PILOT PRODUCTION SYSTEM

COST/BENEFIT ANALYSIS
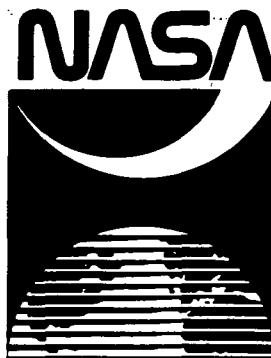
Digital Document Storage Project

FINAL

NASA

STI PROGRAM
SCIENTIFIC &
TECHNICAL
INFORMATION

NASA

Scientific and Technical Information Facility

PILOT PRODUCTION SYSTEM

COST/BENEFIT ANALYSIS

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SUMMARY: The DDS Pilot Production System will provide cost-effective electronic document storage, retrieval, hard-copy reproduction, and remote access for users of NASA Technical Reports. The DDS Pilot Production System will result in major benefits, such as improved document reproduction quality within a shorter time frame than is currently possible. In addition, the DDS Pilot Production System will provide an important strategic value through the construction of a digital document archive.

It is highly recommended that NASA proceed with the *DDS Prototype System* and a rapid prototyping development methodology in order to validate recent working assumptions upon which the success of the DDS Pilot Production System is dependent.

December 29, 1989

Operated by

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MANAGEMENT SUMMARY

This Cost/Benefit Analysis report presents the results of an analysis conducted at the NASA Scientific and Technical Information (STI) Facility during the first quarter of Federal Fiscal Year 1990. RMS Associates, the management contractor for the STI Facility, prepared this Cost/Benefit Analysis report in response to NASA Headquarters Technical Directive (TD) 88-061 issued under contract NASW-4070. This TD has been the primary vehicle for directing the Digital Document Storage (DDS) project at the STI Facility. The report was prepared consistent with the work plan provided by STI Facility staff in response to TD 88-061. The Level of Effort (LOE) resources that were applied to this Cost/Benefit Analysis were authorized through NASA Task Assignment (TA) 90-31.

In order to minimize initial investment in document analysis and user requirements determination for a potential DDS system, NASA directed the use of a project approach based upon a series of speculative rather than actual DDS requirements. Additionally, the current DDS project approach is based upon the deployment of three different system levels: prototype, pilot production, and full-scale. Critical to the successful use of this project approach is the procurement and use of the DDS Prototype System to validate and/or refine the assumptions upon which this Cost/Benefit Analysis of the proposed Pilot Production System was based. Coincident with the delivery of this Cost/Benefit Analysis report, STI Facility staff delivered the Acquisition Plan for the DDS Prototype System required by TD 88-061.

As indicated during previous project discussions between NASA and STI Facility staff, due to the use of the above approach to the DDS project, the estimates of costs and benefits presented in this report must be viewed and used carefully. As explained in the body of the report, changes to individual assumptions or combinations of assumptions that underlie the model for the cost/benefit ratios can produce significant changes to the bottom-line estimated cost and benefit values.

In summary of the findings of this Cost/Benefit Analysis for the DDS Pilot Production System, a cost-effective approach to the development and delivery of enhanced levels of service provided by the STI Facility likely can be achieved using digital imaging technology. The rationale for this conclusion is described in the body of this report.

1–INTRODUCTION AND OVERVIEW

NASA currently is examining the desirability of using digital imaging technology to facilitate operations and enhance services at its Scientific and Technical Information (STI) Facility located at Linthicum Heights, Maryland. As part of that effort, RMS Associates, NASA's STI Facility management contractor, completed the Digital Document Storage (DDS) project's Digital Imaging Technology Assessment report and presented it to NASA in August of 1989. The Digital Imaging Technology Assessment report summarizes the current state of the art in image processing technology and addresses the feasibility of incorporating digital document storage and retrieval techniques into the STI Facility operation. Also in this report, a three-phase project implementation was proposed, including prototype, pilot production, and full-scale implementations.

