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6

PHASE II FINAL REPORT

PROJECT CHIVE

Volume VI

DOCUMENT DELIVERY SYSTEM

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CHIVE/R-3-65
1 March 1965

DIRECTORATE OF SCIENCE AND TECHNOLOGY
OFFICE OF COMPUTER SERVICES

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Project CHIVE:

Phase II Final Report

Volume VI

DOCUMENT DELIVERY SYSTEM

CHIVE/R-3-65

1 March 1965

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SCOPE OF VOLUME

This volume, dealing with the Document Delivery system, represents somewhat of a departure from the expository nature of the balance of the report. In this volume more emphasis is placed on rationale with an effort to weigh alternative solutions and to explore the tradeoffs involved. Various systems have been described and analyzed for their adherence to established specifications. A recommendation consisting of two alternative system solutions has been submitted for management evaluation.

The different approach taken in this volume is due primarily to the nature of the problem under study. The document storage and retrieval problem is a well defined, largely independent part of the CHIVE system. The function to be performed by the system is straightforward and clearly defined. It involves essentially a large document storage system with a capability for high volume demand printing. As such, it is a problem susceptible to conventional equipment and techniques.

The study, therefore, dealt in an environment where detailed analysis was warranted and direct comparison of competitive solutions was possible.

Chapter 6.2. briefly outlines the Document Delivery requirements, and a brief description is given of the two systems recommended as most suitable for meeting these requirements.

Chapter 6.3. consists of a description of the other system configurations evaluated during the selection process.

Chapter 6.4. contains the rationale used in arriving at the dual recommendation. An extensive discussion of the operational implications associated with each of the two most favorable candidates is presented as a basis for final management decision.

Chapter 6.5. summarizes the CHIVE document storage requirements which were used as a basis for evaluation of the candidate systems.

In Chapter 6.6., the comparative analysis process itself is described and the findings are reported.

SCOPE OF VOLUME
6.1.

SYSTEM DESCRIPTION AND RECOMMENDATION

6.2.1. DEFINITION OF THE DOCUMENT DELIVERY SYSTEM

The Document Delivery System may be generally defined as that segment of the total CHIVE system which deals with the input, storage, and recovery of identified documents. It is self-contained in the sense that it will not be electronically interconnected with the computer-based indexing system.* The system will have repository

---

*The decision to decouple the document delivery system from the computer-based index system was made early in the study for the following reasons:

(a) It was deemed necessary to provide for some human filter between the computer search results and the actual document retrieval. Some mechanism by which the user may screen the computer selections should be provided in order to weed out non-pertinent or previously held items prior to actual document reproduction.

(b) Previous experience has indicated that, where depth indexing has been employed, attempts to intercouple the index and the document store have produced unsatisfactory results. Acknowledgement of this is reflected in the fact that current equipment design is directed towards independently operated document systems with the exception of Filesearch and MIRACODE, both of which have a limited index search capability.

responsibility for textual documents only, with maps and graphics retained elsewhere. The input will primarily be hard copy documents from a variety of sources and will range from poor to high quality printing. The documents are to be locatable by some identification number such that the file can be interrogated directly by the user (Counter Service Requests) or indirectly through a search of the computer index (Query Requests). In response to either type of request, the system must furnish a usable replica copy of the document master which is not to be circulated outside the file.

In addition to servicing retrospective searches, the subsystem must provide a file backup capability. One duplicate file is to be furnished to the Record Center for backup and reconstruction purposes. In accordance with an existing inter-agency agreement, duplicate copies of selected items are currently furnished the National Security Agency. It has been assumed that this service will continue to be provided, although the agreement is renegotiable. A simplifying assumption has been made for purposes of this study, that a duplicate backup file for all documents would be required. The requirements for selectively providing for Vital Materials storage as well as some archival

retention is recognized but is not distinguished herein from the Record Center Backup file requirement.

The subsystem corpus has the potential of growing to an extremely large size over a period of time. The magnitude of the system is defined within this volume at two points on the projected growth curve referred to as:

- Initial System
  - Input--100,000 documents/year
  - Request rate--500 requests/day
- Total System
  - Input--1,000,000 documents/year
  - Request rate--5,000 requests/day

A maximum repository volume of 10,000,000 documents has been assumed as a long range design goal. Although the specific hardware to be used does not necessarily have to be identical throughout, some upward compatibility must be demonstrated to allow for transitional growth from the Initial to the Total System.

A more complete description of the functional and performance specifications of the Document Delivery subsystem has been included in Appendix 5.E. and a summary of activity volumes and response times is included in Section 6.5.6.

DESCRIPTION AND RECOMMENDATION
Definition of System
6.2.1.

6.2.2. RECOMMENDATIONS

The two systems which were found to be most favorable from the standpoint of economics and performance were the Packed Microfiche and the Filmsort 2000dx Aperture Card systems. Both of these systems as originally configured scored highly on all major criteria (Section 6.6.). When reconfigured to include processing equipment announced subsequent to the first analytical pass, the upgraded versions compared even more favorably. The revised configurations provide procedural and cost improvements over the original systems and as such are posulated here as the two most suitable for implementation. The systems are generally described as follows.

Packed Microfiche: Microfiche are sheet microfilm records considered here as conforming to a 105mm x 148mm (4 in. x 6 in.) standard which can contain up to 60 letter-size page images. Document images are recorded on 105mm roll microfilm by means of a 'step-and-repeat' camera which automatically places consecutive exposures in a matrix format (6 x 12) with the upper row reserved for recording eye-visible identification information. Documents are allocated on the microfiche such that (a) multiple items may be recorded on each microfiche,

(b) each new item would begin a new row with an eye-visible identification number in the left-most column, and (c) no item containing less than 60 pages shall 'spill over' onto a second microfiche. The original silver shall be duplicated onto diazo roll film for backup file purposes. Cut diazo microfiche will be filed in motorized files in the sequence recorded. On demand, selected microfiche are enlarged to hard copy by means of a Xerox Automatic Microfiche Printer.

Filmsort 2000dx: This system utilizes 35mm aperture cards as its basic storage media. With the introduction of the 3M Filmsort 2000dx camera, a fully processed aperture card containing up to eight page images can be produced. Backup records are created from the original by means of a Copy-Reproducer. File copies are stored in motorized card files in Document Control Number sequence. Selected items are pulled from the file and hard copy is produced on the 3M Quadrant Printer.

It is recognized that the two systems recommended are manual systems similar to those currently installed within the Agency (i.e., Intellofax Reference System and SR Library). The question naturally arises what advantages are offered by the microfiche or 35mm aperture

card over the existing 16mm aperture card systems currently employed. It should be pointed out that the study did not attempt to evaluate the efficiency of the existing microfilm systems within the Agency. It was assumed that these systems, which have been operational for a number of years, do an effective job in meeting the current requirements. The requirements, upon which the comparison of the candidate systems was based, represented a theoretical, centralized system required to accommodate a volume equal to the combined volumes of the document components now in operation. This central, all source, system must meet processing demands far in excess of those being met by any of the systems today. Furthermore, the turnaround time requirements, both for input and retrieval, were somewhat more stringent for the 'benchmark' system than for the operational systems.

The configuration specified for the 16mm aperture card system for purposes of comparison varied somewhat from the current systems not only in magnitude but also in technique. Some of the variances introduced were:

- The use of automatic rotary files instead of file drawer cabinets was specified.

- The use of a localized copy station at each file, to produce an intermediate, 'throwaway' aperture card for further processing at a centralized enlargement station was postulated.

- A random rather than a batch mode of retrieval processing was imposed, thus eliminating the need to sort aperture cards prior to refiling.

- Punching indicative information into the aperture cards was accomplished by a straightforward key punch and reproduce process instead of the more sophisticated approach of generating the appropriate punched data through a computer (as in Intellofax).

- Not all exception procedures (such as rework, single copy items and poor copy quality items) were considered in the "benchmark' system.

- Requirements currently fulfilled by the DARE system (i.e., Source Card preparation and dossier file creation) were not considered in any of the candidate configurations postulated.

These departures in design were incorporated as a mechanism for effecting a direct comparison among systems of varying complexity within the framework of the same functional requirements. The systems evaluated ranged from manual to fully automatic retrieval devices. The technique employed in the design of the manual systems reflect an effort to superimpose upon them (to the degree possible) the functional characteristics of random processing and strict file integrity similar to those found in the more automated systems. These same

restrictions were applied across-the-board to all systems. The liberty taken in configuring a 16mm aperture card system which differed in approach from existing, in-house systems was not intended as a reflection on any of these operating systems but was a necessary measure in establishing an equitable basis for comparing a multitude of diverse microfilm equipments.

The rationale for this recommendation, then, is that given a number of alternative microfilm technologies as applied to a given benchmark problem representing the projected requirements for a central document repository, which systems ranked most favorably? The Packed Microfiche and the 35mm Aperture Card systems, based on the cumulative rankings documented in this report, offered the most favorable solution when considered from an equivalent starting point. Whether or not the advantages offered by either of these systems constitute sufficient motivation to adopt either in preference to an expanded version of the existing 16mm systems is a judgment which must be made by Agency management.

DESCRIPTION AND RECOMMENDATION
Recommendations
6.2.2.

6.2.3. DOCUMENT INPUT FLOW

6.2.3.1. Packed Microfiche System

The narrative which follows is keyed by number to sections of Figure 6-1.

1 All documents are received at a central point where receipt is verified, documents are batched by originator (i.e., CIA, DIA, State, etc.) and assigned a Batch Control No. Whenever a Document Control Number (e.g., USIB No., digraph code) has not been pre-assigned, a meaningful number if created and marked on the document. Expedite copies are pulled for OCI, BR and RI/AN according to standing orders. A Processing Copy is pulled for all documents and forwarded for Header Indexing. Remaining copies are forwarded to the appropriate DISSEMINATION SECTION.

2 Processing copies are screened to determine proper handling. Documents for which there is a repository responsibility are forwarded for header indexing. Those with no repository requirement are evaluated for retrieval content and either nodexed (i.e., no further processing) or indexed and forwarded for filming. The Header Index is transcribed onto the Header Index Sheet, which is attached to the document.

DESCRIPTION AND RECOMMENDATION
Document Input Flow
6.2.3.1.

DOCUMENT INPUT FLOW

Packed Microfiche System

Flow Diagram

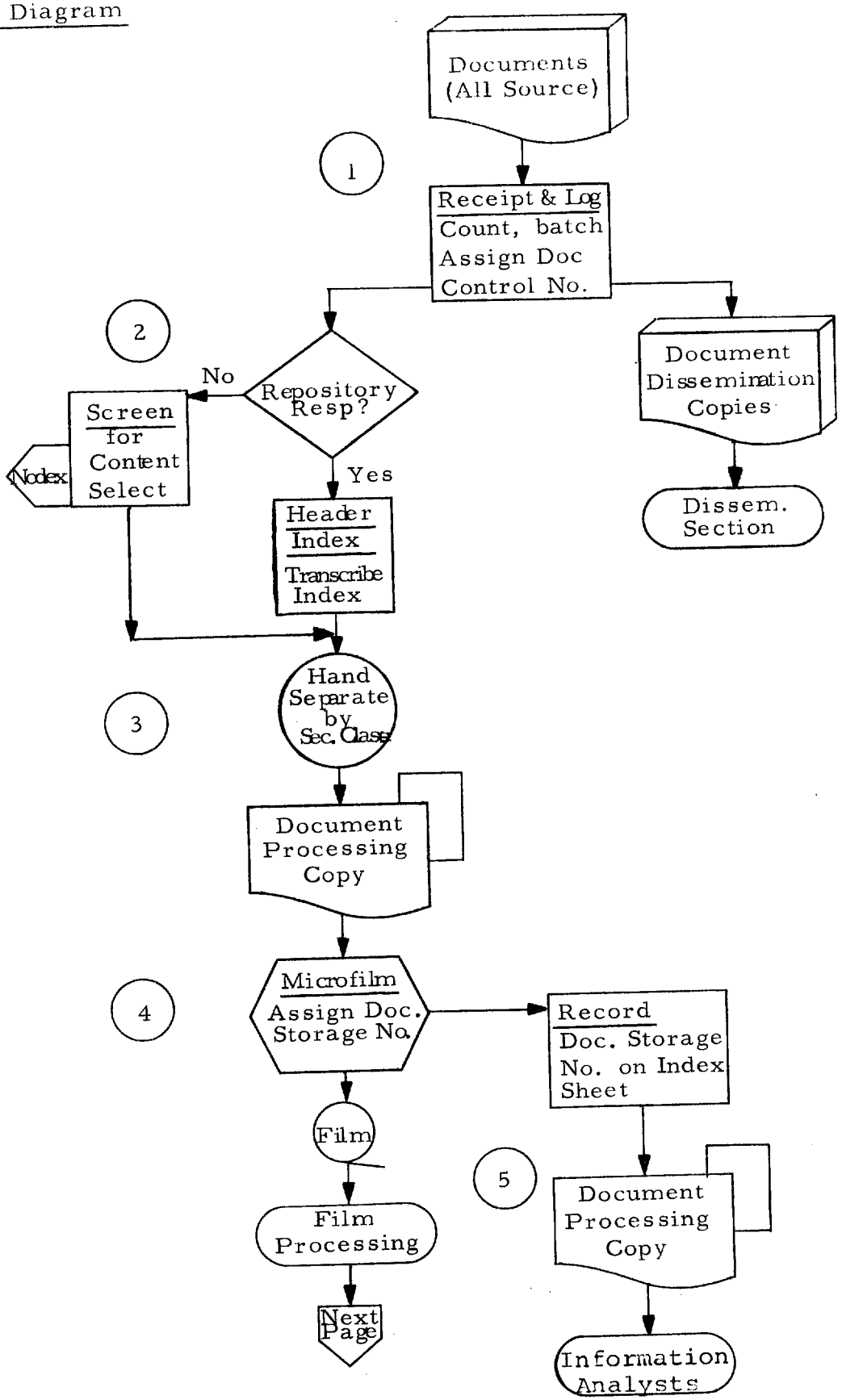

Figure 6-1

3 Documents requiring double backup file processing are manually segregated from those with single backup. Types of documents are separated also by security compartment and kept separate throughout processing.

4 Documents are microfilmed on the Step-and-Repeat Camera such that multiple items may be recorded on the same Microfiche but arranged such that each item starts a new row. A Document Storage Number, assigned sequentially, shall be photographed in the leftmost frame preceding each new item. This number is to be enlarged sufficiently to be eye readable. The Document Storage Number assigned is recorded on the Header Index Sheet to be entered into the computer index for cross reference purposes.

5 Documents and attached Header Index Sheets are forwarded to the Information Analysts for further indexing. The unprocessed film is forwarded for film development.

DESCRIPTION AND RECOMMENDATION
Document Input Flow
6.2.3.2.

6 Each 100 ft. roll of 105mm silver film is developed in the processor and visually scanned for quality control.

7 Each roll of film is contact printed onto diazo rolls for backup storage. Those requiring distribution to NSA are contact copied twice (see step #3).

8 Resultant rolls (both Silver and Diazo) are processed through the automatic Film Cutter where they are cut into individual Microfiche. The original Silver Microfiche is forwarded to Records Center. A complete set of duplicate diazo Microfiche is filed by Document Storage Number in the Document Master File. The remaining set of diazo duplicates are forwarded to NSA as appropriate.

DESCRIPTION AND RECOMMENDATION
Document Input Flow
6.2.3.1.

DOCUMENT INPUT FLOW

Packed Microfiche System

Flow Diagram (Cont'd.)

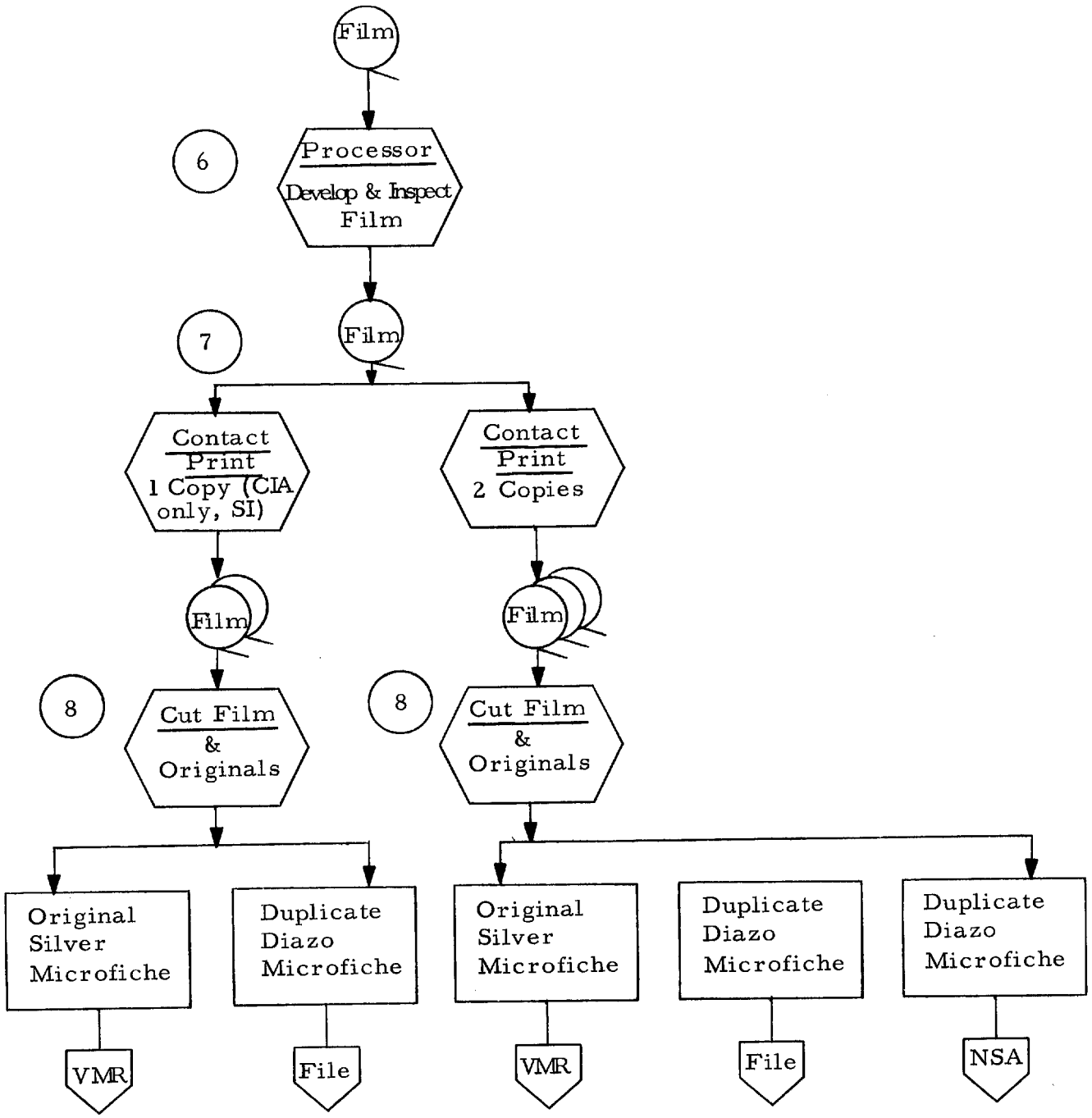

Figure 6-1, Cont'd.

6.2.3.2. Filmsort 2000dx (35mm Aperture Card System)

The narrative which follows is keyed by number to sections of Figure 6-2.

1 All documents are received at a central point where receipt is verified, documents are batched by originator (i.e., CIA, DIA, State, etc.) and given a Batch Control No. Whenever a Document Control No. (e.g., USIB No., diagraph code) has not been pre-assigned, a meaningful number is created and marked on the document. Expedite copies are pulled for OCI, BR and RI/AN according to standing orders. A Processing Copy is pulled for each document. Remaining copies are forwarded to the appropriate DISSEMINATION SECTION.

2 Processing copies are screened to determine proper handling. Documents for which there is repository responsibility are forwarded for Header Indexing. Those with no repository requirement are evaluated by the Information Analysts for retrieval content and either nodexed (i.e., no further processing) or indexed and forwarded for filming. Documents to be filmed are stamped with Batch Serial No.

DESCRIPTION AND RECOMMENDATION
Document Input Flow
6.2.3.2.

DOCUMENT INPUT FLOW

Filmsort 2000 dx (35 mm Aperture Card System)

Flow Diagram

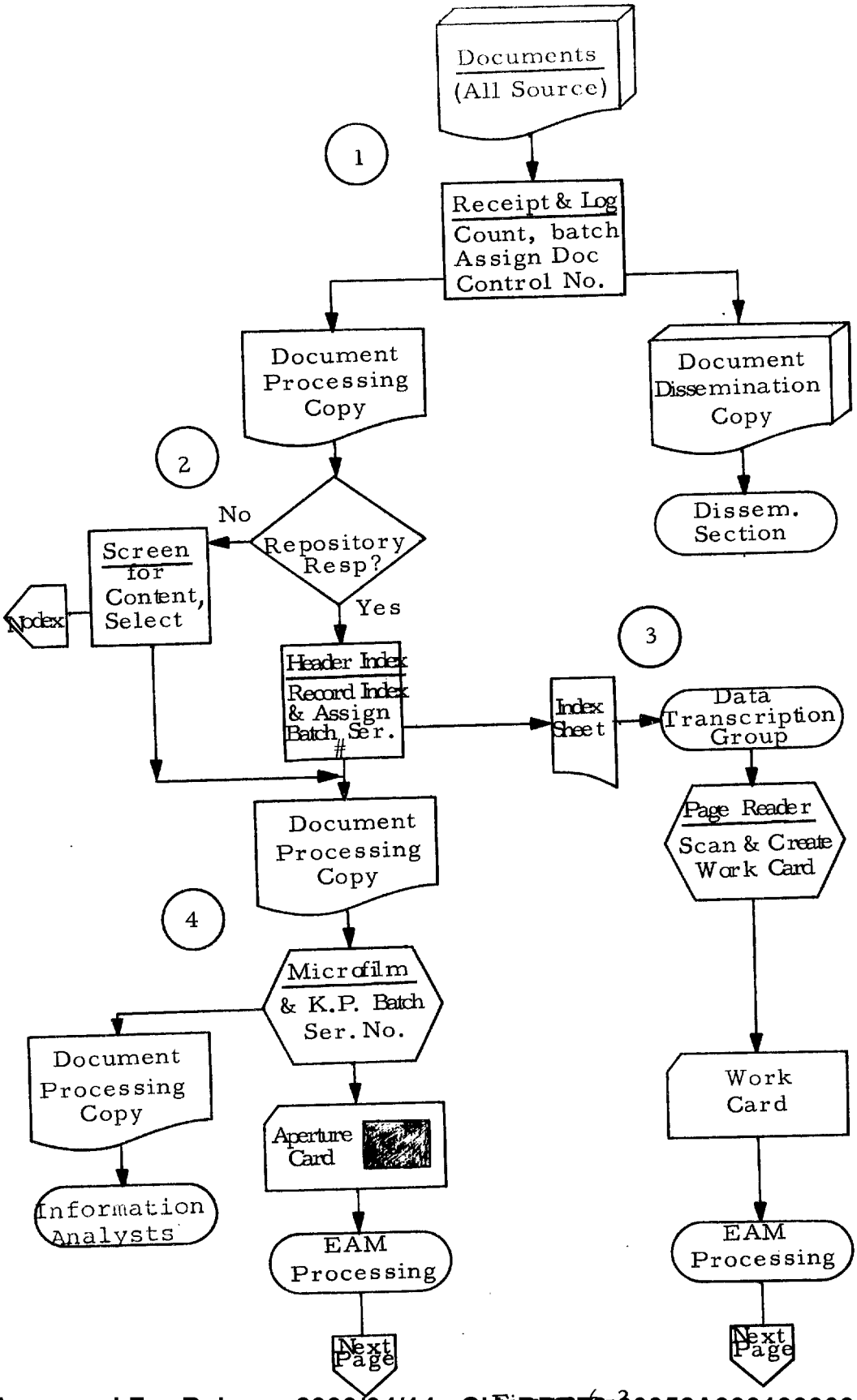

Figure 6-3

3 The Header Index is transcribed onto the Index Sheets which are processed through a Page Reader and converted to digital form. Work cards are punched to include:

- Document Control Number
- Batch Serial Number
- Security Classification
- Number of Aperture Cards required (Card___of___)

Where multiple aperture cards are to be required, additional work cards are created accordingly.

4 Documents are microfilmed seven pages up with a visually legible Batch Serial Number in the Aperture. This number is punched into the processed aperture card. Documents are forwarded to the Information Analysts for further indexing as appropriate.

DESCRIPTION AND RECOMMENDATION
Document Input Flow
6.2.3.2.

5 Both the work cards (from Step #3) and the aperture cards (from Step #4) are sorted into Batch/Serial No. sequence. The resultant decks are matched, one for one on a collator.

6 Indicative data (see Step #3) are reproduced from work cards into the aperture cards. The work cards are destroyed. The punched coding on the aperture cards is interpreted onto the cards. (Processing date--month and year--are gangpunched throughout on this step).

7 Aperture cards are sorted into sequence by Document Control Number. Documents requiring "CIA only" backup storage (i.e., those not duplicated for NSA) are sorted out by Security Classification Code.

8 Aperture cards are copy-reproduced to create backup file apertures which are interpreted before distribution. Duplicate copies are made if NSA distribution is required, a single copy is produced for all others. The original silver apertures are sent to the Records Center. The first duplicates are filed in Document Control Number sequence in the Master Document File. The other duplicate set is forwarded to NSA as appropriate.

DESCRIPTION AND RECOMMENDATION
Document Input Flow
6.2.3.2.

Filmsort 2000 dx (35 mm Aperture Card System

Flow Diagram (Cont'd.)

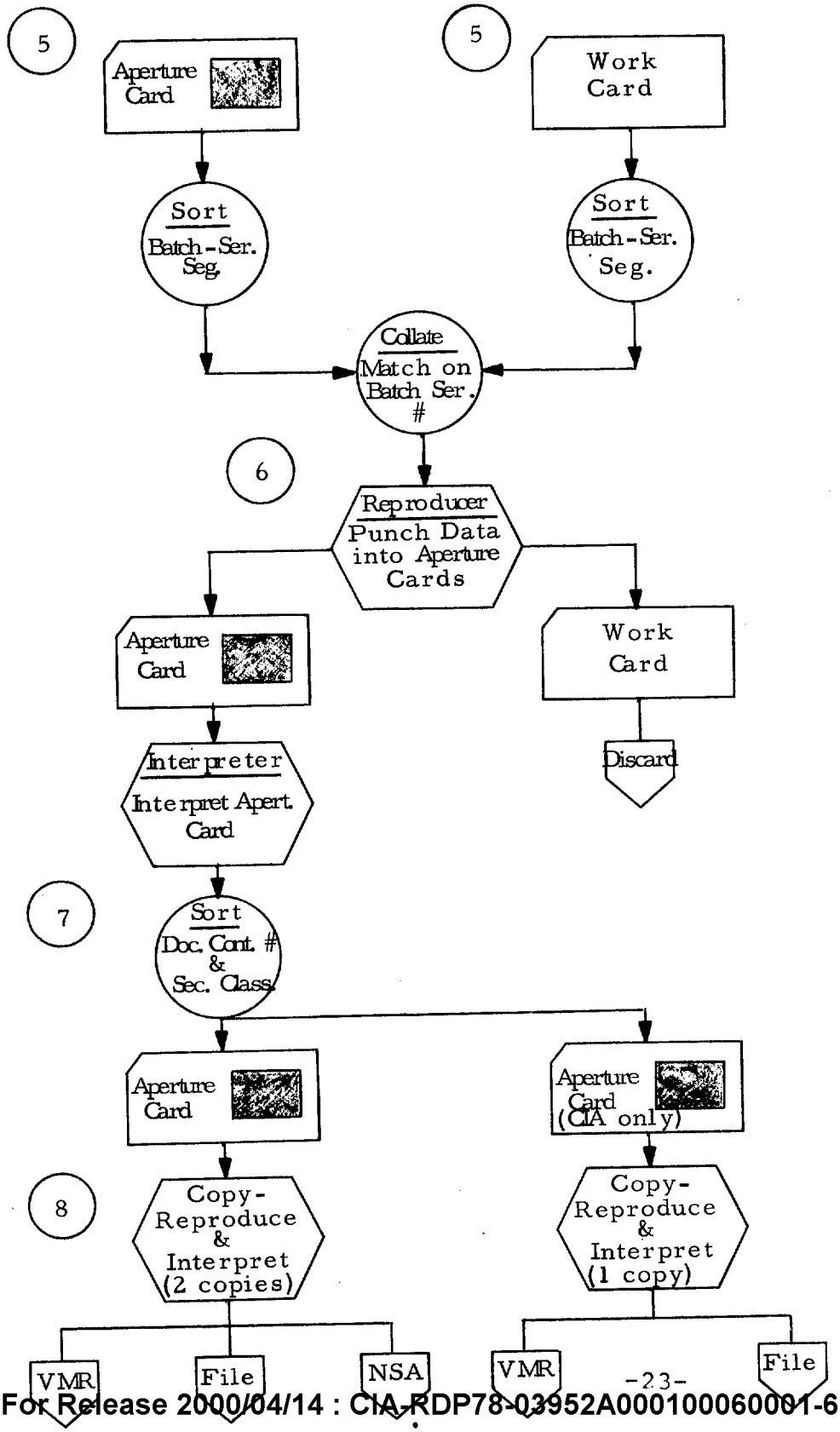

Figure 6-2, Cont'd.

