and performance criteria, the manager must also consider:

- risk factors
- funding factors
- automation objectives
- technology trends
- capability extensions
- supplier credentials

Prudent management consideration must be given to the analysis developed in order to arrive at a justified "go-no go" decision.

CALCULATING THE "BOTTOM LINE"

Year	*Manual Costs ($000)	Automated Costs ($000)	Net Change ($000)	Cumulative ($000)
Current	432.5			
+1	524.2	934.2	+410.0	+410.0
+2	612.2	1,675.7	+1,063.5	+1,473.5
+3	701.2	362.0	-339.2	+1,134.3
+4	738.8	392.6	-346.2	+788.1
+5	879.2	425.4	-453.8	+334.3
+6	890.7	536.4	-354.3	- 20.0
+7	996.8	523.2	-473.6	-493.6
+8	1,107.5	567.0	-540.5	-1,034.1
+9	1,226.1	614.6	-611.5	-1,645.6
+10	1,409.1	666.0	-743.1	-2,388.7

Figure 20

GLOSSARY OF TERMS

Alternate path degradation — Assuming a system has two or more identical elements performing the same function (terminals, printers, etc.) system will con tinue to operate, but at a slower or degraded per formance.

Automation, Full — Provides for complete automation of the specific function with no human intervention. Example, scanning systems which take fingerprint forms as input and supply a single candidate for verification as output.

Automation, Semi — Provides for partial automation of the total function. Requires significant human assistance. Example, a computer assisted technical search that relies on human classification of the input and human screening of multiple candidate output.

Batch (Processing) — Accumulates multiple similar tasks and processes them as sub-sets of the main task for improved efficienty. Example, collecting many fingerprint inquiries and performing all classification before starting the search process.

Background — Time available after performing highest priority functions. Normally used for performing lower priority functions.

Back log — The collection of low priority items that have been temporarily deferred until time is available for processing.

Backup — Unassigned equipment, personnel or files that may be available to assume the functions of similar system elements that are not available due to unforeseen events.

CATS — Computer Assisted Technical Search. The use of a computer to perform technical searches based upon human generated parameters (Pattern, ridge count/tracing, DOB, etc.) and to generate a list of possible candidates for human screening/verification.

Classification — The process of defining a sub-set of the main file for storing and/or searching for similar prints. Popular manual systems include Henry, Vucetich and NCIC. Scanning systems generally utilize classification techniques that are not human compatible.

Civil — Fingerprint submissions as the result of lawful applications, as opposed to those submitted as the result of a criminal act.

Candidates — The result of CATS or scanning system processing. A list of one or more possibilities for human verification.

Cross Search — The process of searching in two or more classification segments as a result of marginal classification data.

Conversion — The process of changing from one operational mode or system to another.

CRT — Cathode Ray Tube as used in many systems for the display of graphic or human readable characters from a data processing system.

CCH — Computerized Criminal History. The storage of criminal history information on a computer.

CPU — Central Processing Unit, a generic term used loosely to refer to a data processing system.

EAM — Electronic Accounting Machine, usually used in conjunction with EAM cards, or punched cards, used as a data entry media.

Facsimile — A reproduction of an original graphic. Usually refers to a paper copy such as generated by an electronic copier or used following electronic transmission of the original.

False floor — A second artificial, or false, floor placed 9-12″ above the natural floor to provide for cabling and other system access requirements.

Find Rate — The ability of a system to locate, or find, a record known to be in the file. In automated systems it is usually the ability of the system to place the known record near or at the top of a list of possible candidates.

File Conditioning — Measures required to prepare a file for conversion to a new system. Includes such steps as purging, reclassifying, sorting, etc.

Hit — The positive association of an inquiry record with an exact match from the file collection.

Hit Rate — The percentage of positive identifications made in relation to the total number of inquiries made.

Index — An ordered list of the file contents containing pointers to the precise file location where the required record may be located.

Interface — The point at which two systems meet. Interface may be physical, such as the electrical connection between two systems, or operational, such as the man/machine interface at a terminal.

Keypunch — The process of converting data contained on cards or documents to machine readable form via punched cards.

Labor Burdens — A percentage applied to a prime labor rate to account for employer cost contributions that do not normally appear in the employee's pay check.

Labor Rate, Prime — The gross amount paid directly to the employee.

Labor Rate, Burdened — The prime labor rate increased by the burden percentage.

Miss — Failure to find a record known to be in the file.

Miss Rate — The number of records missed expressed as a percentage of the known number of identifications possible.

Modem — A device used for matching, or interfacing, one electronic system to another.

MTBF — Mean Time Between Failures

MTTR — Mean Time To Repair

NCIC — National Crime Information Center. In identification coding, refers to the FBI process of coding fingerprints according to the pattern type and ridge count/tracing information for each finger.

On-Line — The data available to the system without human intervention.

On-Site — The user agency facility.

On-Call — Maintenance plans wherein the service engineer responds to a call for service, as opposed to a resident engineer who is on-site.

Off-Line — Data that is not available for computer processing until such time as an operator installs the data for processing.

Off the shelf — Refers to standard equipment elements that are usually manufactured and stored in anticipa tion of requirements. Contrast to low volume or new design elements that must be manufactured after the need arises.

Peak Loading — Temporary increases in demand as a result of seasonal or one time events that are not representative of daily operations.

Purge — The process of destroying or transferring or otherwise removing inactive or unnecessary records from the active files.

Real Time — In fingerprint processing, attempting to effect an identification as soon as the inquiry is re ceived, potentially while the contributor waits. Contrast to batch processing.

Scanning — Automated systems that utilize electronic scanning devices to extract fingerprint data for processing.

Search Integrity — The reliability of finding a known record in the file. The inverse of miss rate.

Serial Search — The sequential process of responding to a single search inquiry. Usually a high priority search that is processed immediately. Contrast to Batch Searching.

Sort — The process of reorganizing material into a more efficient system organization. Example, sorting a batch of records into primary classification order for further processing.

Technical Search — The process of searching through the fingerprint collection on the basis of fingerprint characteristics. Contrast to name index search.

Test Bed — A sample of the file selected to be represen tative of the total file to be used for preliminary test purposes.

Throughput — The total volume of work that can be processed in a given unit of time.

Turn Around Time — The time elapsed from the submission of an inquiry until the response is available.

Unit Task — A single transaction to be performed. Example, a single card to be classified, a single record to be purged, etc.

Update — The process of adding new material to the file.

V.I.P. — Very Important Person. An expression applied to a high priority transaction. Also known as an expedite transaction.

END