Although a detailed requirements analysis of the DDS project's approach has yet to be authorized by NASA, the DDS staff has gained considerable insight thus far into the applicability of the technology to the STI Facility's mission. The DDS staff has recommended that the DDS Prototype System be acquired and implemented at the STI Facility to facilitate further investigation of the technology and to develop specific requirements for the Pilot Production System. An acquisition plan for the DDS Prototype System has been developed by STI Facility staff and currently is being reviewed by NASA Headquarters staff. In the meantime, NASA Headquarters staff has directed the STI Facility staff to conduct a Cost/Benefit Analysis to evaluate the relative merits of three alternatives for providing on-demand remote access from NASA Code NTT to a postulated Pilot Production System at the STI Facility. This report presents the results of that Cost/Benefit Analysis.

In order to understand this Cost/Benefit Analysis, the scope of this analysis, and the description of the proposed system are explained in section 2, *Background*. In section 3, *Approach*, many assumptions and constraints that form the basis for the analysis in subsequent sections are presented as well as the analysis methodology. The current system and three remote-access methods are described in section 4, *Description of Alternatives*. Costs and benefits, both tangible and intangible, for these alternatives are provided in section 5, *Costs*, and section 6, *Benefits*, respectively. In section 7, *Comparison of Alternatives*, the alternatives are compared in terms of standard financial evaluation techniques. The sensitivity of total cost per alternative against a variety of tangible benefit values is evaluated in section 8, *Risk Assessment/Sensitivity Analysis*, in addition to a number of risk factors that have been ranked. In section 9, *Analysis of Findings*, and section 10, *Recommendations*, discussions present the critical findings and recommendations regarding the implementation of the proposed DDS Pilot Production System.

The following system objectives represent critical success factors by which the proposed system ultimately will be evaluated and compared against performance of the existing microfilm-based document handling system:

a. Higher quality document reproduction
b. Faster turnaround time for reproduced documents
c. Convenient remote electronic access and document manipulation
d. Reduced labor and equipment costs

The results of this Cost/Benefit Analysis demonstrate the feasibility and benefits of proceeding with the DDS Pilot Production System despite the initial capital equipment costs. DDS has many short term and significant long term advantages including both tangible and intangible improvements to service and the establishment of a sound technological foundation for the future. The most important element to ensure the success of the proposed system is the evaluation of the labor impacts and document volume throughputs by way of a thorough prototyping activity as suggested in the proposed DDS Acquisition Plan document currently under review at NASA headquarters. After an adequate amount of experience and evaluation of this prototype, the major assumptions that underlie the DDS Pilot Production System would be tested and refined. This will reduce the level of implementation risk and maximize the benefits to be derived through the Pilot Production System.

2-BACKGROUND

Having discussed the Cost/Benefit Analysis and DDS project in general terms in the previous section, this next section provides important background information on which the Cost/Benefit Analysis has been developed. The scope of this Cost/Benefit Analysis is presented with an emphasis on anticipated improved service as a result of the DDS Pilot Production System. Corresponding functional characteristics that recently have been assumed are described in a general fashion and then in greater detail.

2.1 Scope of Analysis

This Cost/Benefit Analysis has been developed according to the guidelines as set forth in the NASA Automated Information Management (AIM) Project Feasibility Study and Cost/Benefit Analysis Data Item Description (AIM-sfw-DID-02). For NASA-specific requirements associated with the DDS project, additions to the AIM Cost/Benefit guideline as well as a reorganization of sections was performed. The STI Facility staff estimates that the remote-access delivery method is the most sensitive cost element for full-scale implementation at the estimated 16 DDS remote sites that would be involved. The purpose of this study is to examine alternative mechanisms for delivering a remote access capability for connecting Code NTT to the proposed DDS Pilot Production System at the STI Facility over a five-year life cycle. A cost/benefit description has been developed for each alternative to be examined and the expected cash inflows and outflows pertinent to each are characterized relative to the current method of handling document requests.

NASA Headquarters staff has directed the DDS staff to bypass detailed DDS requirements analysis and workload characterization and to make broad assumptions concerning system requirements, document characteristics, and system configuration for the Pilot Production System, in order to develop a reasonable scenario from which to drive the Cost/Benefit Analysis.