DESCRIPTION OF OTHER CANDIDATE SYSTEMS

6.3.1. MANUAL SYSTEMS

These systems are characterized by a manual access and refile of requested document masters. The specified items are removed from the file by a file clerk, duplicated or enlarged on appropriate equipment and physically returned to the file.

6.3.1.1. Paper File

This is a manual system in which the original documents themselves are stored in open vertical shelf files and reproduced on demand by conventional office copying equipment. Document retrieval and refiling are done manually. (CHIVE/R-1-65, System A)

6.3.1.2. Packed Paper File

This is a variation of the previous system in that the original hard copy is stored in compact, moveable, open shelving. (Ibid., System B)

6.3.1.3. 16mm Aperture Cards

This system utilizes 16mm aperture cards (Mil 'E' Specs.) which are in motorized card files with a modified

DESCRIPTION OF SYSTEMS
Manual Systems
6.3.1.3.

Filmsort UNIprinter 086 at each file. File clerks are allocated to a specific group of files where they select requested aperture card masters, prepare expendable duplicate aperture cards which in turn are used for enlargement to hard copy on 3M Quadrant Printers. Master aperture cards are refiled immediately after they have been duplicated. This is a slight departure from the present Intellofax system and the analysis contained in this report should not be interpreted as an evaluation of the OCR/MD system. (Ibid., System C)

6.3.1.4. Filmsort 1000d

Developed by the Minnesota Mining and Manufacturing (3M) Co., the Filmsort 1000d is a combination camera-processing unit which provides a finished 35mm aperture card within 60 seconds after the original document is placed under the camera. This single piece of equipment allows aperture cards to be created without the separate film processing and mounting operations required of other aperture card systems. Duplicate backup files are created by an automatic aperture card copier. The cards are filed in motorized card files and on demand, may either be duplicated at the file using the UNIprinter 086 approach (similar to that for the 16mm aperture cards system) or be removed

from the file to a central automatic hard copy enlarger. This is the original configuration of the aperture card system recommended in Section 6.2.3., (Ibid., System D)

6.3.1.5. Filmsort 1000d with Rotary Camera

Identical to the previous system except that backup copies are recorded on roll microfilm by means of rotary cameras in addition to filming onto aperture cards using the Filmsort 1000d. (Ibid., System E)

6.3.1.6. Microfiche

The file medium used by this system is the same as that described in Section 6.2.2. except that for this system, one item per microfiche is assumed. Original recording is performed by a 'step-and-repeat' camera similar to the recommended system. As originally configured, an intermediate disposable copy is created at the file and processed through a Microcard Model E1-3 Enlarger to create a hard copy sensitized roll paper which, in turn, is developed on the Recordak Ektaline Processor and automatically cut for distribution. (Ibid., System F)

6.3.1.7. Packed Microfiche

This system is the original version of the recommended system described in Section 6.2.2. Allocation of multiple items per microfiche is identical to recommended system. The main difference lies in the camera unit and the enlarging device employed. (Ibid., System G)

6.3.2. SEMI-AUTOMATIC SYSTEMS

The systems conceptually incorporated in this class are characterized by a manual accession to a cluster of document image masters coupled with an automatic search of the cluster for the requested item. The storage media might be in the form of discrete group of film cards (as in MEDIA) or of roll film (as in MIRACODE, CRIS, and Filesearch). In either case, the cluster (i.e., magazine, cartridge, scroll or reel) is attached to a search mechanism which scans a photo-optically coded representation of the document, logically compares it to a search argument (i.e., item number) inserted by means of keyboard or card entry, and copies the identified item directly to hard copy or intermediate microfilm. A more detailed description of each system with its most probable approach to the CHIVE problem is included below.

DESCRIPTION OF SYSTEMS
Semi-Automatic Systems
6.3.2.

6.3.2.1. MEDIA

MEDIA is a semi-automatic microfilm searching system developed by Magnavox Company. Using a special camera unit, document images are recorded on individual film cards (about 1 x 3 inches) containing up to three letter-size pages each. A number is recorded on the film chip with the images, and is used as the basis for file searching with a mechanized Selector-Reproducer unit. A file clerk locates the appropriate capsule (containing 200 cards) and delivers it to the Selector-Reproducer operator who mounts the capsule into the feeding station and keys in the desired document number. The unit rapidly scans the film cards and, upon locating the requested item, produces hard copy on line. There are five known MEDIA installations in operation currently. (Ibid., System H)

6.3.2.2. MEDIA with Copyflo 11-1

This is a modification of the previous system with the one variation that selected items on the Selector-Reproducer are contact copied onto 16mm roll microfilm for subsequent enlargement to hard copy on a Xerox Copyflo 11-1 Continuous Printer. (Ibid., System I)

6.3.2.3. MIRACODE

MIRACODE is a semi-automatic, roll microfilm searching system developed by Recordak. Using a special camera unit, documents are recorded on 16mm roll microfilm along with an associated coded representation of the indexing system. Approximately 2100 images can be stored on 100 foot rolls of film which are cartridge loaded. Requests are serviced by selecting the appropriate cartridge, inserting it into the Viewer-Printer, and keying in the document number. Selected items are projected on a viewing screen and/or printed on-line to hard copy. About five MIRACODE installations are currently in operation. (Ibid., System J)

6.3.2.4. CRIS

The Command Retrieval Information System (CRIS) is a semi-automatic, microfilm searching system marketed by Information for Industry, Inc. The storage medium employed by this system is a cartridge-loaded 400-foot scroll, 17 inches in width. A coded representation of the document image location is recorded on the scroll itself. The coding is initially recorded by photographing the document onto 35mm film which, in turn, is contact

printed onto the scroll by means of a Scroll Preparation Unit. Upon request, the appropriate scroll is inserted in the scroll positioning mechanism which is part of the CRIS Console Unit. The unit is capable of locating a specified subframe (i.e., a two page cluster) within the scroll which contains 28,160 frames, each containing up to 12 legal size pages. The document number is entered via a keyboard and the scroll is rapidly scanned until the requested item is located, projected onto a viewer and contact printed onto a 35mm aperture card. Hard copy is produced from the aperture cards on the Xerox 1824 Printer. There is only one known CRIS system currently installed. (Ibid., System K)

6.2.3.5. CRIS with Copyflo 24C

This system is identical to that discussed previously except that the Xerox 24C Continuous Printer is used for high volume production of hard copy from aperture cards. (Ibid., System L)

6.2.3.6. Filesearch

The Filesearch is a relatively complex roll microfilm searching system developed by FMA, Inc. It utilizes 1000 foot rolls of 35mm microfilm, with indexing information

photo-optically recorded on the film along with the document images. Using the coded search criteria, the search unit can rapidly scan and locate the desired document(s) on the manually mounted film. Output options are viewer presentation, hard copy enlargement or contact print to roll microfilm. The system has the logical ability to accommodate a combined image and index in a self-contained document system and is normally used in this way rather than as a document delivery system. Approximately seven of these units have been delivered and installed. (Ibid., System M)

6.3.2.7. Filesearch with Copyflo 11-1

This system is identical to that just described with the exception that located items are contact printed onto 35mm silver film for off-line hard copy preparation on the Xerox Copyflo 11 Continuous Printer Model 1. (Ibid., System N)

6.3.3. AUTOMATIC SYSTEMS

These systems are classified here as automatic in the sense that, once the document identification number has been entered into the system, it can locate and furnish in some form the specific item requested

without the need for manual intervention. The systems as described are not completely automatic since there are a number of manual operations peripheral to the input and retrieval functions. The three systems in this category are described below.

6.3.3.1. Magnavue

Magnavue is a highly mechanized microfilm card handling system developed by Magnavox Corp. It consists, essentially, of one or more rapid access files, a transport unit (card handler) and contact copy station all under stored program control of a data processor. Microimages are stored on 1 1/3" x 3" Mylar cards, containing associated digital coding in either photo-optical or magnetic form. Up to 3,000 cards are stored in each magazine which may be fetched randomly or sequentially under control of the processor. The selected magazine is automatically inserted into the card handler where the cards are rapidly scanned until the requested item is contact printed onto roll microfilm from which the hard copy is produced on the Xerox Copyflo 24C Continuous Printer. The Magnavue system also is capable of producing aperture card output. The first

Magnavue system is scheduled for delivery to the U. S. Army Missile Command, Redstone Arsenal, Alabama in late April 1965. (Ibid., System O)

6.3.3.2. Cypress*

Cypress is an automatic image processing system currently under development by IBM Corp. The system consists of one or more files under stored program control serviced by a Projection Input/Output Converter. Page images are recorded on diazo film chips which are enclosed in plastic molded cells (32 chips/cell). Cells may be randomly accessed according to address location and conveyed pneumatically to an Output Converter where the designated chip may be directly picked from the cell. Selected images may be copied through projection lenses onto aperture cards which, in turn, are used to produce off-line hard copy on the Xerox Copyflo 24C Continuous Printer. The system is still in the developmental stage, with no systems delivered to date. Prices and performance specifications quoted in this report are tentative,

*The IBM Cypress system is developmental equipment which is proprietary in nature. Information relating to the tentative specifications and cost ranges cited in this report should be treated accordingly.

reflecting the best available estimates at the time of this report. (Ibid., System P)

6.3.3.3. Videofile

The Ampex Videofile is a document storage system in which images of the documents are stored on reels of video tape in conventional TV recording form. A separate digital addressing track accompanies the video track on each tape transport to retrieve the image at the specified address. Selected images are recorded onto an output video tape which, in turn, is converted to hard copy by means of a special video tape printer. With a large file, it is impractical with existing equipment to have all video file tapes on-line simultaneously, thus some manual mounting and dismounting of tapes is required. Because of this manual intervention, the system approximates but does not fulfill the definition of an automatic system in the same sense as the two previous systems. Realistically, Videofile could be categorized completely independent of all others since it is the only system not using some form of microfilm. The first Videofile system is scheduled for delivery to NASA, George C. Marshall Space Flight Center, Huntsville, Alabama, in late 1965. Costs quoted herein are approximate. (Ibid., System Q)

RATIONALE FOR RECOMMENDATION

6.4.1. SELECTION PROCESS

Based on the comparative analysis of the various candidate systems as summarized in Section 6.6., the results were interpreted to determine which system was most suitable to the CHIVE document storage and retrieval requirements. The approach taken was to narrow down the alternate configurations reviewed by a process of elimination, excluding those systems which for one reason or another did not offer an effective nor economical solution to the problem. The remaining systems were then submitted to closer scrutiny and an extensive comparison of their relative merits was drawn in order that a final selection might be made. This section will consist of two major parts: first, a summary of the exclusion process with a brief discussion of the shortcomings of each of the rejected systems and second, a thorough discussion of the tradeoffs involved in the implementation of those contenders surviving the cutoff.

RATIONALE
Selection Process
6.4.1.

In all, there were seventeen different configurations of equipment considered (Chapter 6.3.). Each was evaluated on the basis of seven criteria: (1) system cost, (2) space, (3) manning level, (4) responsiveness, (5) hard copy output quality, (6) file integrity and (7) purge capability. Section 6.6. summarizes the relative ranking of the systems for each of these parameters. The first three criteria (cost, space and manning) were considered to carry the heaviest weighting with responsiveness and output quality of somewhat lesser importance, although under no circumstance would a degradation from the current system performance by permitted. It was observed that all of the systems, when designed with the proper system controls, furnish an equivalent degree of file integrity. Although the facility for file purging ranged, to a degree, among the candidates, a review of existing in-house document systems revealed a minimal amount of purge activity and therefore the requirement for a purge capability was considered a relatively insignificant parameter.

The exclusion process was conducted on three levels as follows:

RATIONALE
Selection Process
6.4.1.

- Gross exclusion: assuming that cost, space and manpower were the principle parameters, systems ranking substantially out of line in any of these categories were initially dismissed.

- "Twin" exclusion: several of those systems remaining consisted of alternate configurations of the same basic processes (e.g., CRIS with Xerox 1824 and CRIS with Xerox 24C hard copy output). These were matched against each other and the less attractive 'twin' configuration was rejected.

- Cumulative ranking: among the systems still in contention, the relative rankings were reviewed with general weighting applied as described above and the two systems consistently receiving high marks throughout were recommended for more detailed analysis. As indicated in Section 6.2.2. the two systems recommended were (a) Packed Microfiche and (b) 35mm Aperture Cards (Filmsort 2000dx).

A summary of the principle reasons for rejection of the other candidate systems is included below. It should be emphasized that this critique of the various systems is not intended to be derogatory towards any vendor's equipment per se, but merely is intended as an evaluation of their suitability to the specific requirements peculiar to the CHIVE document problem.

6.4.1.1. Paper File and the Packed Paper File*

The floor space required for filing all documents in original hard copy is considerably greater than any of the other candidate systems (Table 6-6) even when

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*For descriptions of these systems see Chapter 6.3.

TABLE 6-6

RANKING OF CANDIDATE SYSTEMS BY FLOOR SPACE

Initial System	Intermediate System	Final System
CHRIS-with Xerox 1824 (245-405)	Microfiche-packed (915-1415)	Microfiche-packed with Xerox printer (1545-1765)
Miracode (380-480)	CRIS-with Xerox 24C (940-1640)	Microfiche-packed (1650-2450)
Filesearch (400-610)	CHRIS-with Xerox 1824 (965-1665)	CRIS-with Xerox 1824 (1675-2855)
CHRIS-with Xerox 24C (400-560)	Microfiche-packed with Xerox printer (990-1170)	CHRIS-with Xerox 24C (1760-2940)
Microfiche-packed (420-560)	Videofile (1480-1960)	Videofile (2690-3560)
Filmsort 2000 DX (460)	Microfiche (1555-2055)	Filmsort 2000 DX (2800-3000)
MEDIA (490-590)	Filmsort 2000 DX (1585-1685)	Microfiche (2920-3720)
Filmsort 1000D (515-655)	Miracode (1790-2330)	Filesearch-with Copyflo 11-1 (3300-4100)
Microfiche-packed, with Xerox printer (520-540)	Filesearch (1930-2510)	Filesearch (3440-4240)
16-mm aperture cards (530-670)	Filesearch-with Copyflo 11-1 (2060-2520)	Miracode (3580-4380)
Filmsort 1000D-with rotary camera (545-565)	16-mm aperture cards (2075-2715)	16-mm aperture cards (3890-4990)
Videofile (550-790)	Cypress (2255-2655)	Cypress (4985-5685)
Microfiche (565-665)	Filmsort 1000D (2690-2970)	MEDIA (5150-5960)
Filesearch-with Copyflo 11-1 (620-720)	Filmsort 1000D-with rotary camera (2800-3205)	MEDIA-with Copyflo 11-1 (5170-5980)

MEDIA-with Copyflo 11-1 (650-750)

Cypress (975-1075)

Magnavue (1050-1150)

Magnavue-with ap. card output (1430-1530)

Paper file-packed (4095)

Paper file (5095)

Magnavue (3095-3495)

MEDIA (3120-3360)

MEDIA-with Copyflo 11-1 (3550-3990)

Paper file-packed (40,340-40,435)

Paper file (50,340-50,435)

Magnavue-with ap. card output not analyzed for this case

Magnavue (5220-5920)

Magnavue-with ap. card output (5250-6090)

Filmsort 100D-with rotary camera (5370-6015)

Filmsort 1000D (5430-5990)

Paper file-packed (80,535-80,725)

Paper file (100,535-100,725)

NOTE: Numbers in parentheses are the estimated floor space requirements in square feet for the candidate systems, exclusive of the miscellaneous space requirements that are common to all candidates.

moveable, open shelving is used. Since space is a major parameter, shelf storage of hard copy was rejected as the principle storage medium. In fact, the space required for these systems is so far out of line with the other candidates, it consitutes a strong argument for the need for some type of microform storage. Nevertheless, it is recognized that because of the nature of the documents themselves, a portion of the corpus will be retained in paper form as a practical measure.

6.4.1.2. 16mm Aperture Card

Use of the Mil 'E' aperture card as a primary mode of document storage was rejected for the following reasons. The system ranked unfavorably in the manpower required category (Table 6-5). Furthermore, since this storage medium has not enjoyed wide acceptance, more advanced processing equipment has not been developed to date by the microfilm industry nor can it be anticipated. The more widely used 35mm aperture card (Mil 'D') represents a more probable area for future commercial development by various manufacturers, thereby enhancing the chances for future system upgrading as the file base expands.

RATIONALE
Selection Process
6.4.1.2.

TABLE 6-5

RANKING OF CANDIDATE SYSTEMS BY MANPOWER LEVELS

Initial System		Intermediate System		Final System	
Microfiche (packed, with Xerox printer)	3	Microfiche (packed)	9-13	Microfiche (packed)	14-22
Microfiche (packed)	3-4	CRIS (with Copyflo 24C)	10-19	Microfiche (packed, with Xerox printer)	18-20
Microfiche	3-4	Microfiche (packed, with Xerox printer	11-12	Magnavue	19-26
CRIS (with Copyflo 24C	3-4	Cypress	11-15	CRIS (with Copyflo 24C)	19-33
CRIS (with Xerox 1824)	3-5	Filmsort 2000 DX	12-14	Filmsort 2000 DX	21-25
Filesearch (w/Copyflo 11-1)	3-5	Magnavue	12-16	Cypress	21-28
Filesearch	3-5	Microfiche	13-17	Microfiche	22-30
Paper file	4	Videofile	14-22	Magnavue (ap. card output)	23-31
Paper file (packed)	4	CHRIS (with Xerox 1824)	14-23	Videofile	24-38
Magnavue	4-5	Filesearch (w/Copyflo 11-1)	16-20	CRIS (with Xerox 1824)	24-39
Filmsort 2000 DX	5	Paper file	16-21	Paper file	26-35
Miracode	5-6	Paper file (packed)	16-21	Paper file (packed)	26-35
Cypress	5-6	Filesearch	17-22	Filesearch (w/Copyflo 11-1)	27-34
Magnavue (ap. card output)	5-6	MEDIA (w/Copyflo 11-1)	19-24	Filesearch	30-37
MEDIA (w/Copyflo 11-1)	5-6	Miracode	21-27	MEDIA (w/Copyflo 11-1)	32-41
MEDIA	5-6	MEDIA	22-27	MEDIA	36-45

Videofile	5-9	16mm aperture cards	23-33	Miracode	40-47
16-mm aperture cards	6-8	Filmsort 1000D	25-31	16mm aperture cards	42-58
Filmsort 1000D	6-8	Filmsort 1000D (w/rotary camera)	26-32	Filmsort 1000D	47-55
Filmsort 1000D (w/rotary camera)	7-8	Magnavue (ap. card output) not analyzed for this case.		Filmsort 1000D (w/rotary camera)	49-59

NOTE: The numbers are the estimated total manpower levels for the candidates. These estimates do not include the labor that is common to all candidates.

6.4.1.3. Microfiche

The use of microfiche for storage of individual documents was originally considered but compared less favorably in cost, space, and manpower than the Packed Microfiche and therefore was eliminated from further consideration.

6.4.1.4. MEDIA and MEDIA with Xerox Copyflo 11-1

A direct comparison of these two 'twin' systems reveals that the MEDIA with Xerox Copyflo has a slight edge in ranking by cost, manning level and copy quality although it requires slightly more floor space. The most favorable version of the MEDIA system (i.e., that with Copyflo printing) constituted a close contender but was excluded primarily because of its relatively poor ranking in manning and space. Furthermore, since it involves an on-line contact print to roll microfilm with subsequent off-line processing and continuous flow printing, the system responsiveness is downgraded to a degree unsuitable for meeting counter service turnaround requirements. The on-line printout of hard copy on the Selector-Reproducer was of marginal quality, although the Copyflo approach, which could not be observed, would probably be an improvement.

RATIONALE
Selection Process
6.4.1.4.

6.4.1.5. Miracode

Although this system compared favorably in the initial system, it gradually dropped off in ranking in all categories when configured to meet the high activity demand printing required of the final system. The system is designed primarily for on-line browsing at a viewing station with low volume, selective printout and as such does not provide a suitable match for the voluminous CHIVE printing requirement.

6.4.1.6. CRIS with Xerox 1824 and CRIS with Copyflo 24C

Both CRIS configurations compared favorably in cost, space and manning with the latter being the more attractive twin in all categories except space. The major objection to CRIS was that the system is not suitable for a random mode of processing once frequent scroll changing is required. The weight of the scroll cartridge makes frequent mounting impractical, thereby forcing the operation into a batch processing mode with a resultant retardation of responsiveness. Furthermore, the excessive down time encountered while attempting to test copy quality raised a serious doubt as to the inherent reliability of the equipment as well as the manufacturer's capacity to service it properly.

RATIONALE
Selection Process
6.4.1.6.

6.4.1.7. FMA Filesearch and Filesearch with Copyflo 11-1

The principal reason for excluding the Filesearch configurations is the high cost involved. The systems rank among the more expensive contenders within range of the more fully automatic systems (see Table 6-4.). Why then a trend towards widespread adoption of this system within the DIA? There is a fundamental difference between the CHIVE system requirements and those of the Defense Department. The DIA system is predicated on a shallow indexing system which is oriented towards document retrieval only. The CHIVE concept is predicated on a deep index beyond the logical search capability of the Filesearch system. Furthermore, the DIA is working with a decentralized data base and has a requirement for compatibility between decentralized organizations (U and S Commands) which are to be provided products from a central index facility. The FMA system has a powerful roll to roll copy capability suitable for this mode of operation. However, the decentralized characteristic of the DIA system is in direct contrast with the centralized document facility postulated in the CHIVE system. The Filesearch approach, though it offers a valid solution to the DIA problem, involves a

TABLE 6-4

RANKING OF CANDIDATE SYSTEMS

INITIAL SYSTEM		INTERMEDIATE
Microfiche (packed, with Xerox printer	(52,000 - 53,000)	Microfiche (packed, with Xerox printer)
CRIS (with Xerox 1824)	(57,000 - 75,000)	Filmsort 2000 DX
Paper Files	(59,000)	CRIS (with Copyflo 24C)
Paper Files (packed)	(62,000)	MEDIA (with Copyflo 11-1)
Filmsort 2000 DX	(65,000)	CRIS (with Xerox 1824)
CRIS (with Copyflo 24C)	(70,000 - 78,000)	Paper Files
MEDIA (with Copyflo 11-1)	(74,000 - 80,000)	Microfiche (packed)
MEDIA	(79,000 - 86,000)	Paper Files (packed)
16mm Aperture Cards	(89,000 - 100,000)	MEDIA
Filmsort 1000D (with rotary camera)	(92,000 - 99,000)	16mm Aperture Card
Filmsort 1000 D	(92,000 - 103,000)	Filmsort 1000 D (with rotary camera)
Microfiche (packed)	(95,000 - 121,000)	Filmsort 1000 D
Miracode	(124,000 - 133,000)	Filesearch (with Copyflo 11-1)
Filesearch (with Copyflo 11-1)	(124,000 - 140,000)	Videofile
Microfiche (unit record)	(129,000 - 154,000)	Microfiche (unit record)
Videofile	(152,000 - 227,000)	Magnavue (ap. card output)
Filesearch	(191,000 - 242,000)	Magnavue (roll film output)
Magnavue (ap. card output)	(248,000 - 254,000)	Miracode
Magnavue (roll film output)	(257,000 - 273,000)	Cypress
Cypress	(267,000 - 283,000)	Filesearch

NOTE: The numbers in parentheses are the estimated annual dollar operating costs of candidates. These estimates do not include the costs that are common to all candidates.

B Y O P E R A T I N G C O S T

SYSTEM	FINAL SYSTEM	
(185,000 - 201,000)	Microfiche (packed, with Xerox printer)	(310,000 - 334,000)
(227,000 - 238,000)	Filmsort 2000 DX	(401,000 - 419,000)
(268,000 - 352,000)	MEDIA (with Copyflo 11-1)	(473,000 - 552,000)
(279,000 - 324,000)	CRIS (with Copyflo 24C)	(480,000 - 614,000)
(281,000 - 365,000)	CRIS (with Xerox 1824)	(495,000 - 633,000)
(313,000 - 338,000)	Paper Files	(541,000 - 587,000)
(333,000 - 465,000)	Microfiche (packed)	(597,000 - 811,000)
(349,000 - 374,000)	Paper Files (packed)	(613,000 - 659,000)
(391,000 - 436,000)	MEDIA	(653,000 - 731,000)
(430,000 - 489,000)	16mm Aperture Cards	(768,000 - 864,000)
(450,000 - 485,000)	Filesearch (with Copyflo 11-1)	(799,000 - 1,032,000)
(454,000 - 489,000)	Filmsort 1000 D (with rotary camera	(810,000 - 868,000)
(492,000 - 629,000)	Filmsort 1000 D	(828,000 - 874,000)
(526,000 - 831,000)	Videofile	(881,000 - 1,377,000)
(532,000 - 665,000)	Microfiche (unit record)	(978,000 - 1,192,000)
Not evaluated in this case	Miracode	(1,170,000 - 1,227,000)
(648,000 - 711,000)	Magnavue (ap. card output)	(1,201,000 - 1,349,000)
(676,000 - 723,000)	Magnavue (roll film output)	(1,203,000 - 1,344,000)
(737,000 - 831,000)	Cypress	(1,446,000 - 1,637,000)
(1,091,000 - 1,263,000)	Filesearch	(1,868,000 - 2,090,000)

search capability which is too limited to handle the deep CHIVE index and too expensive to be used as an aspect system for merely locating a specific document number. It provides a powerful means of creating satellite files on demand which is quite significant for DIA but cannot be appreciably exploited within the CHIVE requirement. Aside from this 'over-design' from the CHIVE point of view, the system is more suitable to batch processing. Because of its slow reel interchange and relatively slow scanning rate, the system ranks unfavorably in performing random counter service retrieval activity.

6.4.1.8. Videofile

Based on preliminary specifications of the Ampex system, the use of video tape as the CHIVE document storage medium was rejected. It does not appear that the state of the art of video recording is, as yet, competitive with microfilm either from the standpoint of cost or resolution quality. The current status of the Videofile equipment is oriented more towards visual display output and a capability for high volume printing has yet to be demonstrated.

RATIONALE
Selection Process
6.4.1.8.

6.4.1.9. Magnavue and Cypress

The preliminary specifications and pricing information for these similar, automatic systems indicates that they both have a response capability in excess of CHIVE requirements and consequently are placed in an unfavorable cost position. The advantage of the automatic over the less sophisticated systems does not seem significant enough to warrant the added cost and for this reason these systems are tentatively rejected. However, proposals for implementing these systems have been received from the respective manufacturers. Both proposals, and particularly the Cypress proposal suggest a solution different from those described and evaluated in this study. As such, they are to be evaluated outside the scope of this report. Since the Cypress proposal involves a number of advanced technologies of considerable promise, a continuous tracking of this and other developmental efforts is warranted.

It should be noted that an RFP has been issued to the manufacturers of Videofile, Magnavue and Cypress in order to ascertain firmer specification and cost information. The response shall be evaluated on the individual merit of each proposal outside the scope of this report.

RATIONALE
Selection Process
6.4.1.9.

6.4.1.10. Shortcomings of Recommended Systems

It should not be construed from the foregoing summary discussion that the two systems selected as most favorable are without some drawbacks. Most of these are pointed out in the subsequent discussion wherein the two systems are subjected to a detailed comparison on many facets. A summary of some of their respective shortcomings is included here.

Packed Microfiche

This system necessitates the filing of items by document accession number (Section 6.4.3.1.) thereby introducing the problem of assigning and maintaining some form of cross reference numbering system as well as the requirement for a lookup of this cross reference in servicing counter requests. By collocating multiple items on the same fiche the advantage of a unit record is lost and multiple items are absent from the file when one of the items is removed for processing. Also, the microfiche is strictly a manual record which cannot be mechanically sequenced before refiling as is possible in the case of the two aperture card systems.

Filmsort-35mm Aperture Card

The Filmsort 1000d, which was evaluated during the first phase of the study, compared somewhat unfavorably

in both manning and space but introduction of the Filmsort 2000dx in the later stages of the study improved these rankings substantially. A major question arises with the Filmsort system concerning the archival quality of the aperture cards produced (Section 6.4.3.4.). The GSA has yet to recognize the aperture cards produced on the Filmsort device as meeting the NBS standards for storage of permanent records.

6.4.2. QUANTITATIVE COMPARISON OF REMAINING CANDIDATES

The foregoing exclusions left the two remaining candidates--Packed Microfiche and 35mm aperture cards--as finalists suitable for further evaluation prior to final selection. Based on the findings of the survey, summarized in Chapter 6.6., the Microfiche system compared more favorably in cost, space and manpower requirements. However, the recent product announcement by the 3M Company of the Filmsort 2000dx camera has made available an improved capability for creating 35mm aperture cards. The new device provides a means for recording eight rather than four images per aperture card, thereby reducing the space required through more compact storage. Furthermore, the new unit is designed

RATIONALE
Comparison of Remaining Candidates
6.4.2.

with a faster process cycle, allowing more rapid throughput, fewer camera units and an equivalent reduction in camera operators. On the other hand, a survey of microfilm manufacturers has revealed a number of new microfiche processing devices, which offered improved cost and/or improved performance. Both the Microfiche and Filmsort systems were re-configured to constitute an optimum equipment mix and the ranking process was repeated. The revised calculations resulted in the following comparative position of the two systems.

COMPARISON OF PACKED MICROFICHE (WITH XEROX PRINTER) VS. FILMSORT 2000dx SYSTEM

Factor	Packed Microfiche* (with Xerox printer)	Filmsort 2000dx **
Cost of total system	$310,000/yr	$401,000/yr.
Cost of intermediate system	$184,000/yr.	$227,000/yr.
Cost of initial system	$ 52,000/yr.	$ 65,000/yr.
Staff of total system	18	21

*See Appendix 6.B.1.

**See Appendix 6.B.2.

RATIONALE
Comparison of Remaining Candidates
6.4.2.

Staff of intermediate system	11-12	12-14
Staff of initial system	3	4-5
Floor space of total system	1545 sq. ft	2800 sq. ft.
Floor space of intermediate system	990-1170 sq. ft	1585-1685 sq. ft
Floor space of initial system	520-540 sq. ft.	460 sq. ft.

6.4.3. OPERATIONAL IMPLICATIONS OF REMAINING CANDIDATES

In addition to the direct comparison on cost, space, and staff, some further value judgments relating to the adoption of either system must be made before a final decision can be reached. It is impossible to assign an objective weight to the significance of these factors, since their relative importance will vary according to the standpoint of the reader. For this reason, the following discussion will draw a qualitative evaluation of the ability of each system to meet various operational requirements, without any attempt to interpret the significance of each requirement.

6.4.3.1. File Organization

Fundamentally, there are two ways of organizing items within the document store. These are:

RATIONALE
Operational Implications
6.4.3.1.

- Document Control Number Sequence: in which the items in the file are arranged by a unique, meaningful number that has been pre-assigned to the document (e.g., USIB number, digraph code, etc.)

- Document Accession Number Sequence: in which the items in the file are arranged by a unique, sequence number which is assigned during the input process and which identifies its relative location in the file (e.g., storage location)

An extensive discussion of the operational implications relating to each method follows in Section 6.5.3. In summary, it establishes that the Packed Microfiche system is restricted to use of the second method whereas the aperture card system is adaptable to either method. This means that the Packed Microfiche would require that an Accession Number be assigned to identify the item storage location. The microfiche would be filed in Accession Number sequence and a cross index would be maintained on the computer and printed out periodically as a cross reference directory for servicing counter requests. The aperture card system, by providing a means for organizing the file in sequence by meaningful Document Control number, eliminates the requirement for maintenance of a dual numbering system as well as the lookup function in retrieving specific items.

RATIONALE
Operational Implications
6.4.3.1.

6.4.3.2. Output Media

Although the end product output of the system has been defined as hard copy, it is conceivable that other means of distribution might be required. Both systems appear to have an equivalent flexibility in providing contact printing (to either card or fiche) or viewer browsing, should either need arise.

6.4.3.3. Backup Copy

The Microfiche system has two alternative methods for providing the necessary backup microfilm copy--105mm roll microfilm or cut microfiche. Since there is no equipment existing which can selectively access and process items within a 105mm roll, cut microfiche appears to be the only suitable option. With the Filmsort approach duplicate aperture cards represent the only reasonable backup because no intermediate roll film is produced during the input process. Of course, for either system a rotary camera could be employed to create reel backup but this would introduce the additional cost of a separate photographic operation and probably would result in a poorer image quality. For Records Center purposes either discrete microfiche or aperture card

RATIONALE
Operational Implications
6.4.3.3.

would provide a workable form of security storage although both would result in increased storage space over the current 16mm roll film files. The aperture card backup approach would require approximately five times as much floor space as microfiche for filing equipment (Appendix 6.B.). Presumably, the Record Center would be equipped with some form of contact print capability such as, for microfiche--an Ozalid Duplicator and Developer Unit or for aperture cards--a Filmsort UNIprinter 086. Contact copies would be produced on demand and transmitted to headquarters where they would be enlarged to hard copy and/or filed as necessary. Of course, any change to existing practices would require coordination with NSA.

6.4.3.4. Archival Responsibility

A permanent copy of all CIA originated documents must be furnished for archival purposes. The original microfiche silver copy would fulfill this requirement. On the other hand, 35mm aperture cards created by the Filmsort camera are not currently recognized by the GSA as an acceptable form of permanent storage. Unless a favorable ruling is forthcoming, either a hard copy or

RATIONALE
Operational Implications
6.4.3.4.

some other acceptable substitute would be required. One approach would be to process Agency generated documents through a rotary camera and retain the roll silver film produced. Since the items requiring archival storage represent a relatively small percentage of the total volume handled, either hard copy or roll film would be a reasonable solution to the problem.

6.4.3.5. Timing

Although both systems are manually operated with many procedural similarities, there are functions peculiar to each system which effect the time required to input and to retrieve file items. The input procedure is essentially a batch process with fairly liberal time restrictions and as such, throughput is the most important measure. On the other hand, the retrieval function is typified by spasmodic, random activity in which turnaround time is of greater import. Factors effecting the time characteristics are summarized as follows.

6.4.3.5.1. Input Timing

A summary comparison of input functions involved with each of the two systems is included in Table 6-1. There are obviously some advantages to either system.

RATIONALE
Operational Implications
6.4.3.5.1.

TABLE 6-1

Input Processing - Functional Comparison

	Function	Packed Microfiche	Filmsort-Aperture Card
(a)	Assign Cross Reference Number	Assign Accession Number and transmit to EDP system	No cross reference required
(b)	Preprocess	Equivalent manual processing (i.e., stape removal, etc.)	
(c)	Sequencing	Some manual segregation by document type, security class, etc., required	No manual sequencing--machine sorted after aperture cards created
(d)	Data Transcription	Limited header typing	Indicative information must be transcribed and converted to machine readable form and later transferred to aperture cards.
(e)	Photography	Equivalent throughput rate (approximately one item per minute)	
(f)	Film Processing	Film must be developed and cut	Not required. Aperture developed in previous step.
(g)	Sequence for Filing	Not required	Machine sorted
(h)	Prepare Backup Files	Continuous flow contact print and automatic cutting	Automatic copy reproduction of aperture card
(i)	File Document Images	Rapid filing. Add on by Accession No.	Slower selective filing by Document Control No.

The microfiche flow would allow the documents to reach the camera sooner than the aperture card system because it does not require an intervening data transcription step. Once the microfiche have been cut the bulk filing process is considerably easier than the selective placement of aperture cards throughout the file. However, there is a built-in processing delay because the microfiche step-and-repeat camera records a large number of documents for each roll of film processed. The cameras normally operate with a 100-foot roll of 105mm microfilm which can accumulate up to 200 microfiche (or approximately 800 items) amounting to more than one days' camera production. Shorter microfilm rolls could be used to shorten the time interval for getting documents into the file, should this delay be intolerable.

On the other hand, the Filmsort system requires the original transcription of identification data, creation of a work card containing this data for subsequent punching into the aperture card masters. None of these functions are required of the microfiche system and although part of this effort might be done in parallel with the filming operation, some processing delay would be involved. Furthermore, as indicated above, the manual

insertion of items into the file would be a slightly slower process than for microfiche. However, these delays would be offset by the advantage of the single step photographic process provided by the Filmsort camera, plus the fact that there might be some delay in creating a workable cross reference to the proper microfiche.

Based on the foregoing discussion the following input timing generalizations may be drawn:

- Both systems are capable of processing items into the file within a time frame consistent with CHIVE requirements.
- The aperture card system, although it requires more manual effort to enter items into the file, involves a shorter input processing time cycle than the packed microfiche system.

6.4.3.5.2. Retrieval Timing

The procedural flow in accessing requested items is quite similar for the two systems. Both systems involve manual pulling from the same type of motorized file. The Xerox Microfiche Printer and the 3M Octant printer are still somewhat vague as to their specifications but since they both require one-at-a-time manual insertion of master images of documents having a bias towards a minimal number of pages, the effective rate for either unit would approximate operator speed. The smaller file area

RATIONALE
Operational Implications
6.4.3.5.2.

required by the microfiche system would offer some efficiencies of file operation, whereas the aperture cards, by virtue of their suitability to mechanical sequencing, would enhance the item refile rate. Although the physical manipulation of the two file systems would seem to be equivalent, the aperture card system would provide a faster overall responsiveness for counter service activity because it obviates the necessity of a cross reference lookup. This additional function required of the microfiche system would prolong the request turn-around time to some degree.

6.4.3.6. File Integrity

The relative merits of both the Aperture Card and the Microfiche systems with regard to file integrity is discussed in Section 6.6.4.6.1. In summary, the aperture card system has a slight advantage because (a) the file can be periodically sequence checked on a collator to locate misfiled items and (b) misplacement of a unit of storage would result in only a single item being out of file in the aperture card system, whereas with packed microfiche from one to five items could be effected.

RATIONALE
Operational Implications
6.4.3.6.

6.4.3.7. Purge Capability

The analysis of susceptibility of each system to purge activity is summarized in Section 6.6.4.7. The relative ranking of the systems by this criterion (Table 6-14) shows the Filmsort aperture card system to have a rating of excellent with Packed Microfiche rated as fair.

6.4.3.8. Security

The question of the security regulations governing an all source document image file has not as yet been resolved. Presumably, it would be a basic precaution to segregate collateral and special materials into discrete, identifiable sections of the file, in order to facilitate proper security control. The aperture card system, by storing documents in Document Control Number sequence, provides an inherent division of materials into these categories. A similar separation could be effected in the microfiche system by keeping collateral and special documents segregated during the input process, thereby preventing the collocation of the two categories on the same microfiche and even their interposition within the same section of the file. Both

RATIONALE
Operational Implications
6.4.3.8.

TABLE 6-14

ESTIMATE OF RELATIVE RANKING OF EASE OF FILE PURGING

System	Capability to Purge Selected Items	Comments
Magnavue	Excellent	Machine extraction of selected items No reprocessing required of remaining file items
MEDIA Microfiche (unit record) Paper File 16-mm Aperture Cards F-1000d	Excellent	Manual extract of selected items. No re-processing required of remaining file items.
Microfiche (packed)	Fair	Manual extraction of selected items. Some processing of remaining items on selected microfiche.
Cypress	Fair	Machine extraction of selected items. Re-processing required to remove film chip voids.
Miracode Filesearch	Fair Poor	Cutting and splicing of roll film required.
Videofile	Poor	Machine re-write of video tapes with some image degradation with each of the analog re-writes.
CRIS	Poor	New scrolls must be prepared from cut and spliced roll film originals for every updating cycle.

systems would be equally amenable to techniques such as color striping on the top of the card or microfiche as an aid in visually distinguishing between various security compartments.

6.4.3.9. Upgrading Potential

Another consideration in determining which system is to be adopted should be an assessment of the technology surrounding each of the storage media. Concentration of developmental effort by manufacturers in the industry is bound to result in the introduction of devices of improved economy and efficiency. Furthermore, a general acceptance of one or the other medium offers the advantage of compatibility with other organizations processing like documents. It is, of course, difficult to predict exactly what the future holds for aperture card and microfiche but there are current trends which do give some insight. At this time, the Mil 'D' aperture card is perhaps the most widely accepted form of microfilm storage, although there has been a recent move towards microfiche among large government scientific information organizations (viz., OTS, AEC, NASA). Aperture card standards have long since been established and a wider variety of associated

RATIONALE
Operational Implications
6.4.3.9.

processing devices has been developed. Microfiche has evolved into four basic sizes and, although standards have been adopted by the NMA, standardization among users has not been effected. Indicative of the recent trend towards wider industry acceptance of microfiche has been the developmental effort in step-and-repeat cameras (viz., Microcard, Bell and Howell, Photo Devices, Houston Fearless) and enlargers (viz., Microcard, Xerox). As proof that improvements to 35mm aperture card handling equipment are continuing to be made, we need only look to the recently announced Filmsort 2000dx camera and the IBM Copy-Reproducer. Furthermore, the fact that the newer, automatic systems (viz., Magnavue, Walnut, and Cypress) are designed to be compatible with aperture card input and/or output, is an acknowledgement of the wide acceptance of the Mil 'D' aperture card. It would seem that at the present time, the 35mm aperture card equipment is in wider use and in a more advanced stage of development than that for microfiche handling.

6.4.4. RECOMMENDATION SUMMARY

In this Chapter the rationale for rejection of all but two of the candidate systems has been outlined. A

RATIONALE
Recommendation
6.4.4.

more extensive comparison of the two remaining systems was drawn and some of the operational implications associated with the adoption of either system were discussed pro and con. It is apparent from this foregoing discussion (a) that either the Packed Microfiche or the Filmsort 2000dx aperture card system is capable of meeting CHIVE requirements; (b) that each has an equivalent measure of advantages and disadvantages; and (c) that both are fairly close in cost of operation. The final choice as to which of the two systems is most practical for implementation can best be made by Agency management. The supporting data presented in this volume is intended as a basis upon which this decision may be made.

RATIONALE
Recommendation
6.4.4.

DOCUMENT STORAGE REQUIREMENTS

6.5.1. LEVELS OF STORAGE REQUIRED

During the process of evaluating various document storage media, a simplifying assumption has been observed that the total CHIVE corpus would be filed in some homogeneous storage medium. In reality, the document store will be hybrid, consisting of some microform and some hard copy files. Specific criteria for determining which documents are suited for which storage medium will necessarily have to be developed empirically within an operational environment. However, certain general guidelines to the selection of the most appropriate file medium can be derived from the experience of currently existing systems. Documents, currently filed within OCR, are reduced to microfilm form or stored in the original paper copy according to a rather complex set of rules which have evolved over a period of time. In general, the present criteria for excluding documents from microfilm processing are:

STORAGE REQUIREMENTS
Levels Required
6.5.1.

- document type (series) - certain categories of documents of transitory or limited intelligence value.

- document length - documents of excessive page length such as in the existing Intellofax operation, documents over 300 pages are not mounted in aperture cards.

- document size - frequently document enclosures are oversized and some alternate provision for their retention must be made.

- document print quality - poor quality printed pages below the threshold of proper microfilm recording and blowback.

A further possibility exists that within the class of documents suitable for microfilming, more than one type of microfilm media might be employed. Since the CHIVE documents cover such a wide range of physical characteristics, different media might conceivably prove more suitable for various portions of the corpus. For example, the 35mm aperture card is more suitable for documents under 8 pages in length than the microfiche and conversely the microfiche offers a more effective storage medium for lengthier documents (i.e., in the 40-60 page range). However, an effort was made to identify one storage system capable of handling all documents. This was done partially to facilitate system comparison and partially because there are some valid arguments for implementing a single standardized

system. There are currently a number of filing systems in operation in OCR. Many of these will continue in operation because of the impracticality of total file conversion. (See Section 5.5.9.) Initiation of multiple new filing processes would only add to the myriad of files, thereby further complicating the operation of a sole source retrieval point. In fact, one of the major benefits to be derived from the installation of a document delivery system would be to standardize filing practices within OCR. Furthermore, standardization of equipment and procedures would result in high volume processing through a multitude of like devices, thereby providing increased efficiency through more flexible scheduling and improved reliability through backup equipment availability. Therefore, the arguments weighed heavily toward selecting a single microfilm system which was most suitable to the total OCR document requirement within an attractive economic framework.

6.5.2. FILE MAINTENANCE

6.5.2.1. File Integrity

Regardless of the document delivery equipment selected for installation, certain control procedures must

be designed into the system to insure the integrity of the file. As a design objective, document master copies, whether hard copy or microform, will not be removed from the file for circulation. Instead, replica copies are to be produced on demand and distributed to the requestor. The document master is to be retained in its proper storage location after the replica copy has been produced. It would be an ideal condition for the file to remain intact during reproduction of selected items, but for those systems where a master must be physically removed from the file as an individual item (such as aperture card, hard copy, microfiche) or as a group of items (such as a reel, capsule, scroll), it should be a system design goal to minimize the out-of-file time span. Furthermore, positive controls must be provided to prevent loss or misplacement of a document master on refiling. An effort has been made in configuring the candidate systems to provide procedural adaptations to meet these general control regulations. A discussion of the degree to which the various systems attain these objectives is contained in Section 6.6.4.6.

6.5.2.2. File Purging

The document delivery system should be capable of selectively purging document masters from the store.

It is evident that a file absorbing the large input volume predicated for the total CHIVE system would, over a period of years, eventually become unwieldy. For this reason, some means of regulating the active file size should be provided. Complete destruction of purged items is not the only alternative and the term purging is used here to connote the relocation of documents to successively lower levels of accessibility, the lowest of which might be actual destruction.

Criteria for obsoleting documents have not been formalized and experience has shown that no simple criterion, such as age, is a valid guide for document retirement. The survey of existing document files (Appendix 5.D.) revealed the following Agency purging attitudes and practices:

- In general, there is a reluctance to discard documents once they have been filed in either hard copy or microform. Analysis of the hard copy files reviewed shows that, based on the cumulative survey estimates, the total number of items purged annually represents less than one percent of the total number of items in the files. It should be noted that the survey encompassed only CHICOM sections of the file and therefore the sample may be somewhat biased. Since there is a natural reluctance to discard materials relating to a denied area, this estimate of one percent may be lower than that for the total file inclusive of all areas. The survey also revealed that for microfilm files the practice has been not to purge but rather to retain all document microimages at headquarters.

STORAGE REQUIREMENTS
File Maintenance
6.5.2.2.

- There is an absence of definite, formalized regulations and practices in performing the file purge function. Very few of the files undergo scheduled screening for purposes of weeding out obsolete items. For the most part, the limited purging effort expended is applied to active dossiers by analysts who remove duplicated or superseded information prior to refiling. Thus, the current purging practice is quite limited and consists primarily of an ad hoc determination of individual items by an experienced analyst.

Although there is currently no logical basis for automatic file purging, the possibility exists that some such rationale may be developed. In any event, if formal purging rules can be posulated, these would be applied to the computer index to identify those items to be downgraded in storage. Functionally, the purge requirement, within the document delivery context, would merely consist of the facility to locate the specific item and to remove it physically from the store. The degree to which the candidate systems provide this capability is evaluated in Section 6.6.4.7.

6.5.3. FILE ORGANIZATION

As indicated in Section 6.4.3., there are two ways of organizing items within the document store: (a) Document Control Number and (b) Document Accession Number Sequence. Each method has its advantages and disadvantages and an

attempt will be made in this section to summarize the 'trade-offs' involved. The procedural implications involved in adopting either of the two file organizations will be explored and the adaptability of the various candidate systems to each filing approach will be discussed in this section.

Essentially, the first method of ordering the file in Document Control Number sequence requires a single unique number to be associated with each document, whereas the latter method involves two numbering systems with the need of maintaining a workable cross reference capability. A summary of some of the 'tradeoffs' between the two approaches is included in Table 6-2.

The decision as to which file sequence is adopted is closely dependent on the storage medium being utilized. In general, the unitized microfilm systems (i.e., those in which one item constitutes a discrete, physical unit of storage) are equally adaptable to either file sequence. This would, of course, be true of the hard copy file as well. On the other hand, the 'clustered' microfilm systems (i.e., those in which a group of items are recorded on a single physical unit of storage) are more adaptable to filing by accession number. This is

TABLE 6-2

COMPARATIVE SUMMARY OF FILE ORGANIZATIONS

	Document Control Number Sequence	Document Storage Number Sequence
1. Procedural		
a. Input	Slower file process due to selective storing.	Ease of filing due to batch; add on storage.
	No assignment of storage number required.	Storage number must be assigned (may be automatic).
	No communication of storage number to document index.	Storage number must be recorded and transmitted to the document index for cross reference.
b. Output		
Query Requests	Equivalent. Index provides Document Number	Equivalent Index provides Document Storage Number
Counter Service	Faster response. Direct access. No cross reference required.	Lookup and cross reference of numbers required
2. Security	Results in segregation of collateral and special materials by retention of existing coding systems (e.g., USIB number, digraph code).	All-source materials inter-filed
3. Conversion (Inherited files)	Compatible with inherited document files (e.g., Intellofax, SR).	Introduces new numbering system.

true because items are grouped during the initial photographic recording of the documents. Once recorded, there is a degree of difficulty, varying by system type, in rearranging the order of the documents. For systems utilizing roll film (MIRACODE, Filesearch, CRIS) a cumbersome amount of cutting and splicing effort is required. Videofile would have a similar problem except that reordering would be accomplished through selective reproduction of document images into the specified sequence. Systems utilizing cards or chips grouped within a container, such as Media (capsule), Magnavue (magazine) and Cypress (cell), also present a problem, in that miniature sized pieces of film would have to be manually inserted into the proper container. Of the three, MEDIA alone has a recorded reference number which is eye visible to facilitate manual filing. Microfiche when used as a unitized record is equally adaptable to either file organization but once multiple items are stored on the same physical record it becomes virtually impossible to change the juxtaposition of individual items within the microfiche. For all of the 'clustered' systems the re-sequencing problem could be somewhat alleviated by batching and pre-sorting the

documents prior to microfilming; but because of the spasmodic arrival rate of items within a given series, it would necessitate the microfilm process to be delayed to a point inconsistent with CHIVE input timing requirements.

In summary, the candidate systems can be aligned into two groups--those adaptable to either method of file organization and those limited to storage number sequence only.

Adaptable to Document Control Number or Document Accession Number Sequence	Adaptable to Document Accession Number Sequence only
Paper (file)	Packed Microfiche
Aperture cards	MIRACODE
Microfiche	MEDIA
	CRIS
	Filesearch
	Magnavue
	Cypress
	Videofile

6.5.4. FILE BACKUP CAPABILITY

Provision of a backup capability for the master document store is a major design goal. The system must be capable of providing:

- a means of fall back (or bypass) operation in the event of temporary or prolonged failure to any processing device and

- a means of reconstruction of master document records in the event of limited loss or destruction of the main file.

The former may be accomplished either through duplication of processing devices or through an alternate procedural approach to handling records in the file. A temporary degradation of system performance is tolerable but the fall back mode of operation should at least be capable of servicing priority requests. This capability preferably should be operable entirely within the headquarters premises, but remote files may be employed provided excessive degradation of responsiveness does not result.

The reconstruction capability is to be effected by means of a remotely located, duplicate file. This file need not be identical in form to the main file but it should be searchable and it should be suitable for reconstruction of the main file in whole or in part. It should be searchable to the extent that specific items may be located and copies provided, though not necessarily at the same sustained volume level or the same turnaround speed as the primary store. In summary, the function of the Backup File is threefold:

STORAGE REQUIREMENTS
File Backup Capability
6.5.4.

- to respond to specific requests temporarily unserviceable by the primary store

- to furnish replacement masters for lost or misplaced items in the master file

- to reconstruct the master file in the event of total destruction.

As a specific CHIVE requirement, two duplicate files must be furnished in addition to the main document file.

- Record Center: The Record Center is an off-premises file consisting of duplicate copies of items contained in the primary store, as well as a primary repository for documents selected for off-premise storage. An arbitrary schedule requirement specified by CHIVE is that materials be filed such that the Record Center backup file is not more than one week in arrears of the primary document store. Furthermore, it is anticipated that the current one-day service for normal requests and one-half day service for priority requests must be provided.

- NSA: There is currently an inter-agency agreement whereby microfilm copies of collateral materials (with the exception of CIA Internal Use Only documents) are provided to NSA by MD/OCR. At this time, NSA is provided with 16mm reel microfilm and punched cards containing a cross-reference between Document Control Number and the location of the item within a specific reel (i.e., Reel and Flash Number). It is assumed that this inter-agency service will continue and that an equivalent microfilm reference capability will be furnished by the Document Delivery Subsystem. For purposes of convenience within the scope of this report, this inter-agency requirement is referred to summarily as a second backup file.

STORAGE REQUIREMENTS
File Backup Capability
6.5.4.

6.5.5. RELIABILITY REQUIREMENTS

In general, it is assumed that all equipment being considered is consistent with good commercial reliability standards. The specific reliability characteristics of each individual unit and the ability of each vendor to provide proper maintenance and repair service should, of course, be ascertained prior to actual procurement. In addition to its inherent reliability, the system must provide some alternate capability for processing during periods of disablement as outlined in Section 6.5.4. The overall system is intended for operation primarily on a single shift basis with capability for on-demand operation at any time. A CHIVE imposed reliability threshhold has been established to the effect that units should not be out of service for a period of more than 2 consecutive hours nor more than a total of 3 hours in a single day.

6.5.6. SUMMARY OF PERFORMANCE REQUIREMENTS

A summary of the activity volumes and response times required of the Document Delivery Subsystem is contained in Table 6-3. The volume figures for the Initial System represent the projected activity requirement involved in

handling CHICOM materials only. The response times have been established as requirements for the system operating at that level of activity.[14] The volumes specified for the Final System reflect a gross projection of processing the total document handle. The response times for the Final System are long range design goals which would constitute a more stringent requirement than that specified for the Initial System.

A brief definition of terms used in Table 6-3 is included below:

- All activity is measured in number of documents.
- All response times are measured in minutes or hours as indicated.
- Input response time is measured from initial receipt of a processing copy of the document by the Document Delivery Group until it has been fully processed into the document image file.
- Output response time is measured from the initiation of a demand for a specific document either over the counter (Direct Mode) or as a result of a computer index search (Query Mode), until a replica hard copy of the document has been produced for delivery.

STORAGE REQUIREMENTS
Performance Requirements
6.5.6.

TABLE 6-3

SUMMARY OF VOLUMES AND RESPONSE TIME REQUIREMENTS

	INITIAL SYSTEM				TOTAL SYSTEM			
	Perc. of Total Volume	Per Annum (1) Doc.	Per Diem (1) Doc.	Maximum (2) Allowable Time	Perc. of Total Volume	Per Annum (1) Doc.	Per Diem (1) Doc.	Maximum (2) Allowable Time
I. Input								
1. Total Volume	-	100,000	400	-	-	1,000,000	4,000	-
a. Standard Items	90%	90,000	360	32 hrs.	90%	900,000	3,600	16 hrs.
b. Allowable Lag Items	10%	10,000	40	80 hrs.	10%	100,000	400	40 hrs.
II. Output								
1. Total Activity	-	125,000	500	-	-	1,250,000	5,000	-
a. Direct Mode Counter Service	(3) 20%	25,000	100	10 min.	(3) 20%	250,000	1,000	10 min.
b. Query Mode (Subject Search)	(3) 80%	100,000	400	-	(3) 80%	1,000,000	4,000	-
1. Priority Service	20%	25,000	100	2 hrs.	20%	250,000	1,000	30 min.
2. Standard Service	55%	68,750	275	8 hrs.	55%	687,500	2,750	4 hrs.
3. Allowable Lag Service	5%	6,250	25	16 hrs.	5%	62,500	250	8 hrs.

Assume: (1) 250 work days per year assumed.
(2) Hours based on 8 work hours per 24 hour day.
(3) 20% Direct Mode Activity
80% Query Mode Activity

COMPARATIVE ANALYSIS OF CANDIDATE DOCUMENT DELIVERY SYSTEMS

The study effort was initiated in May 1964 to perform the initial planning and design of the CHIVE document delivery system. One necessary part of this study effort was the review and evaluation of the alternative designs in the light of several criteria such as cost, staff, space, and the degree to which the design satisfied the established requirements [14,20] as summarized in Chapter 6.2. Because of the magnitude and complexity of the application under study, it was important that a rather detailed and comprehensive study be made of the many alternative systems that were potential candidates.

The main body of this section briefly describes the 17 preliminary designs and summarizes the results of their relative evaluation by cost, staff, space, and other factors. CHIVE/R-1-65, which has been issued separately provides a more detailed description and cost, space and staff analysis for each system. Appendix 6.A. provides

a detailed description of the computer simulation studies of several of the candidate systems. Appendix 6.B. contains the detailed calculations supporting the cost, space, and manpower ranking of the final contending systems. Appendix 6.C. contains a narrative description of the efforts involved in determining the ability of the various systems to produce quality hard copy.

6.6.1. CANDIDATE SYSTEMS

Our attention was directed primarily to equipment that was commercially available and had already been demonstrated with working models and actual installations. Some equipment that is still under development by the manufacturers and some modifications of existing equipment were also considered. The systems discussed in this report are:

- Paper file (storage of the original paper records with duplication on demand)
- Paper file (packed shelving)
- 16mm aperture cards
- 3M Filmsort 1000d
- 3M Filmsort 1000d with rotary camera
- Microfiche (unit record)
- Microfiche (packed--i.e., multiple items per microfiche)

- Magnavox MEDIA (with hard copy output)
- Magnavox MEDIA (with Xerox Copyflo 11-1
- Recordak MIRACODE
- CRIS (with Xerox 1824)
- CRIS (with Xerox Copyflo 24C)
- FMA Filesearch (with hard copy output)
- FMA Filesearch (with Xerox Copyflo 11-1)
- Magnavox Magnavue
- IBM Cypress
- Ampex Videofile

Several systems were not subjected to detailed evaluation procedures because preliminary analysis or results of prior studies showed them to be inappropriate for this particular application. For example, because of the high cost of the initial film preparation, the NCR photochromic microimage (PCMI) system does not become economically competitive unless it is used as a microform dissemination or publication facility that distributes 50 or more copies of each item to be filmed. Furthermore, the PCMI system does not have a means for furnishing large volumes of hard copy printout. The NCR representatives concur in the initial assessment that the present PCMI system is inappropriate for this particular application.

The present Walnut equipment was bypassed primarily because of its high cost for a relatively limited amount of storage capacity. The final system would have required some 51 Walnut Image Files to hold the specified volume on-line. A compromise off-line system was not practical because the Image Files have no mechanism to permit quick and simple machine loading and unloading of cells from shelf storage. The Walnut equipment was designed as a custom built installation rather than as a production item, hence the costs to provide additional units would be inherently more expensive than the second generation equipment, (Cypress) which IBM is currently developing and evaluating for volume production as a successor to the Walnut system. The Cypress equipment is analyzed in this report. The IBM representatives concur in the initial assessment that the Walnut system is inappropriate for this particular application.

The Minicard equipment (Eastman Kodak Company) was felt to be inappropriate for this application primarily because:

- its powerful and complex logical capability for subject searching of indexed microfilm records would not be needed for this straightforward task of on-demand printing and removal of this superfluous search capability through redesign would in all probability prove too costly.

ANALYSIS OF CANDIDATES
Candidate Systems
6.6.1.

- the equipment had limited capability for large volume hard copy printing.

- many of the features required for this particular application are now available on the more recent Magnavue, a similar system developed by the Magnavox Company.

The Magnavue equipment which reflects a more recent state of the art and technology than the older Minicard system, is analyzed in this report.

The detailed cost analysis of the various configurations (Appendix 6A), in most cases, quotes standard GSA catalog prices for specific equipment and supply materials, (e.g., Recordak Micro-file Camera, Model MRD-2). This was done, wherever possible, to attain a maximum degree of accuracy in deriving total system costs. The equipments and materials cited in the report were intended to be typical (in cost and performance) of the class of units available from various manufacturers to suit a given function. It is not the intent of this report to endorse any unit cited by manufacturer's name as being superior to similar equipment available from other sources. Selection of specific supporting equipment units is beyond the scope of this report and must be determined on an operational level, once the general systems approach has been determined.

6.6.2. METHODOLOGY AND ASSUMPTIONS

The design effort concerned itself with suggesting configurations of equipment, people, and processes that could meet the following general requirements:

- A capability to grow easily from a relatively small installation to a large and active file situation.
- An eventual capability of handling 5000 item requests* per day, one million input items per year, and a file size of ten million items.
- A capability of providing two duplicate backup microfilm copies of the file contents in accordance with the current practice of furnishing copies to Records Center and NSA.
- A capability of filling user requests with paper copies ("hard copies") of the original file items.

Initial interest was focused on the evaluation by cost, staff, and space, because these were some of the more important factors, and because much of the work to obtain these figures would still have to be done in preparing for evaluation by other criteria. Evaluation in terms of response time was done for several systems that seemed to be representative of general types of systems.

Since this study concerned the relative performance and cost of each candidate, rather than the absolute

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*A "request" is defined as a demand for a single document. Thus a user with a list of 20 documents to be furnished would be contributing 20 "requests" as defined in this study.

performance, an effort was made to exclude from the analyses of cost, staff, and space, those features (such as management) that would be about the same for all candidates. The following operations were omitted from the analysis because it was assumed that the same operations would be performed in all candidate systems with about the same demands for money, space, and people:

- Quality control and rework
- Preparation for filming (assign serial no., remove staples, etc.)
- Disposition of original document after filming
- Pre-processing of requests (taking the order, routing it to proper file station)
- Collating hard copy with associated request and packaging for delivery
- Management and supervision
- Preparation of maintenance of cross-reference indexes to backup files or machine address files
- Storage and maintenance of backup files.

No costs were included for the possible conversion of the existing files. These costs can be added relatively easily at some later date if it becomes appropriate. No costs were figured for waste material (e.g., paper, film).

Each candidate system was examined in detail to determine what staff, equipment, and materials were

required. Considerable survey and experimental work was done to establish elemental processing rates and material costs for all of the major processes. The elemental times and cost figures were used to develop a cost function for each candidate to predict the upper and lower cost bounds of that system under different operating conditions. A computer program was written to evaluate the cost functions at several different operating points. Separate configurations were established, and the candidates evaluated at what amounts to three different points in the growth cycle of the CHIVE system:

- Initial system (500 requests per day, 100,000 input items per year, file size of one-half million file items),
- Intermediate system (3000 requests per day, 500,000 input items per year, file size of five million file items),
- Final system (5000 requests per day, one million input items per year, file size of ten million file items).

The costs, staff, and space requirement (optimistic and pessimistic) were determined for each candidate for each of these three situations and the results are described in Sections 6.6.4.1. to 6.6.4.3. of this report and in CHIVE/R-1-65.

ANALYSIS OF CANDIDATES
Methodology and Assumptions
6.6.2.

As a means of checking the validity of the candidate configurations, computer models were constructed for eight representative systems at both the initial and the final points on the growth cycle. Simulation permitted the introduction into the analysis of the elements of priority and the random arrival rate of transactions. Only the output procedural flow of these systems was simulated, since the output timing and interrupt requirements were the most stringent. The transaction rate of the various request types, representative of the volumes postulated in the system requirements section (Section 6.5.6.), were imposed upon the various system configuration models and the responsiveness of each system was measured accordingly.

For purposes of simulation, the document requests were classified according to type as follows:

- Query Mode Requests: demands on the document store as a result of normal subjective search of the computer index. Within this class of transaction there were two levels of responsiveness:
  - Normal: lowest level of urgency, processed on a first-in-first-out (FIFO) basis
  - Priority: next highest level of urgency which took precedence over Normal Query Mode Requests only.

- Counter Service Requests: demands on the document store imposed by directly identifying the specific document(s) required. This class had the highest urgency and the most stringent response requirement and therefore pre-empted all other transactions types in demanding processing facilities. Counter Service Requests were subclassified as:

    - Single Requests: a top priority request for an individual document

    - Burst Mode Requests: for purposes of evaluating the ability of the various systems to respond to a sudden influx of high priority transactions, demands for a batch of documents (arbitrarily set at 20 documents per batch, called a 'burst') were imposed at random intervals on the simulation models.

The number of requests in each type are specified below.

	Initial System	Final System
- Query Mode Requests		
- Normal	320 items	3200 items
- Priority	80 "	800 "
- Counter Service Requests		
- Single Requests	80 "	800 "
- Burst Requests (1 for)	20 "	(10 for) 200 "
Total	500 items	5000 items

By imposing the above patterns of activity on the initial and final system configurations respectively, a

theoretical measure of the responsiveness of each system was derived. The methodology, assumptions and results of the simulation effort are described in Appendix 6.A. A summary of results is included in Section 6.6.4.4. of this report.

6.6.3. FILE CHARACTERISTICS

The input documents are primarily hard copy textual records that come from a variety of sources and range from poor to high quality in printing, generally from typewritten material on white paper prepared on offset or spirit duplicators or Xerox copying equipment. No maps, photographs, or other high resolution records are meant to be included in the system.

The records have the following distribution by physical size.[28]

Size of original page	Percent of Total File (in Documents)
Letter size and smaller (≤ 8 1/2 by 11 in.)	77.5
Greater than letter size but (≤ 8 1/2 by 14 in.)	22.5

Approximately 20 percent of the pages are printed on the back side of the page as well as on the front side.

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File Characteristics
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The documents have the following distribution by page size.

No. of printed pages per document	Percent of Total Documents	Cumulative Percentage of Total Documents
1	46.5	46.5
2	19.7	66.2
3	9.8	76.0
4	3.8	79.8
5	3.2	83.0
6	1.9	84.9
7	1.2	86.1
8	1.1	87.2
9	1.3	88.5
10	0.9	89.4
11	0.9	90.3
12	0.6	90.9
13-18	2.6	93.5
19-24	1.1	94.6
25-32	0.9	95.5
33	4.5	100.0

No documents are expected to exceed 1,000 pages. The average number of pages is 7.62; the distribution by physical size and number of pages is assumed to be the same for both the input material and the requested items.

Hard copy is to be provided to the user in response to his document request.

Two microform copies of all incoming file items* will be provided for external use (Records Center, NSA).

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*Certain items (e.g., Special, Internal use only collateral) are not supplied to NSA. For purposes of cost comparison, a simplifying assumption has been made that dual backup is required for all documents.

All manual unit record microform systems must provide a printed description (e.g., serial number), readable without special aids, as a permanent part (e.g., affixed or punched) of each unit-record used as the file copy. Examples of such identification are the printing at the top of an aperture card or microfiche.

In the system configurations postulated, where parallel processing stations are required (e.g., multiple file stations), it is assumed that the requests will be distributed among them in a uniformly random distribution.

6.6.4. RESULTS

6.6.4.1. Results of the Cost Analysis

The estimated costs for each of the candidates at each of the three operating situations are illustrated in Figures 6-3. The upper and lower cost bounds reflect the variance or precision of our elemental time and cost data for each candidate. The relative rankings by optimistic costs are given in Table 6-4. As mentioned earlier, (Section 6.6.2.), these are not the total costs to operate each system since the costs common to all systems have not been included.

6.6.4.2. Results of the Manpower Analysis

The estimated total manpower required for each of the candidates at the three operating situations is given

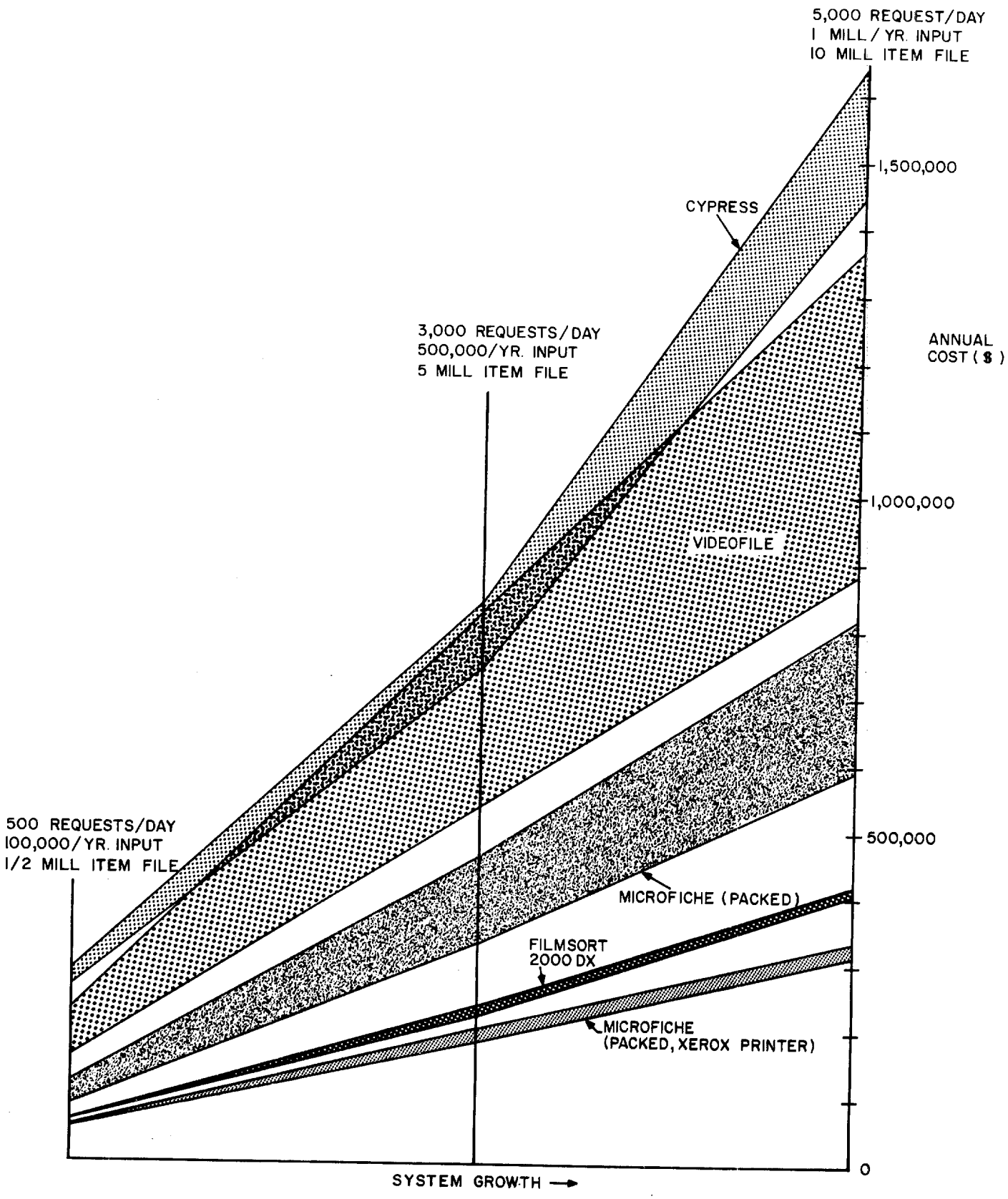

Figure 6-3

ANNUAL OPERATING COSTS OF FIVE OF THE CANDIDATE SYSTEMS

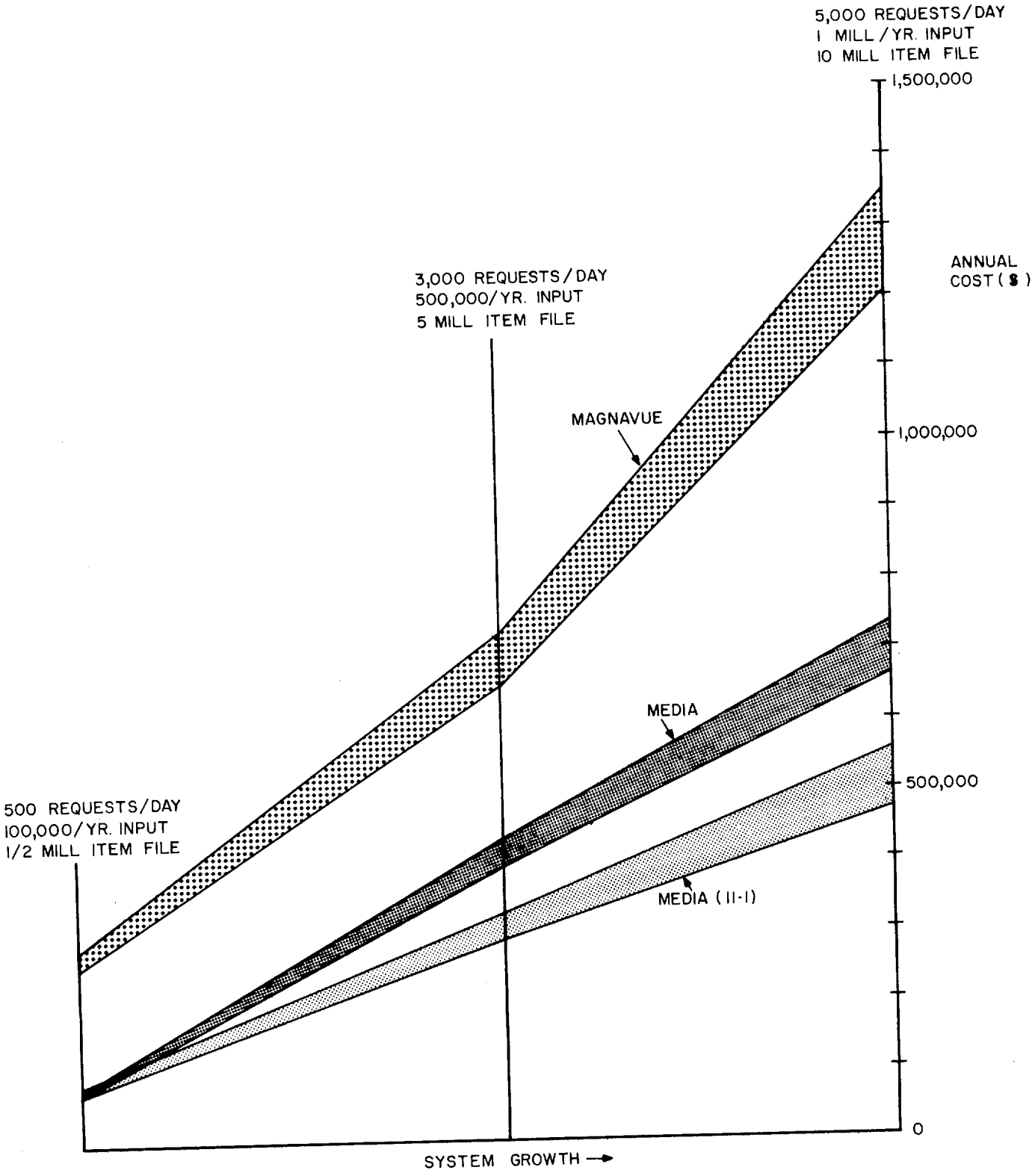

Fig. 6-3 (cont'd)
ANNUAL OPERATING COSTS OF TWO OF THE CANDIDATE SYSTEMS

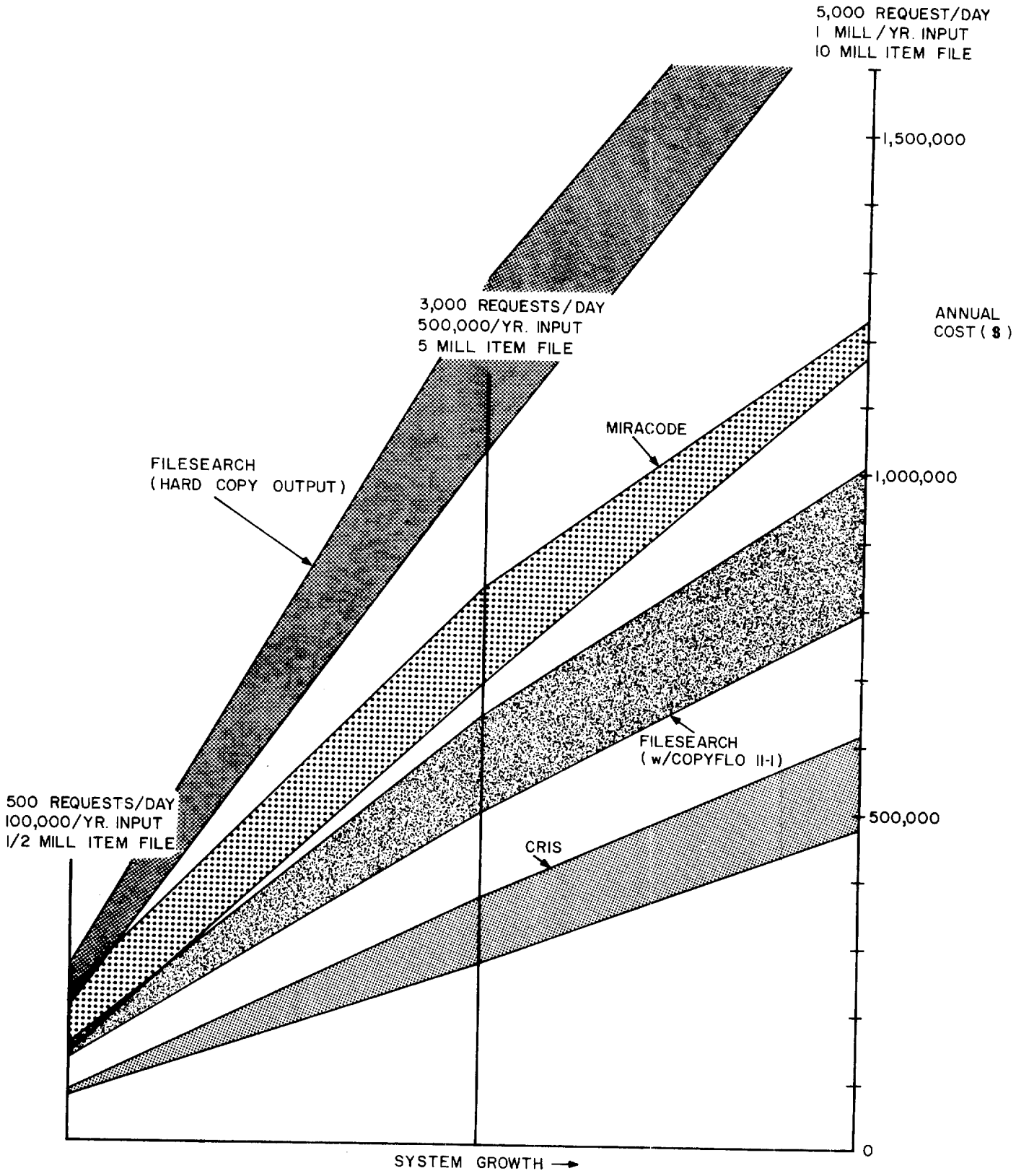

Fig. 6-3 (cont.'d)

ANNUAL OPERATING COSTS OF FOUR OF THE CANDIDATE SYSTEMS

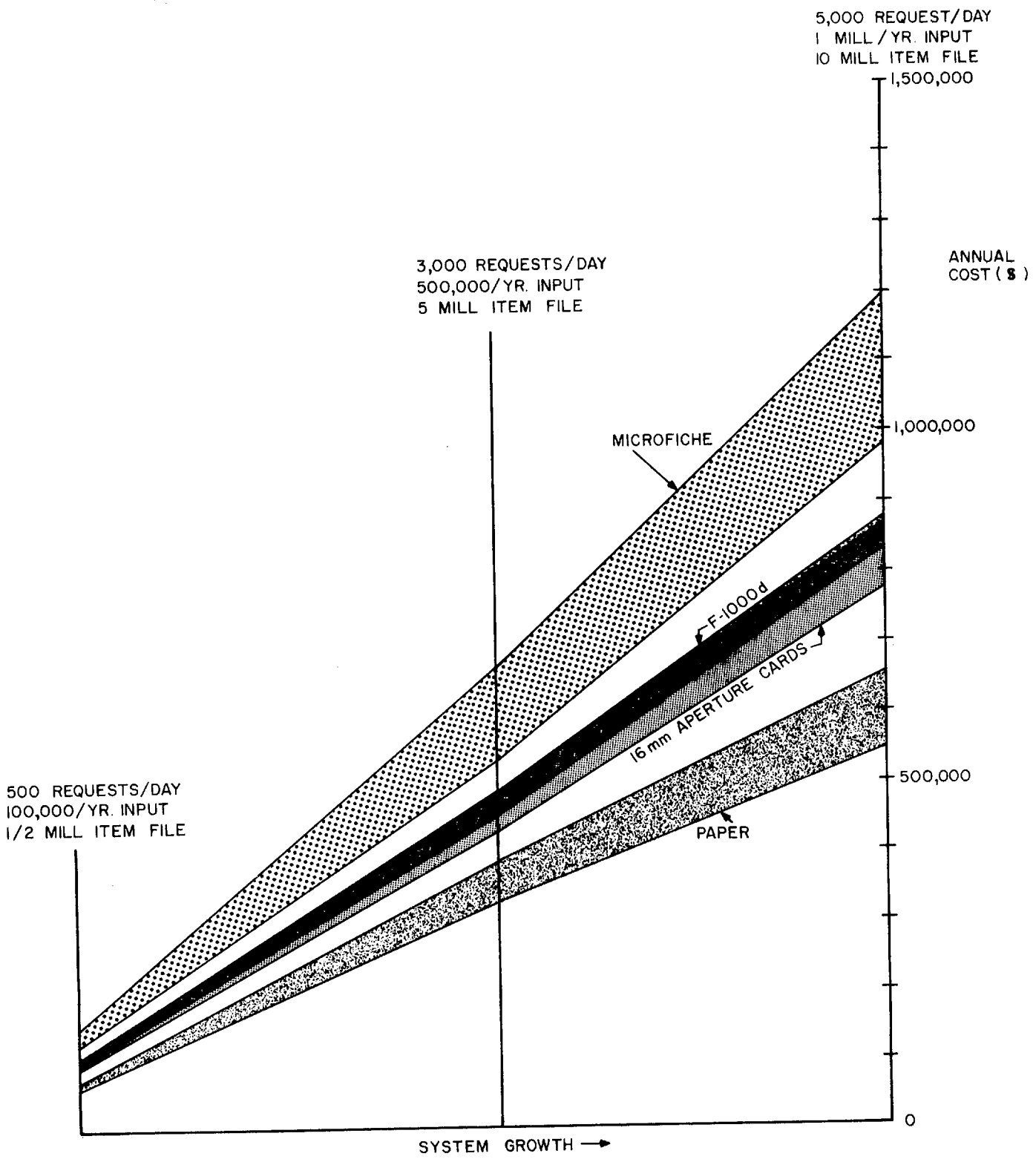

Fig. 6-3 (cont'd)

ANNUAL OPERATING COSTS OF FOUR OF THE CANDIDATE SYSTEMS

in Table 6-5. As with the cost analysis, the manpower required to perform the functions common to all candidates has not been included.

6.6.4.3. Results of the Space Analysis

The estimated total space required for each of the candidates at the three operating situations is given in Table 6-6. As with the cost analysis, the space required to perform the functions common to all candidates has not been included.

6.6.4.4. Results of the Analysis of Response Times

The results of the analysis of the several systems chosen for computer simulation indicated that except for a few marginal cases, all of the systems tested met the original specifications for the speed of response to requests for hard copy output in the query mode for both the initial and the total system. Because of the similarity of the remaining systems to the ones that were tested, it appears that essentially all of the systems would be able to provide the output response speeds required for the query mode in both the initial and the total systems. Furthermore, it appears that all of the systems will also be able to meet the requirements for input response times required for both the initial and total systems.

However, the simulation efforts indicated that none of the systems tested was able to meet the specification that all counter service requests must be serviced in 10 minutes or less in both the initial and final system. The various systems ranged from 0 to 91 percent for servicing counter requests in 10 minutes or less. A graphic presentation of the theoretical counter service response times for the various systems is included in Figures 6-4 and 6-5 in this report. In addition, a summary of simulation results for both counter service and query requests with a ranking by average response time is included as follows:

ANALYSIS OF CANDIDATES
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Figure 6-4

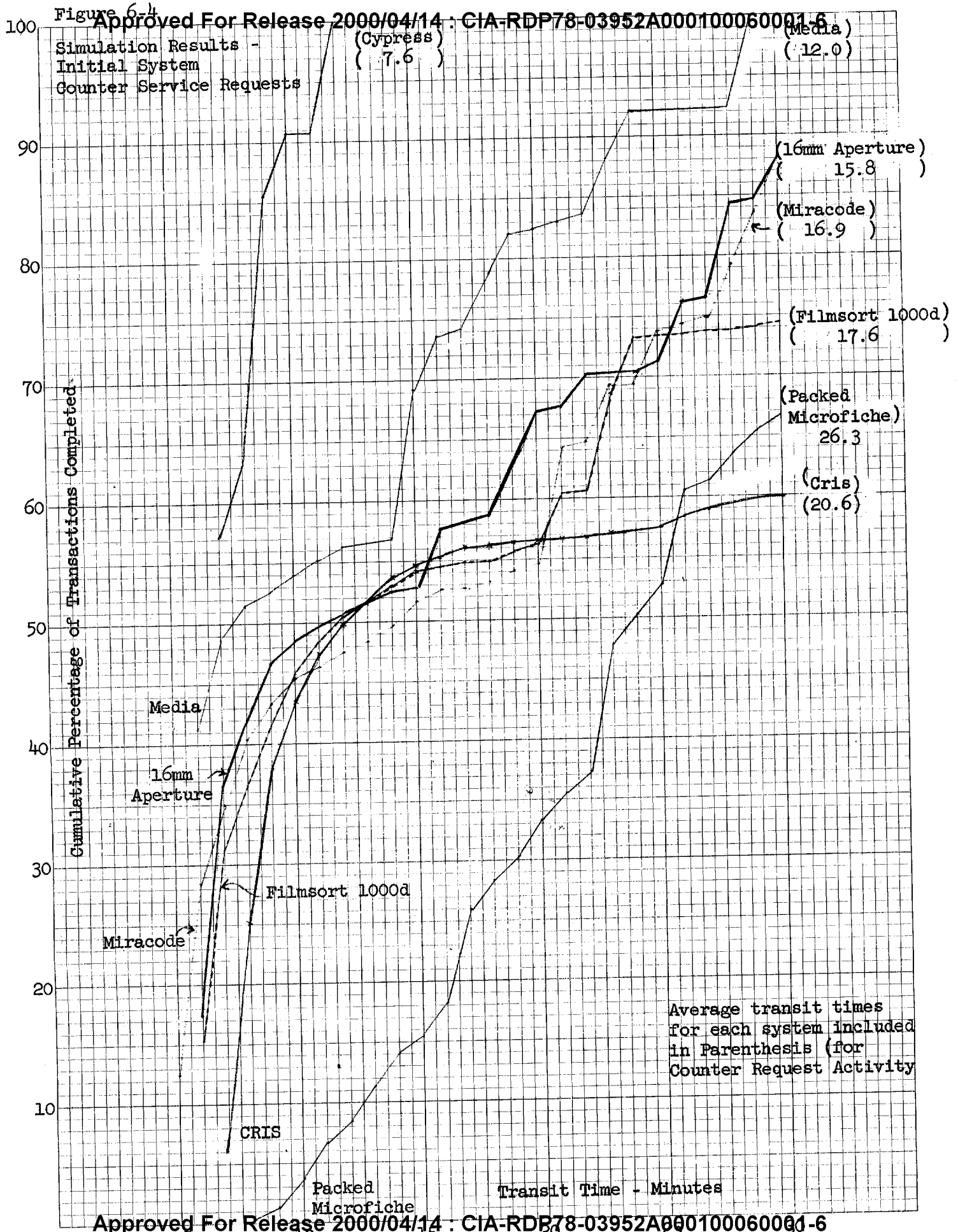

Figure 8-5

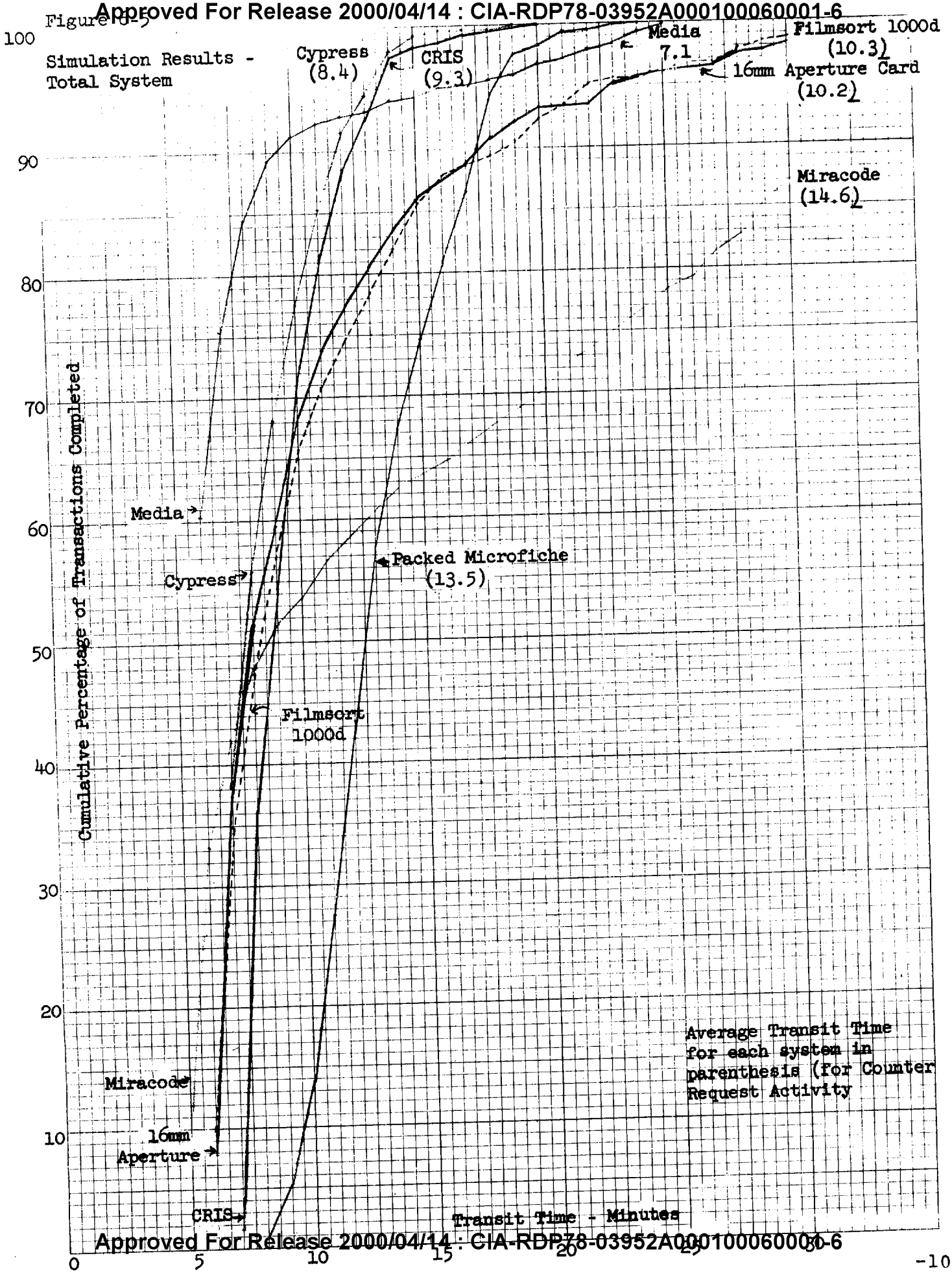

Table 6-7 Initial System - Counter Requests (including bursts)

6-8 Initial System - Query Requests (including Normal and Priority)

6-9 Total System - Counter Requests (including bursts)

6-10 Total System - Query Requests (including Normal and Priority)

6-11 Degree to which Simulated Systems meet the CHIVE Output Performance Specifications

More detailed information regarding the simulation efforts is given in Appendix 6.A.

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6.6.4.4.

TABLE 6-7

SIMULATION RESULTS - INITIAL SYSTEM

Transit Times - Counter Service Requests (inc. Bursts)

System	Average Thruput Time (min)	Thruput Time Distribution (by Percentage) Under 5 Minutes	Under 10 Minutes	Under 15 Minutes	Under 20 Minutes	Under 25 Minutes	Under 30 Minutes	Maximum Thruput Time (min)	Average Overflow time (min)
Cypress	7.6	0.0	90.7	100.0	-	-	-	12.0	-
MEDIA	12.0	0.0	54.0	69.2	82.4	92.1	100.0	29.0	-
16mm Aperture	15.8	0.0	48.4	52.8	67.1	72.3	88.3	-	34.5
Miracode	16.9	12.4	45.5	51.8	54.7	73.8	88.1	-	38.5
Filmsort 1000d	17.6	0.0	45.9	54.1	56.1	73.4	74.4	-	35.0
CRIS	20.6	0.0	43.5	54.6	56.5	57.5	59.9	-	36.5
Packed Microfiche	26.3	0.0	3.7	15.3	33.3	52.8	66.7	-	40.2
Magnavue	67.6	0.0	0.0	0.0	0.0	0.0	0.4	-	67.7

TABLE 6-8

SUMMARY OF SIMULATION RESULTS - INITIAL SYSTEM

Transit Times - Query Requests (inc. Priority)

System	Average Thruput Time (min)	Thruput Time Distribution (by Percentage) Under 20 Minutes	Under 40 Minutes	Under 60 Minutes	Under 80 Minutes	Under 100 Minutes	Under 120 Minutes	Maximum Thruput Time (min)	Average Overflow Time (min)
Cypress	5.9	100.0	-	-	-	-	-	10.0	-
MEDIA	7.1	97.4	100.0	-	-	-	-	40.0	-
Filmsort 1000d	11.8	85.2	98.8	100.0	-	-	-	60.0	-
16mm Aperture	11.8	83.9	97.3	99.9	100.0	-	-	80.0	-
Miracode	16.1	73.4	91.0	96.7	98.7	99.1	99.6	160.0	-
CRIS	22.7	53.7	86.5	96.4	99.8	100.0	-	100.0	-
Packed Microfiche	27.0	33.0	86.5	98.9	100.0	-	-	100.0	-
Magnavue	64.9	0.0	14.3	45.3	75.0	94.0	99.4	140.0	-

TABLE 6-9

SUMMARY OF SIMULATION RESULTS - TOTAL SYSTEM

Transit Times - Counter Service Requests (inc. Bursts)

System	Average Thruput Time (min)	Thruput Time Distribution (by Percentage) Under 5 Minutes	Under 10 Minutes	Under 15 Minutes	Under 20 Minutes	Under 25 Minutes	Under 30 Minutes	Maximum Thruput Time (min)	Average Overflow Time (min)
MEDIA	7.1	0.0	91.2	94.2	96.9	100.0	-	25.0	-
Cypress	8.4	0.0	77.6	99.1	100.0	-	-	19.0	-
CRIS	9.3	0.0	71.6	98.2	100.0	-	-	20.0	-
16mm Aperture	10.2	0.0	68.3	86.0	93.3	96.0	98.2	-	35.0
Filmsort 1000d	10.3	0.0	65.8	85.7	92.4	96.2	98.7	-	31.4
Packed Microfiche	13.5	0.0	13.8	74.6	98.1	100.0	-	24.0	-
Miracode	14.6	11.1	53.8	63.7	70.3	78.2	87.0	-	36.8
Magnavue	99.7	0.0	0.0	0.0	0.0	0.0	0.0	150.0	99.7

TABLE 6-10

SUMMARY OF SIMULATION RESULTS - TOTAL SYSTEM

Transit Times - Query Requests (inc. Priority)

System	Average Thruput Time (min)	Thruput Time Distribution (by Percentage) Under 20 Minutes	Under 40 Minutes	Under 60 Minutes	Under 80 Minutes	Under 100 Minutes	Under 120 Minutes	Maximum Thruput Time (min)	Average Overflow Time (min)
Media	7.4	98.2	100.0	-	-	-	-	40.0	-
Cypress	7.6	100.0	-	-	-	-	-	20.0	-
CRIS	13.5	85.0	98.9	100.0	-	-	-	50.0	-
Packed Microfiche	14.2	98.0	100.0	-	-	-	-	30.0	-
Filmsort 1000d	19.4	62.9	70.3	98.4	99.9	100.0	-	90.0	-
Miracode	22.0	66.3	85.0	91.8	95.4	97.5	98.5	180.0	-
16mm Aperture	22.7	55.8	83.1	96.1	100.0	-	-	80.0	-
Magnavue	104.8	0.0	0.0	0.0	3.2	54.3	69.8	170.0	-

TABLE 6-11

THE SIMULATED SYSTEMS
vs.
THE CHIVE OUTPUT PERFORMANCE SPECIFICATIONS

	Specifications %	Specifications min.	MEDIA %	MEDIA min.	Cypress %	Cypress min.
TOTAL SYSTEM						
QUERY MODE						
Priority (800)*	100	30	100	25	100	16
			Av. =	6.4	Av. =	6.9
Priority + Normal (4000)			90	20	90	10
			100	40	100	20
			Av. =	7.4	Av. =	7.6
COUNTER SERVICE						
All (800)	100	10	91.2	10	77.6	10
			100	25	100	19
			Av. =	7.1	Av. =	8.4
Bursts of 20 Requests (10 bursts)			90	20	90	14
			100	25	100	19
			Av. =	9.8	Av. =	11.6
INITIAL SYSTEM						
QUERY MODE						
Priority (80)	100	120	100	30	100	10
			Av. =	6.7	Av. =	5.9
Priority + Normal (400)			90	20		
			100	40	100	10
			Av. =	7.1	Av. =	5.9
COUNTER SERVICE						
All (80)	100	10	54	10	90.7	10
			100	29	100	12
			Av. =	12	Av. =	7.6
Bursts of 20 Requests (1 burst)			100	29	100	12
			Av. =	19.9	Av. =	9.5

*The numbers in parentheses are the number of requests per day that are to be processed in this mode.

CRIS %	CRIS min.	16-mm Aperture Card %	16-mm Aperture Card min.	Filmsort 1000d %	Filmsort 1000d min.	Miracode %	Miracode min.	Magnavue %	Magnavue min.
100	28	96.8	30	89.5	30	93.1	30	0	30
		100	60	100	60	100	89	100	170
Av. =	9.7	Av. =	11.5	Av. =	15	Av. =	12	Av. =	104.8
90	30	90	50	90	30	90	60	0	30
100	50	100	80	100	90	100	280	100	170
Av. =	13.5	Av. =	22.7	Av. =	19.4	Av. =	22	Av. =	104.8
71.6	10	68.3	10	65.8	10	53.7	10	0	10
100	20	98.2	30	98.7	30	87	30	100	150
		100	n.a.	100	n.a.	100	n.a.		
Av. =	9.3	Av. =	10.2	Av. =	10.3	Av. =	14.6	Av. =	99.7
90	14	90	27	90	22	46.9	30	0	30
100	17	100	n.a.	100	n.a.	100	n.a.	100	140
Av. =	11.3	Av. =	12.9	Av. =	12.3	Av. =	31.5	Av. =	100.9
100	50	100	42	100	59	100	82	100	140
Av. =	11.9	Av. =	9.1	Av. =	10.1	Av. =	11.1	Av. =	64.9
90	50	90	30	90	30	90	40	90	100
100	100	100	80	100	60	100	160	100	140
Av. =	22.7	Av. =	11.8	Av. =	11.8	Av. =	16.1	Av. =	64.9
43.5	10	48.4	10	45.9	10	45.5	10	0	10
100	n.a.	100	n.a.	100	n.a.	100	30	100	130
Av. =	20.6	Av. =	15.8	Av. =	17.6	Av. =	16.9	Av. =	67.6
0	30	72.7	30	40	30	77.8	30	0	30
100	n.a.	100	n.a.	100	n.a.	100	n.a.	100	130
Av. =	36.6	Av. =	26.2	Av. =	30	Av. =	28	Av. =	74.6

Note: n.a. = data not available.

6.6.4.5. Results of Analysis of Hard Copy Characteristics

Of the eleven candidate systems described in CHIVE/R-2-64 Interim Report, dated August 1964, six were available for some additional 'hands-on' testing. Those six were: Microfiche, MEDIA, Miracode, 16mm aperture card, CRIS, and Filmsort 1000d. Several of the systems were still in development (e.g., Videofile, Magnavue) and were not available for testing. However, it was felt that some of the results could be extrapolated to cover the systems not specifically tested.

The primary reason for this 'hands-on' testing was to observe the quality of the hard copy blowbacks produced by each of the units. It had been planned also to observe actual processing rates through various equipment units but this did not prove feasible because of the limited availability of most of the units and because of the artificial circumstances of processing an experimental batch of documents. The results of the comparison of the hard copy characteristics is included in Table 6-12. A narrative report on the testing effort is included in Appendix 6.C.

TABLE 6-12

CHARACTERISTICS OF HARD COPY OUTPUT

System	Overall User Ranking of Output Quality[1]	No. of Generations from Original
16-mm aperture cards with Photostat printer (present OCR system)	1[3]	2
Microfiche	2	2-3
Miracode	3	2
F-1000d with Xerox 24C Printer	4[3]	2-3
MEDIA with hard copy output	5	2
F-1000d with Quadrant Printer	6	2-3
Paper system	n.a.[4]	1
16-mm aperture cards with Quadrant printer	n.a.	2-3
MEDIA with Copyflo 11-1	n.a.	3
CRIS with Xerox 1824	n.a.	4
CRIS with Copyflo 24C	n.a.	4
Filesearch with hard copy output	n.a.	2
Filesearch with Copyflo 11-1	n.a.	3
Magnavue with Xerox 24C	n.a.	3
Cypress with Xerox 24C	n.a.	4
Videofile	n.a.	-

NOTES: n.a. = not available

1. Where ranges are given, the minimum value corresponds to the case where the master unit record is sent to the print station, the maximum value corresponds to the case where a throw-away film copy is sent to the print station.

2. These ratios assume 8½ by 14 in. pages, and represent figures for the specific configurations considered in this report. The ratios can probably be made any designated value from 0.5 - 1.0 for any system at little cost or developmental effort.

Output Size / Input Size	Maximum Reduction Ratio for Working File	Output Resolution (lines/mm)
0.66	16:1	6.16
0.6	18:1	8.30
0.75	27:1	4.66
0.93	24:1	n.a.
0.95	30:1	2.77
0.78	24:1	5.76
1.0	none	n.a.
0.66	16:1	n.a.
0.95	30:1	n.a.
0.71	29:1	n.a.
0.71	29:1	n.a.
0.57	24:1	n.a.
0.83	24:1	n.a.
0.96	25:1	n.a.
n.a.	44.5:1	n.a.
n.a.	-	n.a.

3. These systems were included only for the hard copy comparison. They are not discussed in any other sections of the report.

4. During the survey of document copy quality, test samples were processed through three paper duplicators (Xerox 914 Copier, Copytron 2000 and SCM 33 Electrostatic Copier). Although these were not included in the User Consensus Survey, the observed quality produced from all three units was at least as good as that produced by any of the six microfilm to hard copy systems included in the ranking.

6.6.4.6. Analysis of File Integrity

Although file integrity is a significant system parameter, it is a rather intangible concept which defies any valid quantitative measurement. Many of the elements which contribute to the 'integrity' of a file consist of design and procedural innovations imposed in an operational environment. Still there are those characteristics, inherent to the file media themselves, which provide the systems with a variable degree of adaptability to positive control of file items. Three such characteristics shall be suggested here as a basis for evaluating the various classes of systems. These are:

- the susceptibility of the system to loss or misfile
- the length of time an active item is 'out of file'
- and the amount of file effected by the removal of a single item.

These constitute qualitative as well as quantitative criteria in measuring file integrity and consequently an absolute, objective ranking of systems is not practical. In lieu of such a ranking, each of the classes of systems will be briefly discussed relative to the three measures of file integrity postulated above.

ANALYSIS OF CANDIDATES
Results
6.6.4.6.

6.6.4.6.1. Manual Systems

All of these systems as configured in this report are characterized by manual removal of a unit record from the file, processing in the file area (i.e., contact duplication or enlargement printing) and immediate refiling of the item. This is a design precaution imposed in an effort to reduce the probability of misfile as well as the amount of time out of file. Operation of these files in a batch mode would allow, in most cases, for centralized processing of requests on high speed equipment with a resultant cost reduction. All of these systems could be considered to have the same degree of inherent file integrity with the following qualifications.

- Aperture card systems (both 16mm and 35mm) have a slight advantage over other unit record systems in that they are machine processable, allowing for presorting of items before filing (at initial input) as well as mechanical sequence checking of the file (periodically).

- Although all systems can regularly furnish hard copy without requiring that the master record leave the custody of the main file area, the Packed Microfiche configuration described in this report calls for removal of the master record to a central enlargement processor prior to refile, rather than the remote production of a throwaway copy at the file for central processing. This interval to some degree. This is similar to current OCR proactice, however, and no resultant file integrity problem has been observed.

- In all systems except the Packed Microfiche the items are discretely separated so that removal of an item results in that item alone being out of file. With the Packed Microfiche system removal of a single fiche causes from 1-5 items to be out of file. Although this compares somewhat unfavorably with the other manual systems, it compares favorably with most of the semi-automatic and automatic systems in this regard.

6.6.4.6.2. Semi-automatic Systems

This class of file media is also characterized by manual fetch and store in response to request activity and consequently is vulnerable to misfile to a same degree. However, these systems involve substantially fewer physical units in storage (see Table 6-13) and occupy a more compact filing space than the manual systems. Presumably, the probability of loss or misfile of a cluster (scroll, roll, cartridge, capsule) of records would be reduced. Furthermore, three of these systems (CRIS, Filesearch and MIRACODE) utilize a continuous reel mode of storage thus eliminating the possibility of misplacement of an item within the cluster. MEDIA alone, among this class, utilizes discrete storage elements within the cluster (viz. cards within a capsule). Although individual cards may be removed from a capsule, there is no need to do so in normal processing and procedural safeguards could

TABLE 6-13

TOTAL NUMBER OF PHYSICALLY SEPARATE RECORDS STORED IN FINAL SYSTEM

System	Number of Physically Separate Records Stored in File of Final System
CRIS	237 scrolls
Videofile	294 rolls
Magnavue	4,350 magazines, (13,050,000 chips)
Filesearch	11,900 rolls
MIRACODE	26,300 magazines
Cypress	74,500 cells (2,380,000 chips)
MEDIA	137,000 magazines (27,390,000 chips)
Microfiche (packed)	2,700,000 cards
Microfiche (unit record)	10,000,000 cards
Paper File	10,000,000 documents, (76,200,000 pages)
16-mm Aperture Cards	12,930,000 cards
F-1000d	17,490,000 cards

NOTE: All of the systems can regularly furnish hard copy without requiring that the master record leave the custody of the main file area.

insure the same degree of invulnerability to loss as the other three members of this class.

For these systems, the time out of file is dependent on the mounting and searching time which in turn is a function of the size of the record cluster (i.e., the number of items to be searched). CRIS and Filesearch have larger, more cumbersome storage elements which require a longer mount and search time cycle. In fact, these systems are more suitable for batch processing with serial polling through file. CRIS has much more rapid average search time (17 seconds) than Filesearch (2.5 minutes), but the weight of the CRIS scroll cartridge (approximately 40 lbs) introduces an operator fatigue factor which makes random processing throughout the file completely impractical. (A similar problem exists for the Videofile system.) However, since these storage elements are either in file bins or mounted on-line on a search unit, they may be considered as not being out of file at all. MEDIA and MIRACODE are similar in the sense that they both utilize small, readily handled microfilm containers capable of being mounted and searched rapidly. For this reason, they are both amenable to a random mode of searching. The MIRACODE

system is designed around the concept of a single operator responsible for fetching and searching within a specific segment of the file. This operator pulls, mounts, searches and refiles cartridges which are stored in files located within reach. With this mode of operation the out-of-file time is virtually eliminated and the probability of misfiling is greatly reduced. The MEDIA system, as configured in this report, involves several clerks operating the storage bins and delivering the appropriate capsule to one of a group of search operators on a unit availability basis. This results in a slightly increased out-of-file interval caused by double handling and introduces the problem of identifying the search unit which is processing a particular out of file capsule. However, because of the rapid turnaround time achieved by the MEDIA system, it would appear that this out of file situation would not present a severe problem.

6.6.4.6.3. Automatic Systems

The Videofile system is somewhat analogous to the Filesearch system in terms of file integrity. It involves a large number of records per file element (viz. a reel of Videotape), manual mounting and filing, and relatively long reel search time. (The time required to search a

7200 foot reel of videotape is approximately 4.8 minutes.) Comments relating to the Filesearch system would apply equally to the Videofile system.

Magnavue and Cypress are quite similar to one another with regard to control of file items since both possess the following common design characteristics:

- All items are on line within a self-contained system containing an access mechanism which can be directed to any portion of the file.
- Automatic fetching and refiling of storage clusters (viz. magazine or cell) along with automatic selection of specific items within the cluster under computer control.

Both systems provide a high degree of file integrity by eliminating human intervention in the file manipulation process, by enclosing the total file within an on-line controlled environment, and by reducing the fetch, process, and refile cycle.

6.6.4.7. Results of Analysis of File Purging Capability

The various systems differ in the ease with which material can be permanently removed (purged) from their files. Some manual unit record systems (e.g., the paper or aperture card files) are purged very simply by locating the record in question and removing it from the files. No processing of the remaining items is required.

Purging of the roll microfilm systems is more difficult--requiring the locating, cutting, and splicing of film. Purging of other microforms which pack or assemble several items together on the same physical record is more difficult, and usually requires some re-processing of the remaining file items. An estimate of the relative ranking of the systems' ease of file purging is shown in Table 6-14.

6.6.4.8. Results of Analysis of System Reliability

Little definite data can be given at this time to describe the reliability expected for each system. However, a few generalizations with regard to the equipment can be made. First, it can be assumed that all units will be engineered to meet normal reliability standards for commercially available equipment. Secondly, few of them give any indication that the system availability would be severely hampered by a normal amount of down time for particular pieces of equipment. Thirdly, in addition to considering the 'mean-time-to-failure' as a measure of reliability, the 'mean-time-to-repair' is a another parameter for measuring reliability. Prior to procurement of any system, both of these measures should be demonstrated favorably by the equipment suppliers. It is possible that a vendor may have some difficulty

in providing the necessary parts and services for a particular unit. The previously cited instance of one of the CRIS scroll preparation units being inoperative for a two month period is an extreme example. The fourth generalization is that the less centralized the system, the more gracefully the total system performance degrades as one or more units becomes inoperative. The loss of a single MEDIA output station is less disruptive to total system output, for example, than the loss of one of the central processors on the Magnavue or Cypress systems. In several of the systems the output system is completely disabled if a particular piece of equipment is inoperative. This sensitivity to equipment failure can be reduced by the introduction of parallel equipment where appropriate. Table 6-15 lists the critical output units of each system, and shows the additional cost required to reduce this sensitivity to disabled equipment. This same type of analysis was not applied to the input equipment since the response time and availability demands are not as severe as for the output equipment.

ANALYSIS OF CANDIDATES
Results
6.6.4.8.

TABLE 6-15

SENSITIVITY OF SYSTEM PERFORMANCE TO LOSS OF CRITICAL OUTPUT UNITS

System	Most Critical Output Units	Degradation of System Performance Resulting from Loss of Any One of the Critical Output Units		Annual Cost to Provide a Spare Unit	Additional Annual Cost to Keep System from Being Completely Disabled by the Loss of Critical Output Units	
		Initial	Final		Initial	Final
Paper System	Copytron 2000	Completely disabled	1/8 to 1/10 loss in capacity	$ 1,255	$1,255	$
16-mm	Quadrant printer	1/2 loss in capacity	1/15 to 1/20 loss in capacity	559		
Filmsort 1000d	Quadrant printer	1/2 loss in capacity	1/14 to 1/16 loss in capacity	559		
Microfiche	Ektaline Processor, card developer		Completely disabled	4,422; 165		4,587
Microfiche	Enlarger, Ektaline processor, card developer	Completely disabled		18,000; 4422 165	22, 587	
MEDIA	Selector-Reproducer	1/3 loss in capacity	1/21 to 1/24 loss in capacity	7,580		
MEDIA (with Copyflo 11-1)	Paper cutter		1/2 loss in capacity	425		
MEDIA (with Copyflo 11-1)	Copyflo 11-1	Completely disabled		9,600	9,600	
Miracode	File Station	1/4 loss in capacity	1/32 loss in capacity	4,690		
CRIS (with Xerox 1824)	Xerox 1824		1/7 loss in capacity	3,300		
CRIS (with Xerox 1824)	Xerox 1824, CRIS viewers	Completely disabled		3,300; 7100	10,400	
CRIS (with Copyflo 24C)	Xerox 24C		1/2 loss in capacity	18,000		
CRIS (with Copyflo 24C)	Xerox 24C, CRIS viewers	Completely disabled		18,000; 7100	25,100	
Filesearch	Flexowriter	Completely disabled	Completely disabled	940	940	940
Filesearch (with Copyflo 11-1)	Flexowriter		Completely disabled	940		940
Filesearch (with Copyflo 11-1)	Flexowriter, Copyflo 11-1	Completely disabled		940; 9600	10,540	
Magnavue	Xerox 24C		1/2 loss in capacity	18,000		
Magnavue	Xerox 24C, 026 keypunch, Magnavue components	Completely disabled		18,000; 720; ?	18,720 +	
Cypress	Xerox 24C, Cypress output unit		1/2 loss in capacity	18,000; ?		
Cypress	Xerox 24C, 026 keypunch, Cypress components	Completely disabled		18,000; 720; ?	18,720 +	
Videofile	Printers	Completely disabled	1/2 loss in capacity	50,000 est.	50,000 est.	

Appendix 6.A.

COMPUTER SIMULATION OF CANDIDATE DOCUMENT DELIVERY SYSTEMS

The reason for employing simulation techniques in the document delivery system study is two-fold:

- to validate the equipment configurations postulated for cost comparison in Cost Analysis Section of the report and
- to measure the performance capability of each candidate configuration in its responsiveness to high volume reference activity.

The candidate systems, as originally configured, reflected an ability to cope with a given average daily input/output activity rate, whereas through simulation the use of random arrival rates and the added operating complication of transaction priority was introduced. Each system was defined in terms of a mathematical model and both normal and priority transactions were imposed randomly on the model. Input activity was not simulated since this is essentially a FIFO batch operation without priority

interrupt and the validity of the input processing configurations can be demonstrated by direct arithmetic calculation. Furthermore, camera processing rates for all systems are similar and simulation of one typical input configuration (MEDIA) indicated that the throughput time achieved was well within specified time requirements (CHIVE-W/17-64). Therefore, it was decided that simulation of the various input processes as a measure of relative system efficiency was not warranted.

Output activity is not only subject to more stringent timing restrictions but also involves multi-levels of priority with an implicity interrupt capability. Therefore, simulation was adopted as a necessary means of proving the soundness of the configurations of people and equipment postulated. It also served as a means of quantitatively rating the response performance of the various systems.

COMPUTER SIMULATION
Basic Model Descriptions
6.A.

6.A.1. BASIC MODEL DESCRIPTIONS

Each system was evaluated for request responsiveness at two discrete levels of system evolution. These two points were chosen as bench marks for purposes of comparison and were referred to throughout the report as the Initial System and the Final System, described generally as follows:

	Initial	Final
File Size (items)	500,000	10,000,000
New items per year	100,000	1,000,000
Doc. Requests per day	500	5,000

The document requests were classified according to type as follows:

(a) Query Mode Requests - Demands on the document store as a result of normal subjective search of the computer index. Within this class of transaction there were two levels of responsiveness:

(1) Normal - lowest level of urgency, processed on a first-in-first-out basis

(2) Priority - next highest level of urgency taking precedence over Normal

Query Mode Requests only.

(b) Counter Service Requests - demands on the document store imposed by an individual directly identifying the specific document(s) required. This class had the highest urgency and the most stringent response requirements and therefore preempted all other transaction types in demanding processing facilities.

Counter Service Requests were subclassified as:

Single Requests - a top priority request for an individual document

Burst Mode Requests - for purposes of evaluating the ability of the various systems to respond to a sudden influx of high priority transactions, demands for a batch of documents (arbitrarily set at 20 documents per batch) were imposed at random intervals on the models. Throughput time for each batch demand (burst) was measured from initiation of the request until retrieval and delivery of the entire 20 documents.

6.A.2. TRANSACTION VOLUME

The following transaction volumes were imposed on all systems. Since the transactions are randomly generated within the simulator, slight variances in total transactions may occur between systems.

	Initial System	Final System
Query Mode Requests		
Normal	320 items/day	3000 items/day
Priority	80 "	1000 "
Counter Service Requests		
Single Requests	60 "	800 "
Burst Requests (2@20) =	40 "	(10@20)=200 "
Total	500 items/day	5000 items/day

6.A.3. SCALING

In certain cases, subsets of the total configurations were simulated with a proportional reduction in the number of transactions. This technique was employed in some cases to prevent the model from exceeding computer storage capacity and in some cases to prevent excessive processing time.

The scale down configurations are described for those systems where scaling has been utilized.

6.A.4. TIMING CONVENTIONS

The processing rates for both manual and mechanical operations are stated in the section entitled Simulation Assumption for each system within this Appendix. In general, these quantities reflect either observed times or rates furnished by equipment suppliers. In addition to these times, each system was taxed to reflect less identifiable or measurable time delays in process. In order to approximate more realistic throughput times, the following standard delay times were adopted as conventions and applied to all systems:

(a) Pre-processing time - receipt, logging, sorting and miscellaneous clerical handling operations required before being ready for processing - 1 minute.

COMPUTER SIMULATION
Timing Conventions
6.A.4.

(b) Inter-station transit time - the indefinable interval of time required to move a transaction from one discrete processing station to another--here arbitrarily assumed to be 1 minute for each such transition between processing locations.

(c) Post-processing time - logging, stapling, bundling and miscellaneous clerical operations subsequent to reproduction of the hard copy and preparatory to distribution of the requested document - 3 minutes.

The basic time unit used in describing all of the system models is one second. Activity for each system has been limited to a duration of five days of simulated single shift operation (i.e., 40 hours).

6.A.5. PAGE DISTRIBUTION FUNCTION

The following distribution of pages per document[28/] has been assumed and the number of pages is randomly

COMPUTER SIMULATION
Page Distribution Function
6.A.5.

assigned each document by the simulator according to this function:

Pages/Document	Cumulative Percentage of Total Documents
1	46.5
2	66.2
3	76.0
4	79.8
5	83.0
6	84.9
7	86.1
8	87.2
9	88.5
10	89.4
11	90.3
12	90.9
13-18	93.5
19-24	94.6
25-32	95.5
33-100*	100.0

6.A.6. SIMPLIFYING ASSUMPTIONS

Perhaps it is a truism to say that there is some variance between any simulation and the real world it represents. Certain simplifying assumptions must

* An arbitrary upper limit of 100 pages/document has been adopted for simulation as a practical measure.

be made in defining a mathematical microcosm of a dynamic situation. When the situation simulated is projected into the future based on currently known facts, the model becomes even more hypothetical. The systems models described in this appendix are of this nature and a number of assumptions were necessary. The primary purpose of the simulation was to compare the various systems. The validity of the models does not depend necessarily on the accuracy of any individual assumption since all systems were subjected to the same general assumptions consistently throughout. Some of the simplifying assumptions, constituting variances between the model and reality, are indicated below.

A cutoff point of 100 pages per document was arbitrarily set in estimating the page size distribution, although some documents observed exceeded this limit (less than 1%).

COMPUTER SIMULATION
Simplifying Assumptions
6.A.6.

Output processes alone were simulated with the result that no sharing of staff and equipment between input and output processing was imposed. There would no doubt be some degrading of system performance by conflicting demands on facilities created by filing and reference activities.

Scaled down systems do not have as much flexibility and productivity as actual full systems. For instance, a transaction from one facility may be forced to go to a specific second facility in a fractional system, whereas in a complete model a transaction could go to one of several facilities operating in parallel on a first availability basis.

The fixed time delays discussed previously are imposed to reflect the recognized variation in delay caused by the number of functional steps involved in each process. The extent of the time delay caused by transfer between processing stations

is highly speculative but the assumed quantities have been applied throughout.

Simplified algebraic expressions have been created to approximate certain time functions.

6.A.7. SCOPE OF SIMULATION

Because of time constraints and because of the fact that similarities of equipment and procedure do exist between certain systems, not all of the candidates were simulated. Those systems for which models were built are:

- 16mm aperture card
- Filmsort 1000d
- Packed microfiche (with Microcard EL-3 Enlarger)
- MEDIA
- MIRACODE
- CRIS (with Xerox 1824)
- Magnavise (with Xerox 24 C)
- Cypress

The specific assumptions made in defining the models of each of the eight systems simulated are described in the following sections.

COMPUTER SIMULATION
Scope of Simulation
6.A.7.

6.A.8. SYSTEM DESCRIPTIONS

6.A.8.1 16 mm Aperture Card

The 16 mm Aperture Cards are filed in motorized card files with a modified Filmsort Uniprinter 086 at each file. File clerks are allocated to a specific group of files where they select requested aperture card master documents, prepare expendable duplicate aperture cards, which in turn are used for hard copy enlargement on 3M Quadrant Printers. Master apertures are refiled immediately after they have been duplicated. Each clerk provides the appropriate priority in selection of transactions. Conceptually, it is assumed that a queue of transactions will accumulate for each file and that the clerk will operate on a sequential polling basis among file units thereby minimizing mobility among the assigned section of the file. In the event of a Counter Service Request the clerk will interrupt normal polling and directly access the counter

requests. Normal and Priority Requests will have essentially the same processing with Priority Requests given token preferential handling within a given file queue. The conventional priorities are observed at the Quadrant Printers for all transactions.

6.A.8.1.1. Timing Assumptions

Fixed Time Delays

- Pre-Processing Time (all requests) -- 1 minute
- Inter-station Transit Delay -- (Between motorized file station and hard copy printer stations) -- 1 minuts
- Post-Processing Time (all requests) -- 3 minutes

Operating Times

- File Clerks
  - to select and refile aperture card(s) -- 18 sec (per item)
  - to make duplicate aperture card(s) -- 12 sec (per card)

COMPUTER SIMULATION
Timing Assumptions
6.A.8.1.1.

- Hard copy printers

  - to produce enlarged copy from aperture cards -- 12 sec (per page)

6.A.8.1.2. Configuration

Final System

- Complete

File clerks	8
Motorized Files (with 086 uniprinters)	30
Quadrant Printers (and operators)	15

- Scaled Down System (scaling factor = 1/8)

File clerks	1
File units	4
Printers	2

(Volumes reduced proportionally)

Initial System

- Complete

File Clerks	1
Motorized Files (with 086 uniprinters)	2

COMPUTER SIMULATION
Configuration
6.A.8.1.2.

Quadrant Printers (and Operators) 2

Scaled Down System

- No scaling

6.A.8.1.3. Page Packing Factor

The 16mm Aperture Cards are available in either 1,2,3, or 4 apertures with the ability to store two pages per aperture. For simulation purposes it is assumed that an additional aperture card is required each time the page length exceeds a multiple of eight, (e.g., a 17 page document would require 3 aperture cards).

6.A.8.2. Filmsort 1000d -- (35mm Aperture Card File)

Mode of operation is identical to 16mm Aperture Card

6.A.8.2.1. Timing Assumptions

Fixed Time Delays

- Pre-processing Time (all requests) -- 1 minute

COMPUTER SIMULATION
Page Packing Factor
6.A.8.1.3.

- Inter Station Transit Delay -- (between motorized file station and hard copy printer stations) -- 1 minute

- Post-Processing Time (all requests) -- 3 minutes

Operating Times

File clerks

- to select and refile aperture card(s) - 18 sec/per item

- to make duplicate aperture card(s) - 12 sec/per card

Hard Copy Printers

- to produce enlarged hard copy from aperture cards -- 12 sec/per page

6.A.8.2.2. Configuration

Final System

- Complete

File clerks	9
Motorized Card Files (and copiers)	40
Quadrant Printers (and operators)	16

- Scaled Down System (Scaling factor = 1/8)

COMPUTER SIMULATION
Configuration
6.A.8.2.2.

File clerks	1
Motorized Card Files (and copiers)	5
Quadrant Printers (and operators)	2

(Volumes reduced proportionally)

Initial System

- Complete

File clerks	1
Motorized Card Files (and Copiers)	2
Quadrant Printers (and operators)	2

- Scaled Down System

No scaling

6.A.8.2.3. Page Packing Factor

The 35mm Aperture Cards can contain up to four page images[1/] per card. For simulation purposes

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1/Simulation was conducted prior to announcement of the Filmsort 2000dx which enables eight page images to be recorded in each aperture card.

COMPUTER SIMULATION
Page Packing Factor
6.A.8.2.3.

the assumption has been made that an additional aperture card would be required each time the page length exceeds a multiple of four (e.g., a 17 page document would require 5 aperture cards).

6.A.8.3. Packed Microfiche

This system utilizes a standard 4" x 6" microfiche (actually 105mm x 148mm) with multiple items recorded on each microfiche. Each item will begin a new line and the left-most frame on each line will be used to record an eye-visible item serial number. All six lines will be used with each line capable of storing up to ten 8½ x 11" pages or five 8½ x 14" pages. Documents exceeding these limits will overflow onto additional lines as necessary. Microfiche are inserted into paper jackets which are filed in motorized rotary card files. To fulfill requests, appropriate jackets are manually pulled and sent to a step-and-repeat enlarger where hard copy is recorded on roll silver

COMPUTER SIMULATION
Packed Microfiche
6.A.8.3.

paper which in turn is developed and cut for delivery to the requestor. Priority regulations are observed by the file clerks in pulling randomly from the files according to the three conventional priority levels. Once the items are processed through the enlarger station various priority transactions are intermingled on the output paper rolls which are handled thereafter on a FIFO basis.

Timing Assumptions

- Fixed Time Delays

Pre-processing time	1 minute
Interstation delay (between file and enlarger)	1 minute
Interstation delay (between enlarger and developer)	1 minute
Interstation delay (between developer and cutter)	1 minute
Post-processing time	3 minutes

COMPUTER SIMULATION
Packed Microfiche
6.A.8.3.

- Operating Times

File and refile micro-fiche jackets	12 sec/item
Enlarger printing (2000-3000 pages/hour)	1.5 sec/page*
Developer (200 ft/min at 75 percent derating and assuming 6.7 lineal inches/ page resulting in 270 pages/minute)	.22 sec/page
Cutter (36,000 pages/day or 75 pages/min derated 75 percent to approximately 56 pages/min)	.9 sec/page

Configurations

- Final System

Complete

File Clerks	3	(each clerk assigned to two files)
Motorized Card Files	6	
Enlarger (Microcard Corp EL-3)	2	
Ektaline Processor (Recordak)	1	

* This rate is equivalent to 2400 pages per hour

COMPUTER SIMULATION
Packed Microfiche
6.A.8.3.

Recordak 12K Cutter 2

Scaled Down System

No Scaling

- Initial System

Complete

File Clerk	1
Motorized Card File	1
Enlarger (Microcard Corp. EL-3)	1
Ektaline Processor (Recordak)	1
Recordak 12K Cutter	1

Scaled Down System

No Scaling

Page Packing Factor

Pages are recorded on the microfiche as described in Section A. Enlarged replicas of the page images are enlarged onto 100 foot rolls of silver paper. It is assumed that up to 180 pages can be accumulated on each 100 foot roll.

COMPUTER SIMULATION
Packed Microfiche
6.A.8.3.

6.A.8.4. Media

The MEDIA system utilizes film chips contained in capsules which are stored in a manually operated file. Requests are processed first by file clerks who pull the appropriate capsule and deliver it to a manned Selector-Reproducer unit. The operator inserts the capsule and keys in the item number, triggering a serial scan of the chips until the requested item is located and hard copy is produced. Access to the manual file is considered random for the file clerks who are operating, at large, over the total file. Priority is provided by the file clerk's selection of the next transaction with the Counter Service, Priority Queries and Normal Queries in that order of priority. Clerks distribute the selected capsules to the selectors based on the earliest availability of the Selector-Reproducer Units.

COMPUTER SIMULATION
Media
6.A.8.4.

Timing Assumptions

- Fixed Time Delays

  Pre-processing time (all requests) -- 1 minute

  Post-Processing time (all requests) -- 3 minutes

- Operating Times

  File clerks - to select and refile capsules -- 30 sec

  Selector Reproducer operator

Insert capsule into feed station	2 sec
Key in 2 digits and scan 200 cards	13 sec
Print output copy - 16 sec for 1st page per clip plus 7 sec for subsequent page	
Rewind and extract capsule from feed station	8 sec

Configurations

Final System

Complete

File Clerks	6

COMPUTER SIMULATION
Media
6.A.8.4.

Selector Reproducers (and operators) 21

Scaled Down System (Scaling factor = 1/3)

File clerks 2

Selector Reproducer 7

(Volumes reduced proportionally)

Initial System

Complete

File Clerks 1

Selector Reproducers (and operators) 3

Scaled Down System

No Scaling

Page Packing Factor

A Media chip can store up to two 8½" x 14" images at a 30:1 reduction ratio. For this simulation it is assumed that all documents will be stored in this format of two pages per chip. (Appendix H., Item #1)

COMPUTER SIMULATION
Media
6.A.8.4.

6.A.8.5. Miracode

The MIRACODE System utilizes 16mm reel film for storage of document images. Each document is locatable by a photo-optically recorded, binary representation of a unique identification number adjacent to it on the reel. The appropriate cartridge loaded roll of film is selected by an operator who inserts the cartridge into the Recordak Reader-Printer and keys in the requested item number. The Reader-Printer scans the reel to locate the requested item and a hard copy is produced on line. Each search unit and operator are allocated to a certain portion of the file. All request activity is considered to be randomly distributed over the total file. Retrieval is considered to be random within file station with priority provided by the operator's selection of transactions, observing the usual order of priority.

Timing Assumptions

COMPUTER SIMULATION
Miracode
6.A.8.5.

- Fixed Time Delays

  Pre-Processing time (all requests) -- 1 minute

  Post-processing time (all requests) -- 3 minutes

- Operating Times

  Locate, insert cartridge; rewind reel and refile cartridge -- 10 seconds

  Key in 9 digit request number -- 10 seconds

  Scan reel of film and locate item 5 $\pm$ 5 seconds

  Print out first page -- 28 seconds

  Print subsequent pages (each) -- 17 seconds

The above time units have been consolidated in the expression:

$$T = 36 + 5 + 17\ P$$

where: T = total time per item, and

p = number of pages per item

COMPUTER SIMULATION
Miracode
6.A.8.5.

- Configurations

Final System

Complete

Retrieval Stations (Lodestar Reader-Printers)	32
Station Operators	32

Scaled Down System

No scaling

Initial System

Completed

Retrieval Stations (Lodestar Reader-Printers)	4
Station Operators	4

Scaled Down System

No scaling

- Page Packing Factor

The assumption has been made that each 100 foot reel of film will contain approximately 380 items and their corresponding coded numbers. It is

COMPUTER SIMULATION
Miracode
6.A.8.5.

further assumed that no item will overflow onto an additional reel of film (i.e., no more than one cartridge access per item requested).

6.A.8.6. Cris

The basic retrieval unit for the CRIS system consists of a desk sized console containing the cartridge insertion and scroll positioning mechanism, projection and display system, the key board entry unit, a contact printer for aperture cards, and general control circuitry. The medium of storage is a cartridge loaded 400 foot scroll, 17 inches in width. Location of the requested document image is performed by a rapid scan of the scroll initiated by keyboard entry of an access number. The unit is capable of locating a subframe (i.e., a two-page cluster) within the scroll which contains 28,160 frames containing up to 12 legal size pages each.

COMPUTER SIMULATION
Cris
6.A.8.6.

For simulation purposes, a batching mode of operation is assumed because of the impracticability of a completely random mode requiring continual changing of a 44 pound scroll cartridge. It is assumed that each viewing station is allocated to its own library of scrolls. Requests are distributed among the stations accordingly. The viewer operator normally processes the accumulated backlog for each scroll, polling successively through the assigned set of scrolls. At the completion of processing for each scroll the operator checks for any Counter Request activity. If any exists, he loads the appropriate scroll and retrieves the requested items, polling in reverse through the scrolls until all pending Counter Request transactions have been processed. Normal request searching is then resumed, accessing randomly within scroll with Priority Query taking precedence over Normal Requests.

COMPUTER SIMULATION
Cris
6.A.8.6.

Timing Assumptions

- Fixed Time Delays

  Pre-processing time -- 1 minute

  Inter-station delay (between viewing station and printer) -- 1 minute

  Post-processing time -- 3 minutes

- Operating Times

  Scroll change time (include rewind and removal of prior scroll and insertion of new scroll -- 1 minute

  Keyboard entry of access number -- 5 seconds

  Scroll search time -- 17 $\pm$ 17 seconds

  Contact print to aperture card - 8 seconds per card

  These times (i.e., line 2 through line four are consolidated in the expression:

  $T = 22 \pm 17 + 8C$

  where T = time to locate and

  output an item within a mounted

  scroll

COMPUTER SIMULATION
Cris
6.A.8.6.

C = the number of aperture cards required to record all the pages of an item (with a 12 pages upper limit per card)

Xerox 1824 printer - 40 sec. for each 18" x 24" sheet containing up to 12 pages.

Configuration

Final System

Complete

Scrolls	240
CRIS viewers	10 (i.e., 24 scrolls each)
Xerox 1824 printers	10

Scaled Down System (Scaling factor = 1/10)

Scrolls	24
CRIS viewers	1
Xerox 1824 printers	1

Initial System

COMPUTER SIMULATION
Cris
6.A.8.6.

Complete

Scrolls	13
CRIS viewers	1
Xerox 1824 printers	1

Scaled Down System

No scaling

Page Packing Factor

It is assumed that each frame on the scroll can contain up to 12 page images and that the complete frame will be contact printed onto the output aperture card and in turn printed out on the 18" x 24" hard copy. For documents less than 12 pages in length a single contact print to the same aperture card and a single sheet of paper are assumed. For those documents in excess of 12 pages the system is assessed for an additional contact print (at 8 sec each) and an additional hard copy print (at 40 sec each) each time the page length exceeds a multiple of 12.

COMPUTER SIMULATION
Cris
6.A.8.6.

6.A.8.7. Magnavue

The Magnavue system is an automatic document image retrieval system consisting of one or more rapid access files, a transport unit and a contact copy station, all under control of a data processor. Micro images are stored on 1 1/3" x 3" Mylar cards along with digital data coded in either magnetic or photo-optical form. The Magnavue cards are, in turn, stored in magazines which may be accessed directly under control of the data processor and inserted in the card handler (transport unit) where a rapid scan selects the indicated card, moving it to an output station where a contact print of the image is made onto roll microfilm. Resultant film is removed in short strips, processed, and converted to hard copy on the Xerox 24C Printer. The digital data identifying those cards which are to be selected from the file is entered through the

data processor, and is assumed to be a by-product of the computer indexing system for subjective queries and to be read in from key-punched cards for counter service requests.

Priority rules governing transaction flow have been specified as follows:

- Key Punch (Counter Request only) - FIFO
- Magnavue Image Retrieval System - sequential, batch mode polling through magazines by each transport unit operating independently within its associated file units with interrupt and direct access of magazines for Counter Service Requests. Priority Queries and Normal Queries are treated interchangeably on a FIFO basis within each cartridge.
- Processor - all 20 foot rolls of film are processed on a FIFO basis.
- Xerox 24C Printer - all 20 foot rolls of film are handled on a FIFO basis.

Timing Assumptions

Fixed Time Delays

Counter Service Requests

Pre-processing time 1 minute

COMPUTER SIMULATION
Magnavue
6.A.8.7.

Inter-station delay (between key punch and Image File) 1 minute

Inter-station delay (between Image File and Processor) 1 minute

Inter-station delay (between Processor and Printer) 1 minute

Post-processing time 3 minutes

Queries

Pre-processing time 1.5 minutes

Inter-station delay (between Image File and Processor) 1 minute

Inter-station delay (between Processor and Printer) 1 minute

Post-processing time 3 minutes

Operating Times

Key punching rate - 8,000 keystrokes/hr (15 characters/request = 7 sec/request card)

Image File Unit

Extract and insert magazine 3.4 sec/magazine

COMPUTER SIMULATION
Magnavue
6.A.8.7.

Scan cards (@ 60 cards/sec)
25 ± 25 sec/magazine*

Refile cards (@ 90 cards/sec)
16.5 ± 16.5 sec/magazine*

Contact copy to roll film
.6 sec/frame (up 8 pg/frame)

Processor (developed at the rate of 400 ft/hr. Therefore, time to develop 20 ft. equals 2.4 minutes plus one minute for setup time = 3.4 minutes/roll

Xerox 24C Printer (@ 10 cards/min) = 6 sec/frame

Configuration

- Final System

Complete

Keypunch - 1 unit

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* The time to scan and refile cards is dependent on the location of the selected card within the magazine. The maximum scan time is 50 seconds and the maximum refile time is 33 seconds. Within the model a random number between 1 and 83 (the sum of the two times) is generated to represent the combined times.

COMPUTER SIMULATION
Magnavue
6.A.8.7.

Image Files System - four independently operating subsystems each containing approximately one quarter of the file. Each subsystem is configured as follows:

	Subsystem Units	Total System Units
Control Unit (computer)	1	4
Vacuum system	1	4
Transport units (card handlers)	2	8
Output copy station	2	8
File station	4	15**
Processor (Film Developer)	1 unit	
Xerox 24C Printer	2 units	

Scaled Down System (Scaling Factor = 1/8)

One card handling transport unit with 2 files and one output copy station, assuming no retardation of operation caused by sharing the same control unit with another like complex of files, copy station and transport unit.

** One of the four subsystems would include only three File Stations

COMPUTER SIMULATION
Magnavue
6.A.8.7.

- Initial System

Complete

Keypunch	1 unit
Image File System - one self-contained system composed of the following:	
Control Unit (computer)	1
Vacuum System	1
Transport Unit (card handler)	1
Output copy station	1
File Station	1

Scaled Down System

No scaling

Page Packing Factor

It is assumed that up to eight page images are recorded on each card within the system. For items less than 8 pages in length a single discrete card is used for storage. Additional cards are required to store items of more than 8 pages with an

additional card necessary each time the page length exceeds a multiple of eight. The Image File system is assessed 0.6 second for each card which must be contacted printed and 6.0 seconds for each additional microfilm frame. Each 20 ft. roll of film can accommodate up to 130 contact prints (frames). A roll is assembled at each output copy station and processed through the Film Developer and the Printer conceptually as a block of transactions.

6.A.8.8. Cypress

The Cypress system consists of one or more files under the stored program control of a Module Controller servicing an Image Input/Output Converter. Document page images are stored on diazo coated chips which are contained in plastic moulded cells. Cells are pneumatically shunted between the files and the I/O Converter where the

appropriate chips are directly accessed and images may be selectively projected onto output aperture cards. Aperture cards, in turn, are used to prepare hard copy on the Copyflo 24C Printer. Requests on the system are read in from punched cards which are key punched for Counter Service requests and prepared as a by-product from the computer indexing system for subjective queries.

- Priority rules incorporated in the computer model are as follows:

  Key Punch -- (Counter Request only) - FIFO

  Image File Unit(s) - normal priority of

  Counter Service

  Priority Query, and

  Normal Query (FIFO within priority) at each I/O Converter.

  Copyflo Printer - (Final System) - one printer assigned to Counter Service and Priority Queries on a FIFO basis; the second printer assigned to all Normal Queries on a FIFO basis

COMPUTER SIMULATION
Cypress
6.A.8.8.

Timing Assumptions

- Fixed Time Delays

Counter Service Requests

Pre-processing time	1 minute
Inter station delay (between key punch and Image File)	1 minute
Inter station delay (between Image File and Printer)	1 minute
Post Processing Time	3 minutes

Operating Times

- Key punching rate - 8000 keystrokes/hr (15 characters/request = 7 sec/request card)

- Image File Unit

The throughput rate of the Projection Output Unit is a function of the punch, print, expose, develop cycles. All of these functions are constant for each output card except for the expose operation which may vary from one to eight cycles per card. The range of throughput time varies between 450 cards/hr (8 sec. each) for cards having 8 exposures to a maximum rate of 1000 cards/hr (3.6 sec each) for cards having one exposure.

COMPUTER SIMULATION
Cypress
6.A.8.8.

A resultant linear description of this function (with rounding to the nearest seconds) yields this table which was used for simulation purposes:

Exposures	Throughput Time per Card (in Seconds)
1	4
2	5
3	5
4	6
5	7
6	7
7	8
8	8

Copy flo 24C - print from aperture card to hard copy @ 6 sec/aperture card.

Configuration

- Final System

Complete

Keypunch - 1 unit

Image File - two independently controlled subsystems each containing half the file (and consequently activity is assumed to be equally distributed over each half of the file on a random basis). Each subsystem configured as follows:

COMPUTER SIMULATION
Cypress
6.A.8.8.

1 - Projection Output Unit
1 - Module Controller
17 - File Modules (5 tray files)

Copyflo 24C - 2 units

Scaled Down System

No scaling

- Initial System

Complete

Key punch - 1 unit

Image file - 1 self-contained system configured as follows:

1 - Projection Input Unit
1 - Projection Output Unit
1 - Module Controller
3 - File Modules (5 tray files)

Scaled Down System

No scaling

Page Packing Factor

The Projection Output Unit has the ability to provide 'composed' output in the sense that images may be selected from different chips onto the same aperture card up to a maximum of eight page images per card. Retrieved output is treated as one

request per card for documents up to eight pages and an additional card for each multiple of eight pages per document for longer documents.

COMPUTER SIMULATION
Cypress
6.A.8.8.

SYSTEM	Average Thruput Time		THRUPUT TIME DISTRIBUTION (by %)						Max. Thru-put Time (min)	Average Overflow Time		Trans-action Sample
	sec	min	Under 5 min	Under 10 min	Under 15 min	Under 20 min	Under 25 min	Under 30 min		sec	min	
Cypress	453.1	7.6	0.0	90.7	100.0	--	--	--	12.0	--	--	428
Media	720.3	12.0	0.0	54.0	69.2	82.4	92.1	100.0	29.0	--	--	506
16mm Aperture	948.5	15.8	0.0	48.4	52.8	67.1	72.3	88.3	--	1070.4	34.5	523
Miracode	1013.8	16.9	12.4	45.5	51.8	54.7	73.8	88.1	--	2309.5	38.5	477
Filmsort 1000d	1058.4	17.6	0.0	45.9	54.1	56.1	73.4	74.4	--	2099.5	35.0	492
CRIS	1238.8	20.6	0.0	43.5	54.6	56.5	57.5	59.9	--	2192.5	36.5	504
Packed Microfiche	1582.6	26.3	0.0	3.7	15.3	33.3	52.8	66.7	--	2411.6	40.2	430
Magnavue	4053.8	67.6	0.0	0.0	0.0	0.0	0.0	0.4	--	4062.8	67.7	519

TABLE 6.A-1
INITIAL SYSTEMS SIMULATIONS
Transit Times - Counter Requests (Inc. Burst)

SYSTEM	Average Thruput Time		THRUPUT TIME DISTRIBUTION (by %)						Max. Thruput Time (min)	Average Overflow Time		Transaction Sample
	sec	min	Under 5 min	Under 10 min	Under 15 min	Under 20 min	Under 25 min	Under 30 min		sec	min	
Cypress	572.6	9.5	0.0	71.4	100.0	--	--	--	12.0	--	--	140
Media	11933	19.9	0.0	0.0	30.0	60.0	80.0	100.0	29.0	--	--	200
16mm Aperture	1571.7	26.2	0.0	0.0	0.0	27.3	36.4	72.7	--	20733	34.6	220
Miracode	16809	28.0	0.0	0.0	0.0	0.0	44.4	77.8	--	23595	39.3	180
Packed Microfiche	18018	30.0	0.0	0.0	0.0	14.3	42.9	57.1	--	24550	40.9	140
Filmsort 1000d	18018	30.0	0.0	0.0	0.0	--	40.0	40.0	--	21022	35.0	200
CRIS	21938	36.6	0.0	0.0	0.0	0.0	0.0	0.0	--	21938	36.6	200
Magnavue		74.6	0.0	0.0	0.0	0.0	0.0	0.0	--	44783	74.6	220

TABLE 6.A-2
Initial System Simulations
Transit Times - Burst Mode Counter Requests

SYSTEM	Average Thruput Time		THRUPUT TIME DISTRIBUTION (by %)						Max. Thru-put Time (min)	Average Overflow Time		Trans-action Sample
	sec	min	Under 20 min	Under 40 min	Under 60 min	Under 80 min	Under 100 min	Under 120 min		sec	min	
Cypress	354.2	5.9	100.0	--	--	--	--	--	10.0	--	--	1,983
Media	428.4	7.1	97.4	100.0	--	--	--	--	40.0	--	--	1,965
Filmsort 1000d	707.6	11.8	85.2	98.8	100.0	--	--	--	60.0	--	--	1,995
16mm Aperture	709.0	11.8	83.9	97.3	99.9	100.0	--	--	80.0	--	--	2,001
Miracode	968.2	16.1	73.4	91.0	96.7	98.7	99.1	99.6	160.0	--	--	2,021
CRIS	1364.0	22.7	53.7	86.5	96.4	99.8	100.0	--	100.0	--	--	2,028
PackedMicrofiche	1617.6	27.0	33.0	86.5	98.9	100.0	--	--	100.0	--	--	1,990
Magnavue	3893.5	64.9	0.0	14.3	45.3	75.0	94.0	99.4	140.0	--	--	2,039

TABLE 6.A-3
INITIAL SYSTEMS SIMULATIONS
Transit Times - Query Requests (Inc. Priority)

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SECRET

SYSTEM	Average Thruput Time		THRUPUT TIME DISTRIBUTION (by %)						Max. Thru-put Time (min)	Average Overflow Time		Trans-action Sample
	sec	min	Under 10 min	Under 20 min	Under 30 min	Under 40 min	Under 50 min	Under 60 min		sec	min	
Cypress	352.5	5.9	100.0	--	--	--	--	--	10.0	--	--	413
Media	401.4	6.7	91.3	97.8	100.0	--	--	--	30.0	--	--	414
16mm Aperture	549.0	9.1	77.6	92.9	99.0	99.8	100.0	--	42.0	--	--	407
Filmsort 1000d	607.4	10.1	70.2	91.7	96.5	99.3	99.8	100.0	59.0	--	--	423
Miracode	664.2	11.1	70.5	85.4	93.6	96.8	98.5	99.5	82.0	--	--	404
CRIS	714.1	11.9	64.9	87.7	94.2	98.3	100.0	--	50.0	--	--	416
Packed Microfiche	1555.4	25.9	1.0	38.1	68.7	86.2	95.9	99.3	63.0	--	--	412
Magnavue	3893.5	64.9	0.0	14.3	45.3	75.0	94.0	99.4	140.0	--	--	2,039

TABLE 6.A-4
INITIAL SYSTEMS SIMULATION
Transit Times - Priority Query Requests

SECRET

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SYSTEM	Average Thruput Time sec	Average Thruput Time min	THRUPUT TIME DISTRIBUTION (by %) Under 5 min	Under 10 min	Under 15 min	Under 20 min	Under 25 min	Under 30 min	Max. Thruput Time min	Average Overflow Time sec	Average Overflow Time min	Transaction Sample
Media	424.5	7.1	0.0	91.2	94.2	96.9	100.0	--	25.0	--	--	1,676
Cypress	504.2	8.4	0.0	77.6	99.1	100.0	--	--	19.0	--	--	4,910
CRIS	559.3	9.3	0.0	71.6	98.2	100.0	--	--	20.0			496
16mm Aperture	612.7	10.2	0.0	68.3	86.0	93.3	96.0	98.2	--	2,098	35.0	656
Filmsort 1000d	618.5	10.3	0.0	65.8	85.7	92.4	96.2	98.7	--	1,881	31.4	628
Packed Microfiche	783.0	13.5	0.0	13.8	74.6	98.1	100.0	--	24.0	--	--	4,870
Miracode	877.3	14.6	11.1	53.8	63.7	70.3	78.2	87.0	--	2,206	36.8	4,954
Magnavue	5979	99.7	0.0	0.0	0.0	0.0	0.0	0.0	150.0	5979	99.7	574

TABLE 6.A-5
SIMULATION OF FINAL SYSTEMS
Transit Times - Counter Requests (including Bursts)

SECRET

Approved For Release 2000/04/14 : CIA-RDP78-03952A000100060001-6

SYSTEM	Average Thruput Time		THRUPUT TIME DISTRIBUTION (by %)						Max. Thru-put Time min	Average Overflow Time		Trans-action Sample
	sec	min	Under 5 min	Under 10 min	Under 15 min	Under 20 min	Under 25 min	Under 30 min		sec	min	
Media	589.2	9.8	0.0	78.8	84.4	92.2	100.0	--	25.0	--	--	359
CRIS	679.6	11.3	0.0	26.7	97.3	100.0	--	--	17.0			75
Cypress	698.3	11.6	0.0	19.6	95.7	100.0	--	--	19.0	--	--	920
Filmsort 1000d	735.7	12.3	0.0	52.0	77.2	85.4	93.5	97.6	--	1819.0	30.3	123
16mm Aperture	775.8	12.9	0.0	47.4	77.4	85.4	89.1	95.6	--	2152.0	35.9	137
PackedMicrofiche	1045.6	17.4	0.0	0.0	4.5	90.9	100.0	--	23.0	--	--	880
Miracode	1890.5	31.5	0.0	0.0	0.0	4.1	20.4	46.9	--	2230.6	37.2	980
Magnavue	6051.9	100.9	0.0	0.0	0.0	0.0	0 0	0.0	140.0	6051.9	100.9	102

TABLE 6.A-6
SIMULATION OF FINAL SYSTEMS
Transit Times - Burst Mode Counter Requests

SECRET

Approved For Release 2000/04/14 : CIA-RDP78-03952A000100060001-6

SYSTEM	Average Thruput Time		THRUPUT TIME DISTRIBUTION (by %)						Max. Thruput Time min.	Average Overflow Time		Transaction Sample
	sec	min	Under 20 min	Under 40 min	Under 60 min	Under 80 min	Under 100 min	Under 120 min		sec	min	
Media	441.5	7.4	98.2	100.0	--	--	--	--	40.0	--	--	6,625
Cypress	457.0	7.6	100.0	--	--	--	--	--	20.0	--	--	19,965
CRIS	810.0	13.5	85.0	98.9	100.0	--	--	--	50.0	--	--	1,994
Packed Microfiche	851.4	14.2	98.0	100.0	--	--	--	--	30.0	--	--	19,969
Filmsort 1000d	1166.1	19.4	62.9	70.3	98.4	99.9	100.0	--	90.0	--	--	2,485
Miracode	1320.0	22.0	66.3	85.0	91.8	95.4	97.5	98.5	180.0	--	--	19,923
16mm Aperture	1363.9	22.7	55.8	83.1	96.1	100.0	--	--	80.0	--	--	2,711
Magnavue	6290.5	104.8	0.0	0.0	0.0	3.2	54.3	69.8	170.0	--	--	2,398

TABLE 6.A-7
SIMULATION OF FINAL SYSTEMS
Transit Times - Query Requests (including priority)

SYSTEM	Average ThruputTime		THRUPUT TIME DISTRIBUTION (by %)						Max. Thru-put Time T_{mTh}	Average Overflow Time		Trans-action Sample
	sec	min	Under 10 min	Under 20 min	Under 30 min	Under 40 min	Under 50 min	Under 60 min		sec	min	
Media	383.1	6.4	94.5	98.6	100.0	--	--	--	25.0	--	--	1,393
Cypress	416.4	6.9	95.8	100.0	--	--	--	--	16.0	--	--	5,004
CRIS	480.7	9.7	68.1	98.7	100.0	--	--	--	28.0	--	--	521
16mm Aperture	688.9	11.5	58.2	89.9	96.8	98.8	99.4	100.0	60.0	--	--	722
Miracode	719.4	12.0	63.9	82.6	93.1	97.5	99.1	99.6	89.0	--	--	5,115
Packed Microfiche	750.8	12.5	9.9	99.8	100.0	--	--	--	23.0	--	--	5,014
Filmsort 1000d	899.8	15.0	44.6	77.5	89.5	95.9	99.1	100.0	59.0	--	--	641
Magnavue	6290.5	104.8	0.0	0.0	0.0	3.2	54.3	69.8	170.0	--	--	2,398

TABLE 6.A-8
SIMULATION OF FINAL SYSTEMS
Transit Times - Priority Query Requests

Appendix 6.B.

COMPARATIVE ANALYSIS OF THE PACKED MICROFICHE

and

THE FILMSORT 2000dx APERTURE CARD SYSTEMS

Included in this Appendix are the detailed calculations supporting the final comparison of the two leading candidate systems as summarized in Chapter 6.4. Subsequent to the initial comparison of all systems as detailed in CHIVE/R-1-65 (Sections D and G) and summarized in Chapter 6-3 of this report, the two systems surviving the cutoff were subjected to closer scrutiny. A survey of alternate available equipments designed to process either 35mm aperture cards or microfiche was conducted and an 'optimum' configuration was developed for each system. The detailed description of these two 'optimum' systems is included in

COMPARATIVE ANALYSIS
6.B.

this Appendix for purposes of comparing them from the standpoint of cost, space, and manpower. The contents of this Appendix have also been published separately in CHIVE/R-1-65 (Sections R and S), and are included as part of this report merely for purposes of convenience.

6.B.1. MICROFICHE (PACKED, WITH XEROX PRINTER)

6.B.1.1. Assumptions for the Final System*

(1) Input items are to be stored on 105mm by 148mm (about 4 by 6 in) microfiche. More than one item will be stored on a microfiche, but each item will begin a new line. There will be six lines per fiche, with the top line used for identification information and each of the remaining lines containing up to 10 pages. The camera reduction ratio will be adjusted by the operator to put an 8½ by 14

* 5000 requests per day, 1,000,000 new items per year, a file size of 10,000,000 items.

COMPARATIVE ANALYSIS
Assumptions for the
Final System
6.B.1.1.

in page in the same size area normally used for an 8 by 10½ in. page. A three or four digit batch serial number will be recorded in the left margin of each image line. Since each input item starts a new line on the fiche, documents that are 10 pages or less will require one line each. Larger documents will require additional lines. The suggested format is shown below.

OCS-1400017864
001
002
003
004
005

The distribution of page sizes shows that of each 1000 file items, approximately:

894 take 1 line = 894 lines

41 take 2 lines= 82 lines

COMPARATIVE ANALYSIS
Assumptions for the
Final System
6.B.1.1.

20 take 3 lines = 60 lines

45 take 4 lines = 180 lines

1000 1216

This results in an average of

$$\left\{\frac{1000 \text{ items}}{1216 \text{ lines}}\right\} \quad \left\{\frac{5 \text{ lines}}{\text{fiche}}\right\} = 4.11 \text{ items/fiche}$$

(2) An eye-legible serial number and other identifying information will be typed for the header of each fiche. The batch serial number will be displayed by an appropriate device at the camera station. Assuming that 25 characters are to be typed for each header,

$$\left\{\frac{\text{typist-hr}}{10{,}400 \text{ char}}\right\} \quad \left\{\frac{25 \text{ char}}{\text{fiche}}\right\} \quad \left\{\frac{\text{fiche}}{4.11 \text{ items}}\right\} \quad \left\{\frac{10^6 \text{ items}}{\text{yr.}}\right\}$$

$$\left\{\frac{\text{yr.}}{12 \text{ mo.}}\right\} \quad \left\{\frac{\text{mon.}}{22 \text{ day}}\right\} \quad \left\{\frac{\text{day}}{8 \text{ hr}}\right\} = 0.28$$

typists and typewriters would be required for the specified input rate.

(3) Filming is done with a step-and-repeat camera at an estimated rate of 1500-2000 exposures/day for each camera station. Two pages are recorded in

COMPARATIVE ANALYSIS
Assumptions for the
Final System
6.B.1.1.

each exposure. (This is a more optimistic revision of the rate of 2000-4000 pages/day for each camera station used for the analysis of the unit-record microfiche system.). Current AEC experience with an equivalent camera is an effective rate of 2250 exposures/day (i.e., 4500 pages/day) for documents that average about 40-50 pages in length. At the estimated rates,

$$\left\{\frac{7.62 \text{ pages}}{\text{item}}\right\} \quad \left\{\frac{\text{machine-day}}{3000\text{-}4000\text{pg}}\right\} \quad \left\{\frac{10^6 \text{ item}}{\text{yr.}}\right\}$$

$$\left\{\frac{\text{yr}}{12 \text{ mo.}}\right\} \quad \left\{\frac{\text{mo}}{22 \text{ day}}\right\} = 7.2 \text{ to } 9.6$$

cameras and operators would be required to handle the specified input volume on a single shift operation. Assuming a double shift operation, this volume could be handled with 4-5 cameras and 4-5 operators on each shift.

(4) Step-and-repeat cameras are currently available from Microcard Corp., Bell & Howell, and Photo Devices, for maximum annual costs of $21,000, $10,000,

and $9000, respectively. Assume that a camera will be chosen which has a cost on the order of $9000 to $10,000 per year.

(5) 105mm roll silver film type AH-U Spec. 830 is used in this camera and records about 200 fiche per 100 ft roll. This results in

$$\left\{\frac{4.11 \text{ items}}{\text{fiche}}\right\} \left\{\frac{200 \text{ fiche}}{\text{roll}}\right\} = 822 \text{ items per 100 ft. roll.}$$

The film costs $24.39 per 100 ft. roll, resulting in a unit cost of $24.39/822 = $0.02967 per input item.

(6) The 105mm roll film is developed on a unit such as the Pako 17-2 which costs approximately $12,000 ($2400/hr. amort.) and processes film at an effective rate of 5 ft./min., with a capability to run up to 3 rolls simultaneously. At this rate,

$$\left\{\frac{\text{roll}}{822 \text{ items}}\right\} \left\{\frac{100 \text{ ft}}{\text{roll}}\right\} \left\{\frac{\text{machine-min.}}{5 \text{ ft.}}\right\} \left\{\frac{10^6 \text{item}}{\text{yr.}}\right\}$$

$$\left\{\frac{\text{day}}{480 \text{ min.}}\right\} \left\{\frac{\text{yr.}}{264 \text{ day}}\right\} = 0.19$$

developers and operators would be required, if no

COMPARATIVE ANALYSIS
Assumptions for the
Final System
6.B.1.1.

films were run simultaneously.

(7) The chemicals for the film developer are estimated to cost $1500/hr. This results in a unit cost of $1500/$10^6$= $0.0015 per input item.

(8) After developing the initial silver film, two duplicate roll copies are made on an Ozalid contact printer. This unit operates at a nominal rate of 8 ft./min. or 3840 ft/day. (Ref. Ozalid rep.) Assuming a 75% de-rating and two copies,

$$\left\{\frac{2}{0.75}\right\}\left\{\frac{\text{machine-day}}{3840\text{ ft.}}\right\}\left\{\frac{\text{ft.}}{2\text{ microfiche}}\right\}\left\{\frac{\text{microfiche}}{4.11\text{ items}}\right\}$$

$$\left\{\frac{10^6\text{items}}{\text{year}}\right\}\left\{\frac{\text{yr}}{12\text{ mo}}\right\}\left\{\frac{\text{mo.}}{22\text{ day}}\right\}$$ =0.32 printers and operators would be required.

(9) The Ozalid 105mm contact printer (printer and developer combined) has an estimated cost of $7500 ($1500/yr. amort.). The maintenance and chemical costs are unknown, but estimated to be a total of about $300/yr (Ref. Ozalid rep.).

(10) The 105 mm diazo film costs about $15 per 100 ft. roll. For two duplicate copies this results

COMPARATIVE ANALYSIS
Assumptions for the
Final System
6.B.1.1.

in a unit cost of $30/.822 = $0.0365 per input item.

(11) The Recordak Model 12K Cutter is used to cut the foll film into microfiche. This unit has a nominal speed of 24,000 ft./day. With a 75% de-rating and 3 rolls to be cut,

$$\left\{\frac{3}{0.75}\right\}\left\{\frac{\text{machine-day}}{24{,}000\text{ ft.}}\right\}\left\{\frac{100\text{ ft.}}{822\text{ items}}\right\}\left\{\frac{10^6\text{items}}{\text{yr.}}\right\}\left\{\frac{\text{yr.}}{12\text{ mo.}}\right\}\left\{\frac{\text{month}}{22\text{ da}}\right\} = 0.077$$

cutters and operators would be required. This unit costs $2024 ($405/yr. amort.) and has an estimated annual maintenance cost of $20.00.

(12) After cutting, an opaque backing strip is applied to each header to facilitate reading of the header information when the cards are in the file drawers. The backing is put on by a special hot stamping press that is manually fed, and operates at an estimated rate of about 20 cards/min. With 3 copies of each fiche to be backed this way,

$$3 \left\{\frac{\text{fiche}}{4.11 \text{ items}}\right\} \left\{\frac{\text{machine-min}}{20 \text{ fiche}}\right\} \left\{\frac{10^6 \text{ items}}{\text{yr.}}\right\}$$

$$\left\{\frac{\text{day}}{480 \text{ min}}\right\} \left\{\frac{\text{year}}{264 \text{ days}}\right\} = 0.29$$

stamps and operators would be required.

(13) The stamping unit is estimated to cost $5000 ($1000/yr. amort.) and has negligible material and operating costs.

(14) Assume that a motorized card file such as the Mosler Selectronic Model 9820 card file will be used at each file station. This unit costs $4680 ($936/yr. amort.) with maintenance costs of about $100/yr. It can store up to 426,000 4 by 6 inch cards. At this rate,

$$(10^7 \text{ items}) \left\{\frac{\text{file station}}{426{,}000 \text{ microfiche}}\right\} \left\{\frac{\text{microfiche}}{4.11 \text{ items}}\right\} = 5.72$$

file stations would be required to hold the specified file volume.

(15) Assume that the appropriate microfiche is pulled from the file in response to a request, sent to the hard copy printer station, and subsequently

returned and re-filed at the filing station. Assume that a file clerk can retrieve or re-file a microfiche in an effective rate of 700/hr. (about 6 sec. each) This means that about 12 seconds of handling by a file clerk will be required to retrieve and subsequently re-file each requested item. Thus one file clerk can handle 350 request/hr. or 2800 requests/day. At this rate,

$$\left\{\frac{\text{clerk-day}}{\text{2800 requests}}\right\} \quad \left\{\frac{\text{5000 requests}}{\text{day}}\right\} = 1.79$$

file clerks and filing stations would be required to handle the specified request rate.

(16) A Xerox Automatic Microfiche Enlarger Printer will be used to obtain hard copy from the microfiche. This unit operates at a nominal speed of 10 sheets/min. Assuming a 75% de-rating, this is 7.5 sheets (min. or 450 sheets/hr.) Assume that the copies will be prepared with two reduced pages per printed sheet. At this rate,

$$\left\{\frac{\text{sheet}}{2\text{ pgs}}\right\}\left\{\frac{7.62\text{ pages}}{\text{request}}\right\}\left\{\frac{\text{machine-hr}}{450\text{ sheets}}\right\}\left\{\frac{\text{day}}{8\text{ hr.}}\right\}\left\{\frac{5000\text{ requests}}{\text{day}}\right\} = 5.3$$

machines and operators will be required to handle the specified request rate.

(17) The above Xerox Printer is available at a cost of $48,000 ($9600/hr. amort.) with a maintenance cost not established yet, but assumed to be about $800/yr.

(18) The materials cost (paper, toner, etc.) for the hard copy is estimated to be about one cent per sheet. This results in a unit material cost of

$$\left\{\frac{7.62\text{ pages}}{\text{request}}\right\}\left\{\frac{\text{sheet}}{2\text{ pages}}\right\}\left\{\frac{\$\ .01}{\text{sheet}}\right\} = \$0.0381 \text{ per request.}$$

6.B.1.2. Costs for Final System

Fixed Costs:

	Min.	Max.
Step-and-repeat cameras (4-5 @ $9-10,000/yr)	$36,000	$50,000 per yr
Camera operators - 1st shift (4-5 @ $4580/yr)	18,320	22,900 per yr

COMPARATIVE ANALYSIS
Costs for Final System
6.B.1.2.

Camera operators - 2nd shift (4-5 @ $5267/yr)	21,068	26,335 per year
Typist (1 @ 4300/yr)	4,300	4,300 per year
Typewriter (1 @ 88/yr)	88	88 per year
Film processor (1 @ $2400/ yr)	2,400	2,400 per year
Ozalid printer (1 @ $1800/ yr)	1,800	1,800 per year
Film backer (1 @ $1000/yr)	1,000	1,000 per year
Motorized card files (6 @ 1036/yr)	6,216	6,216 per year
Film cutter (1 @ $425/hr)	425	425 per year
File clerks (2 @ $4690/yr)	9,380	9,380 per year
Xerox microfiche printers (6 @ $10,400/yr)	62,400	62,400 per year
Photo technicians (7 @ $4690/yr)	32,830	32,830 per year

Film developer	0.19
Contact printer	0.32
Film cutter	0.08
Backing strip	0.29
Xerox printer	5.30
	6.18

$196,227	$220,074 per year

COMPARATIVE ANALYSIS
Costs for Final System
6.B.1.2.

Input Material Costs:

Initial silver roll film	$0.02967 per input item
Diazo copy film	0.03650 " " "
Film processor chemicals	0.00150 " " "
	$0.06767 per input item

Output Material Costs:

Paper, toner, etc. for Xerox printer	$0.0381 per request

Total annual cost (in dollars) = (191,839 to 215,686)

+ $0.06767 per input item

+ $0.0381 per request

191,839
67,670
50,300
309,809

Staff = 4 + 1
4 + 1
2
7
18 - 20

6.B.1.3. Assumptions for Intermediate System*

(1) - Same as R-1. No. (1).

(2) - No. of typists and typewriters required = 0.14

(3) - No. of cameras and operators required = 3.6

* 3000 requests per day, 500,000 new items per year, a file size of 5,000,000 items.

COMPARATIVE ANALYSIS
Assumptions for Intermediate System
6.B.1.3.

- 4.8 for single shift operations. Assuming a double shift operation, this could be reduced to 2-3 cameras and 4-5 operators. (Min. case is 2 cameras with 2 operators on first shift and 2 operators on second shift.)

(4)-(5) Same as R-1. Nos. (4)-(5).

(6) - No. of developers and operators required = 0.1

(7) - Chemicals for the developer as estimated to cost $750.yr. This results in a unit cost of $0.0015 per input item.

(8) - No. of contact printers and operators required = 0.16.

(9)-(10) Same as R-1. Nos. (9)-(10).

(11) - No. of cutters and operators required = 0.04

(12) - No. of backing stamps and operators required = 0.15.

(13) - Same as R-1. No. (13).

(14) - No. of motorized file stations required = 2.86.

(15) - No. of file clerks required = 1.08

(16) - No. of Xerox printers and operators required = 3.18.

(17)-(18) Same as R-1. Nos. (17)-(18).

COMPARATIVE ANALYSIS
Assumptions for
IntermediateSystem
6.B.1.3.

6.B.1.4. Costs for Intermediate System

Fixed Costs:

	Min.	Max.
Step-and-repeat cameras (2-3 @ $9-10,000/yr)	$ 18,000	$ 30,000 pr yr
Camera operators - 1st shift (2-3 @$4580/yr)	9,160	13,740 " "
Camera operators - 2nd shift (2 @ $5267/yr)	10,534	10,534 " "
Typist (1 @ $4300/yr)	4,300	4,300 " "
Typewriter (1 @ $88/yr)	88	88 " "
Film processor (1 @ $2400/yr)	2,400	2,400 " "
Ozalid printer (1 @ $1800/yr)	1,800	1,800 " "
Film backer (1 @ $1000/yr)	1,000	1,000 " "
Motorized card files (3 @ $1035/yr)	3,108	3,108 " "
Film cutter (1 @ $425/yr)	425	425 " "
File clerks (2 @ $4690/yr)	9,380	9,380 " "
Xerox microfiche printers (4 @ $10,400/yr)	41,600	41,600 " "
Photo technicians (4 @ $4690/yr)	18,760	18,760 " "

COMPARATIVE ANALYSIS
Costs for Intermediate System
6.B.1.4.

Film developer	0.10
Contact printer	0.16
Film Cutter	0.04
Backing strip	0.15
Xerox printer	3.18
	3.63

$120,555	$137,135 pr yr

Input Material Costs:

Initial silver roll film	$0.02967 per input item
Diazo copy film	0.03650 per input item
Film processor chemicals	0.00150 per input item
	$0.06767 per input item

Output Material Costs:

Paper, toner, etc., for Xerox printer	$0.0381 per request

Total annual cost (in dollars) = (120,555 to 137,135)

+ $0.06767 per input item

+ $0.0381 per request

COMPARATIVE ANALYSIS
Costs for Intermediate System
6.B.1.4.

6.B.1.5. Assumptions for Initial System*

(1) Same as R-1. No. (1).

(2) No. of typists and typewriters required = 0.03.

(3) No. of cameras and operators required = 0.72 - 0.96.

(4)-(5) Same as R-1. Nos. (4)-(5).

(6) No. of developers and operators required = 0.02.

(7) Chemicals for the developer are estimated to cost $150/yr. This results in a unit cost of $0.0015 per input item.

(8) No. of contact printers and operators required = 0.03.

(9)-(10) Same as R-1. Nos. (9)-(10).

(11) No. of cutters and operators required = 0.01.

(12) No. of backing stamps and operators required = 0.03.

(13) Same as R-1. No. (13).

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* 500 requests per day, 100,000 new items per year, a file size of 500,000 items.

COMPARATIVE ANALYSIS
Assumptions for Initial System
6.B.1.5.

(14) No. of motorized card files required = 0.29.

(15) No. of file clerks required = 0.18. Assume that the file handling and typing are handled by the same person.

(16) No. of Xerox printers required - 0.53.

(17)-(18) Same as R-1. Nos. (17)-(18).

6.B.1.6. Costs for Initial System

Fixed Costs:

	Min.	Max.
Step-and-repeat cameras (1 @ 9-10,000/yr)	$ 9,000	$ 10,000 pr yr
Camera operators -1st shift(1 @ $4580/yr)	4,580	4,580 " "
Typewriter (1 @ $88/yr)	88	88 " "
Film processor (1 @ $2400/yr)	2,400	2,400 " "
Ozalid printer (1 @ $1800/hr)	1,800	1,800 " "
Film backer (1 @ $1000/yr)	1,000	1,000 " "
Motorized card files (1 @ $1036/yr)	1,036	1,036 " "
Film cutter (1 @ $425/yr)	425	425 " "

COMPARATIVE ANALYSIS
Costs for Initial System
6.B.1.6.

File clerks (1@ $4690/yr)		4,690	4,690 per yr
Xerox microfiche printers (1 @ $10,400/yr)		10,400	10,400 " "
Photo technicians (1 @ $4690/yr)		4,690	4,690 " "
Film developer	0.02		
Contact printer	0.03		
Film cutter	0.01		
Backing strip	0.03		
Xerox printer	0.53		
	0.62		
		$40,109	$41,109 per yr

Input Material Costs:

Initial silver roll film	$0.02967 per input item
Diazo copy film	0.03650 " " "
Film processor chemicals	0.00150 " " "

Output Material Costs:

Paper, toner, etc., for Xerox printer	$0.0381 per request

Total annual cost (in dollars) = (40,109 to 41,109)

+ $0.06767 per input item

+ $0.0381 per request

COMPARATIVE ANALYSIS
Costs for Initial System
6.B.1.6.

40,109
6,767
5,030
$51,906

TABLE 6.B-1
SPACE REQUIREMENTS FOR MICROFICHE (PACKED, WITH XEROX PRINTER)

UNIT	Unit Dimensions Estimated SpaceRequire-ments per unit including work space (in.) L W H	(SqFt)	INITIAL # of Units Req.	INITIAL Space Req (Sq. ft)	INTER-MEDIATE # of Units Req.	INTER-MEDIATE Space Req. (sq. ft)	FINAL # of Units Required	FINAL Space (Sq. ft.)
Step & Repeat camera		100*	1	100	2-3	200-300	4-5	400-500
Typist desk		40*	1	40	1	40	1	40
Film processor		100*	1	100	1	100	1	100
Ozalid printer	(table mounted)	45*	1	45	1	45	1	45
Film backer		50*	1	50	1	50	1	50
MoslerSelectron-ic card file		65*	1	65	3	195	6	390
Film cutter	(table mounted)	40*	1	40	1	40	1	40
Xerox printer		80-100	1	80-100	4	320-400	6	480-600
				520-540		990-1170		1545-1765

* Observation of installed units.

6.B.2. FILMSORT 2000 DX (WITH QUADRANT PRINTER)

6.B.2.1. Assumptions for Final System*

(1) Each Filmsort 2000DX aperture card can hold up to eight legal size page images at 24:1 reduction. For the anticipated page size distributions, and assuming that no more than one document will ever be on any card, the following number of cards will be required for each 1000 input items:

872 items require 1 card	=	872 cards
37 items require 2 cards	=	74 cards
37 items require 3 cards	=	111 cards
9 items require 4 cards	=	36 cards
45 items require 5 cards	=	225 cards
		1318 cards

This results in an average of 1.318 cards per item.

(2) The processing rate of the Filmsort 2000DX is estimated to be 400-500 cards per day.

- 3M Company brochures state: "From original record to a fully-processed

* 5000 requests per day, 1,000,000 new items per year, a file size of 10,000,000 items.

COMPARATIVE ANALYSIS
Assumptions for Final System
6.B.2.1.

Filmsort aperture card in less than a minute" and "In just 54 seconds, the Filmsort 1000d converts any document to a microfilm record mounted in a Filmsort aperture card." This would amount to 533 cards per day. Derating the performance 75% results in a rate of 400 cards per day.

- One 3M representative cites one Air Force installation of F-1000 equipment that experiences an average of 400 cards per day.

- Another 3M representative suggests that 320 cards per day is a good conservative estimate, with the Filmsort 1000 camera and that he had seen some installations that experienced 200-250 cards per day.

- 3M Company estimates the 2000DX cycle time to be 45 sec/card. De-rating this 75% gives an effective rate of 480-540 cards per camera.

At the assumed rate, a total of:

$$\left\{\frac{\text{Machine-day}}{\text{400-500 cards}}\right\} \quad \left\{\frac{\text{1.318 cards}}{\text{items}}\right\} \quad \left\{\frac{10^6 \text{ items}}{\text{year}}\right\}$$

$$\left\{\frac{\text{yr.}}{\text{12 mo}}\right\} \quad \left\{\frac{\text{month}}{\text{22 days}}\right\} = 9.97 - 12.5$$

FO2000DX cameras and operators would be required for a single shift operation. For double shift operation,

COMPARATIVE ANALYSIS
Assumptions for Final System
6.B.2.1.

5-7 cameras and 10-13 operators would be required.

(3) The Filmsort 2000DX is expected to cost $5090 ($1018/hr. amortized). The maintenance cost for purchased equipment is estimated to be $341/yr per unit. In order to be able to provide both 16:1 and 24:1 reductions, on the same camera, a modification will be required for each camera at a cost of $1500/unit (Ref., 3M representative). This results in a total equipment cost of $1659/yr per unit.

(4) Filmsort 1000d camera cards come in magazines of 500 cards, at a cost of $26.90 per magazine for large lots (Ref., 3M 1964 GSA price list). This amounts to a cost of

$$\left\{\frac{\$26.90}{500 \text{ cards}}\right\} \left\{\frac{1.318 \text{ cards}}{\text{item}}\right\} = \$0.071 \text{ per input item}$$

(5) Filmsort 1000d requires fixer and developer at the rate of 1 quart each for every 200 cards (ref., 3M representative, June 1964). The cost of fixer and developer is $1.23 and $1.47 per quart,

COMPARATIVE ANALYSIS
Assumptions for Final System
6.B.2.1.

respectively (ref., 3M GSA price list). This amounts to a total unit cost of

$$\left\{\frac{\$2.70}{200 \text{ cards}}\right\} \left\{\frac{1.318 \text{ cards}}{\text{item}}\right\} = \$0.0178 \text{ per input item}$$

(6) An Identification number and other information for each document is to be punched into a work card by a keypunch operator. The cards are also verified by a keypunch operator. Assuming that a 25 - digit number is punched into each card,

$$\left\{\frac{1.0 \text{ cards}}{\text{item}}\right\} \left\{\frac{\text{machine-hr.}}{8000 \text{ digits}}\right\} \left\{\frac{25 \text{ digits}}{\text{card}}\right\} \left\{\frac{10^6 \text{ items}}{\text{yr.}}\right\}$$

$$\left\{\frac{\text{yr.}}{12 \text{ mo}}\right\} \left\{\frac{\text{mo.}}{22 \text{ day}}\right\} \left\{\frac{\text{day}}{8 \text{ hr}}\right\} = 1.48$$

keypunch machines and operators would be required for the specified input rate. The same number of verifier machines and operators would also be required. For double shift operation only 1 of each of the keypunch machines would be required.

(7) The cost of the IBM work card is

$$\left\{\frac{\$1.00}{1000 \text{ cards}}\right\} \left\{\frac{1 \text{ card}}{\text{item}}\right\} = \$0.001 \text{ per input item}$$

COMPARATIVE ANALYSIS
Assumptions for Final
System
6.B.2.1.

(8) Duplicate aperture card copies for the two external files will be prepared on the IBM copier-reproducer at an estimated rate of 1575 cards/hr.

- The nominal speed of this equipment is 2100 cards/hr. Derating this equipment 75% results in an effective rate of 1575 cards/hr.

- 3M representatives cite their operating experience as an effective 1600 cards/hr. for their equivalent machine with a nominal speed of 200 cards/hr.

At this rate, and with the need for 2 duplicate copies, a total of

$$2 \left(\frac{\text{machine-hr}}{1575 \text{ cards}}\right) \left(\frac{1.318 \text{ cards}}{\text{item}}\right) \left(\frac{10^6 \text{ items}}{\text{yr.}}\right)$$

$$\left\{\frac{\text{yr.}}{12 \text{ mos}}\right\} \left\{\frac{\text{mo.}}{22 \text{ day}}\right\} \left\{\frac{\text{day}}{8 \text{ hr.}}\right\} = 0.78$$

machines and operators would be required.

(9) The IBM card copier costs $65,000 ($13,000/yr amortized). The maintenance costs for a purchased unit are $1700/yr. This results in a total cost of $14,700/yr. for a purchased system (ref., IBM representative).

COMPARATIVE ANALYSIS
Assumptions for Final System
6.B.2.1.

(10) The diazo aperture cards used to make the duplicate copies cost $22.50 per thousand in large lots. With two copies required, this results in a unit cost of

$$2 \left\{\frac{\$22.50}{1000 \text{ cards}}\right\} \left\{\frac{1.318 \text{ cards}}{\text{item}}\right\} = \$0.05931 \text{ per input item.}$$

(11) After punching, the aperture cards are interpreted by an IBM 557 Alphabetic Interpreter. This unit operates at a nominal rate of 1000 cards/min. Derating the performance 75% results in an effective rate of 75 cards/min. or 36,000 cards/day. This means that with 3 aperture card copies of each item to be interpreted,

$$3 \left\{\frac{\text{machine-day}}{36{,}000 \text{ card}}\right\} \left\{\frac{10 \text{ items}}{\text{yr.}}\right\} \left\{\frac{\text{yr.}}{12 \text{ mo.}}\right\} \left\{\frac{\text{mo.}}{22 \text{ day}}\right\} \left\{\frac{1.318 \text{ cards}}{\text{item}}\right\} = 0.415$$

interpreters and operators would be required.

(12) A motorized card file will be used for each file station. A representative example is the Mosler

COMPARATIVE ANALYSIS
Assumptions for Final System
6.B.2.1.

Selectronic Model 9820, which costs $4680 per unit ($936/hr. amortized) and can store up to 444,000 aperture cards. Maintenance costs are about $100/hr. Approximately

$$(10^7 \text{items}) \left\{\frac{\text{file station}}{444{,}000 \text{ cards}}\right\} \left\{\frac{1.318 \text{ cards}}{\text{item}}\right\} = 29.7$$

card files would be required to hold the record for 10 million items.

(13) Assume that the appropriate microfiche is pulled from the file in response to a request, sent to a hard copy printer station, and subsequently retrieved and re-filed at the filing station. It is estimated that the cards can be pulled from the file at an estimated rate of 700/hr. (about 6 sec. each), and that they could be refiled at the same rate. A Mosler rep. quoted the following rates:

- filing of checks that are already in numerical sequence: 1200/hr.
- pulling of checks for statements in numerical sequence: 900/hr.
- reference lookups for current balances, etc.: 1200/hr.

- random access tab card pulling: 700/hr.

Similar rates were quoted in a recent journal article. This means that a total of 12 seconds of handling by a file clerk will be required to retrieve and subsequently re-file each requested item. Thus, one clerk can handle 350 request/hr or 2800 requests/day. At this rate,

$$\left\{\frac{\text{clerk-day}}{\text{2800 reqs}}\right\} \left\{\frac{\text{5000 requests}}{\text{day}}\right\} = 1.79$$

file clerks and filing stations would be required to handle the specified request rate.

(14) Hard copy is to be prepared from the aperture card using a modified 3M Quadrant printer. This (the Octant) unit costs $1,795 ($359/hr. amoritzed) (3M quote) with a maintenance cost unstated but estimated to be $200/yr.

(15) The 3M Quadrant printer is expected to operate at the effective rate of 5400 sheets/day, with 2 pages printed on each sheet.

COMPARATIVE ANALYSIS
Assumptions for Final System
6.B.2.1.

At this rate,

$$\left\{\frac{7.62 \text{ page}}{\text{request}}\right\}\left\{\frac{\text{machine-day}}{10{,}800 \text{ pgs}}\right\}\left\{\frac{5000 \text{ requests}}{\text{day}}\right\} = 3.53$$

printers and operators would be required.

(16) The paper for the 3M Quadrant printer costs $6.61 per each 8-½ in. x 400 ft. roll in large lots (3M quote). This amounts to a unit cost of

$$\left\{\frac{\$6.61}{400 \text{ ft.}}\right\}\left\{\frac{\text{ ft.}}{12 \text{ in.}}\right\}\left\{\frac{13 \text{ in}}{\text{sheet}}\right\}\left\{\frac{7.62 \text{ page}}{\text{request}}\right\}$$

$$\left\{\frac{\text{sheet}}{2 \text{ page}}\right\} = \$0.0683$$

per request.

6.B.2.2. Costs for Final System

Fixed Costs:

	Min.	Max.
- Filmsort 2000DX cameras (5-7 @ $1659/yr)	$ 8,295	$ 11,613 pr yr
- Camera operators - 1st shift (5-7 @ $4580/yr)	22,900	32,060 " "
- Camera operators - 2nd shift (5-7 @ $5267/yr)	26,335	31,602 " "

COMPARATIVE ANALYSIS
Costs for Final System
6.B.2.2.

- IBM 026 keypunch (1 @ $720/yr)	720	720	pr yr
- IBM 056 verifier (1 @ $600/yr)	600	600	" "
- Keypunch operators (4 @ $4635/yr)	18,540	18,540	" "
- IBM ap. card copier (1 @ $14,700/yr)	14,700	14,700	" "
- IBM 557 Interpreter (1 @ $1980/yr)	1,980	1,980	" "
- Motorized card files (30 @ $1036/yr)	31,080	31,080	" "
- File clerks (2 @ $4690/yr)	9,380	9,380	" "
- Quadrant printer (4 @ $449/yr)	2,236	2,236	" "
- Photo technicians (5 @ $5010/yr)	25,050	25,050	" "

IBM ap. card copier
0.78
IBM Interpreter
0.42
Quadrant printer
3.53
4.73

$161,816 $179,561 per year

COMPARATIVE ANALYSIS
Costs for Final System
6.B.2.2.

Input Material Costs:

Camera cards	$0.07100 per input item
Fixer & developer	0.01780 " " "
IBM work card	0.00100 " " "
Diazo ap. cards	0.05931 " " "
	$0.14911 per input item

Output Material Costs:

Quadrant paper	$0.0683 per request

Total annual cost (in dollars) = (161,816 to 179,561)

+ 0.14911 per input item

+ 0.0683 per request

161,816
149,110
90,926
400,926

6.B.2.3. Assumptions for Intermediate System *

(1) Same as S-1. no. (1)

* 3000 requests per day, 500,000 new items per year, a file size of 5,000,000 items.

COMPARATIVE ANALYSIS
Assumptions for Intermediate System
6.B.2.3.

(2) No. of cameras and operators required = 4.98 - 6.25 for single shift operation. For an assumed double shift operation, 3 cameras would be required, with 3 operators on first shift and 2 operators on second shift for the optimistic case. For the pessimistic case, 4 cameras would be required, with 4 operators on first shift and 3 operators on second shift.

(3)-(5) Same as S-1. Nos. (3)-(5)

(6) No. of keypunch machines and operators required = 0.74
No. of verifier machines and operators required = 0.74

(7) Same as S-1. no. (7).

(8) No. of aperture card copying machines and operators required = 0.39

(9)-(10) Same as S-1. Nos. (9)-(10)

(11) No. of interpreters and operators required = 0.21

(12) No. of motorized card files required = 14.8

(13) No. of file clerks and operators required = 1.07

(14) Same as S-1. No. (14).

(15) No. of Quadrant printers required - 2.12.

(16) Same as S-1. No. (16)

COMPARATIVE ANALYSIS
Assumptions for Intermediate System
6.B.2.3.

6.B.2.4. Costs for Intermediate System

Fixed Costs:

	Min.	Max.	
Filmsort 2000DX cameras (3-4 @ $1659/yr)	$ 4,977	$ 6,636	per yr
Camera operators - 1st shift (3-4 @ $4580/yr)	13,740	18,320	" "
Camera operators - 2nd shift (2-3 @ $5267/yr)	10,534	15,801	" "
IBM 026 keypunch (1 @ $720/yr)	720	720	" "
IBM 056 verifier (1 @ $600/yr)	600	600	" "
Keypunch operators (2 @ $4635/yr)	9,270	9,270	" "
IBM ap. card copier (1 @ $14,700/yr)	14,700	14,700	" "
IBM 557 Interpreter (1 @ $1980/yr)	1,980	1,980	" "
Motorized card files (15 @ $1036/yr)	15,540	15,540	" "
File clerks (2 @ $4690/yr)	9,380	9,380	" "
Quadrant printer (3 @ $559/yr)	1,677	1,677	" "

COMPARATIVE ANALYSIS
Costs for Intermediate System
6.B.2.4.

Photo technicians (3 @ $5010/yr)	15,030	15,030 per yr
IBM ap. card copier	0.39	
IBM Interpreter	0.21	
Quadrant printer	2.12	
	2.72	
	$98,148	$109,654

Input Material Costs:

Camera cards	$0.07100 per input item
Fixer & Developer	0.01780 " " "
IBM work card	0.00100 " " "
Diazo ap. cards	0.05931 " " "
	$0.14911 per input item

Output Material Costs

Quadrant paper	$0.0683 per request

Total annual cost (in dollars) = (98,148 to 109,654)

+ 0.14911 per input item

+ 0.0683 per request

COMPARATIVE ANALYSIS
Costs for Intermediate
System
6.B.2.4.

6.B.2.5. Assumptions for Initial System *

(1) Same as S-1. No. (1).

(2) No. of cameras and operators required = 0.99 - 1.25. This range could be handled by a single camera working from one to two shifts.

(3)-(5) Same as S-1. Nos. (3)-(5)

(6) No. of keypunch units and operators required = 0.15
No. of verifier units and operators required = 0.15

(7) Same as S-1. No. (7).

(8) No. of aperture card copier machines and operators required = 0.08

(9)-(10) Same as S-1. Nox. (9)-(10).

(11) No. of interpreters and operators required = 0.04

(12) No. of motorized card files required = 1.48.

(13) No. of file clerks required = 0.18.

(14) Same as S-1 No. (14).

(15) No. of Quadrant printers and operators required = 0.35.

(16) Same as S-1. No. (16).

* 500 requests per day, 100,000 new items per year, a file size of 500,000 items.

COMPARATIVE ANALYSIS
Assumptions for Initial System
6.B.2.5.

6.B.2.6. Costs for Initial System

Fixed Costs:

	Min.	Max.	
Filmsort 2000DX cameras (1 @ $1659/yr)	$ 1,659	$ 1,659	per yr
Camera operators - 1st shift (1 @ $4580/yr)	4,580	4,580	" "
Camera operators - 2nd shift (1 @ $5267/yr)	5,267	5,267	" "
IBM 026 keypunch (1 @ $720/yr)	720	720	" "
IBM 056 verifier (1 @ $600/yr)	600	600	" "
Keypunch operators (1 @ $4635/yr)	4,635	4,635	" "
IBM ap. card copier 1 @ $14,700/yr)	14,700	14,700	" "
IBM 557 Interpreter (1 @ $1980/yr)	1,980	1,980	" "
Motorized card files (2 @ $1036/yr)	2,072	2,072	" "
File clerks (1 @ $4690/yr)	4,690	4,690	" "
Quadrant printer (1 @ $559/yr)	559	559	" "

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Costs for Initial System
6.B.2.6.

Photo technicians (1 @ $5010/yr)	5,010	5,010 per yr
IBM ap. card copier	0.08	
IBM Interpreter	0.04	
Quadrant printer	0.35	
	0.47	
	$41,205	$41,205 per yr

Input Material Costs:

Camera cards	$0.07100 per input item
Fixer & developer	0.01780 " " "
IBM work card	0.00100 " " "
Diazo ap. cards	0.05931 " " "
	$0.14911 per input item

Output Material Costs:

Quadrant printer	$0.0683 per request

Total annual cost (in dollars) = (41,205)

+ 0.14911 per input item

+ 0.0683 per request

41,205
14,911
9,093
$65,209

COMPARATIVE ANALYSIS
Costs for Initial System
6.B.2.6.

TABLE 6.B-2

SPACE REQUIREMENTS FOR FILMSORT 2000DX (WITH QUADRANT)

	UNIT Dimensions	Estimated Space Required per Unit, incl. work area	INITIAL # of Units Required	INITIAL Space Req.	INTERMEDIATE # Units Req.	INTERMEDIATE Space Req.	FINAL # Units Req.	FINAL Space Req.
	LWH	(sq.ft.)		(Sq.ft.)		(Sq. ft.)		(Sq.ft.)
Filmsort 2000 DX Camera		100*	1	100	3-4	300-400	5-7	500-700
IBM 026 Keypunch		45*	1	45	1	45	1	45
IBM 056 Verifier		45*	1	45	1	45	1	45
IBM ap.card copier		55	1	55	1	55	1	55
IBM 557 Interpreter		45*	1	45	1	45	1	45
Mosler Selectronic Card File		65*	2	130	15	975	30	1950
Quadrant Printer		40**	1	40	3	120	4	160
				460		1585-1685		2800-3000

* Observation of installed units.
** Standard estimate of desk mounted units of 40 sq. ft. per desk unit taken from the Navy Planning Guide and substantiated by observation of installed units.

Appendix 6.C.

NARRATIVE REPORT ON THE HARD COPY QUALITY TEST

Originally, it was planned to process a test batch of 100 documents through each of the six systems in order to provide a basis for timing the input and output operations and technically evaluating the products. However, only one of the systems had sufficient hardware on hand to accommodate that many test documents. The CRIS system, although originally scheduled, had equipment failures and became unavailable over a two month period for even a limited test. It turned out that the OCR/MD 16mm aperture card system was the only one in a position to process the entire test batch. Recordak had the MIRACODE equipment sporadically available, but the MEDIA, Microfiche, and Filmsort 1000d systems had to be tested in various customers' offices. Consequently, the original plan to process 100 documents and to time the various work steps involved had to be abandoned. Instead, a varying number of document pages, from 10 to 50, (depending on the degree to which we disrupted the various user installations) were processed through the several systems described in more detail

below. By necessity, all of the evaluation factors initially hoped for were unobtainable, but this modified test did provide a means of comparing the quality of the final hard copies produced from each of the systems in terms of line resolution and user acceptability.

For the MEDIA test, 50 documents were filmed on a MEDIA camera at the International Machinists Union in downtown Washington. Negative film (16mm Dynacolor) was processed locally. Positive film print was produced, chopped into MEDIA cards and stored in magazines. A few hard copy prints of very poor quality were produced on their Selector-Reproducer. A MEDIA representative then took a magazine of positive film chips to the John Hancock installation in Boston where the Reproducer unit is equipped with a projection printing apparatus rather than the scan type printer used at the Machinists Union. Hard copies produced in Boston from the same file were of tolerable quality. Six of those hard copy prints were used for subsequent comparison test with hard copy prints from other systems. A MEDIA representative also took a batch of documents to Boston and processed them through the entire system there. Hard copy prints from that operation were not quite as good as those filmed here and printed

in Boston. Unfortunately, the filming and printing of a resolution chart was overlooked for this system. However, an estimate of the resolution was calculated by a rough comparison with the microfiche resolution reading. This system as presently constituted cannot handle 8 1/2" x 14" document printout. The enlargement ratio is 95% of original size and the print paper is only 11" in length, therefore about 2" of the document is not covered by the print. This, of course, would be no problem when the MEDIA with roll film output becomes available.

For the MIRACODE test, about 50 documents were recorded on the MIRACODE camera at the local Recordak office. This was after several false starts due to equipment malfunctioning brought on by moving the equipment to and from various business shows. The 16mm film was processed by Recordak and loaded onto a Lodestar magazine. Twenty-five pages were selected and printed on the Lodestar Reader-Printer Model PEK. Selection was made by the keyboard selector. Six prints were used for comparison with prints from other systems.

For the Filmsort 1000d Aperture Card test about 20 documents were filmed at the office of the local 3M Company distributor. Both letter and legal size

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6.C.

documents were filmed. The 'Mil D' aperture cards produced were contact printed onto diazo aperture cards at an Air Force installation in the Pentagon. The diazo aperture cards were used to produce sample hard copy first by using the 3M Quadrant Printer at the local distributor's office and also by using the Xerox 24C at the Vitro Corporation in Wheaton, Md. Prints from both output printers were used in the user comparison survey.

The 16mm aperture card test was conducted using equipment currently located on premises (in OCR/MD). The 'Mil E' aperture cards were mounted and printed using the Photostat Expediter. About 50 documents were processed and from these the six corresponding pages were selected for comparison purposes.

For the microfiche portion of the test, the equipment used was equipment installed at the Office of Technical Services, Department of Commerce. A limited number of documents were filmed on the Microcard Step-and-Repeat Camera (Model SR-1). The processed silver film was duplicated onto diazo roll film and both the silver and diazo rolls were cut into 4"x6" microfiche. Hard copy was produced on the Microcard Enlarger (Model EL-3) from both the silver and the diazo fiche. The output silver paper was processed

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on the Recordak Ektaline Processor. Resultant prints from the original silver which proved superior to those from the subsequent generation diazo microfiche, were selected for user comparison with prints from the other systems.

Twelve Agency analysts who have been regular users of the Intellofax system volunteered to view, compare and rank the hard copy prints, using sample pages that were common to each system. They were asked to give a subject ranking of the four best samples of hard copy for each corresponding page. The individual scores were merged to form a consensus that is shown in Table 6-12.

In general, all of the samples were acceptable by the users, with some preferences being shown for particular systems. And although each candidate system was not tested completely, most of the components (e.g., Xerox Copyflo printer, 3M Quadrant printer) were shown to give satisfactory printing performance. This would seem to permit the generalization that all of the candidates would give varying degrees of acceptable quality hard copy. The only possible exception is the Videofile which requires a less conventional printing technique that has not been demonstrated with that system to date.

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Most of the configurations under consideration provided hard copy at some degree of reduction from the original size. The users had no particular objection to this reduction, and each system with little extra effort or cost could probably be designed to produce exactly the reduction required instead of the reductions indicated in Table 6-12.

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