Accordingly, the DDS Facility staff has developed and documented an assumed system configuration for the Pilot Production System upon which all subsequent analysis will be based. A functional description of the characteristics of the proposed system and each of the major subsystems that comprise the Pilot Production System are presented in section 2.2, *Functional Description of the System*. This functional description is an extension of the general functionality presented in section 2.4 of the DDS Digital Imaging Technology Assessment report and in the latest DDS Work Plan, dated October 11, 1989.

The Cost/Benefit Analysis that follows assesses the relative merits of three alternative strategies for implementing on-demand, remote access from NASA Code NTT to the DDS Pilot Production System. No attempt is made to address the relative merits of alternative system

configurations as part of this analysis. The configuration is assumed to be a constant within the alternative comparisons, and parallels the configuration described in the Digital Imaging Technology Assessment report, as per recent NASA Headquarters Code NTT direction.

Further, no attempt is made to assess alternative implementation strategies. Solely for the purpose of this Cost/Benefit Analysis, we have assumed that the implementation approach for the DDS Pilot Production System will be for NASA to enter into a competitive procurement to acquire unbundled hardware and software components in accordance with NASA functional and technical specifications. The STI Facility management contractor then will perform all required systems integration and local customization necessary to make the Pilot Production System operational.

The analysis presented herein is intended to provide a quantitative assessment of the cost/benefit tradeoffs realized in choosing among the three alternative remote-access strategies. The focus on costs and benefits will include both quantifiable and nonquantifiable factors. Emphasis on the benefits side has focused on service and quality improvements in document capture, handling, and reproduction.

2.2   Functional Description of the System

The DDS Pilot Production System functional description contains both general and detailed functional requirements that are described below. The Pilot Production System has the following five system-level functional components (referred to as subsystems):

1. Document capture subsystem
2. Quality control subsystem
3. Document archival subsystem
4. Document reproduction subsystem
5. Remote-access retrieval subsystem

These subsystems and their detailed functions are described in section 2.2.2, *System Description*.

2.2.1   General Description of the Pilot Production System

The life cycle of the DDS Pilot Production System is postulated at five years. This system is to have an operating capability to scan, digitize, and store 5,000 NASA Technical Reports annually at the STI Facility as image files. These image files will consist of digitized bilevel bit-mapped page images from NASA Technical Reports. The technology to store these images will be write-once, read-many times (WORM) optical disk.

To be classified as a NASA Technical Report:

a. A document must be accessioned into the Facility Scientific and Technical Information Modular System (STIMS) 1N series (STAR) or the 1X series (LSTAR);

b. A document must be either wholly or partially sponsored by NASA;

c. A document must be received as hard copy at the STI Facility.

Documents exist that meet the above criteria but will not be included in the DDS Pilot Production System. These documents are:

a. Announcement publications such as STAR and STAR Annual Index;

b. Publications classified as Continuing Bibliographies (SP-7000 series);

c. Any other STI Facility-produced publications, such as AGARD, RTOP, and the NASA Thesaurus;

d. Classified documents: Confidential, Confidential Restricted, Secret, Secret Restricted.

The second primary function required of the Pilot Production System is that it must have an operating capability to reproduce in paper media, copies from the 5,000 NASA Technical Reports archived annually at the STI Facility. This functionality will be supported by providing for service of ad hoc requests for copies of NASA documents. Specific hard-copy (paper) service requirements to handle any production load required of the Pilot Production System, prior to full-scale system implementation, will be determined on a case-by-case basis by the STI Facility staff.

The third primary function required of the Pilot Production System is the provision for on-demand, remote, electronic retrieval at NASA Headquarters Code NTT of DDS image files. This remote-access retrieval is assumed to be limited to the one workstation in the Pilot Production System that will be located at NASA Code NTT. Furthermore, it is assumed that limited distribution technical reports will not be transmitted electronically to the remote workstation.

The Pilot Production System will be an open architecture, distributed processing system based upon a local area network (LAN). The Pilot Production System will consist of dedicated, special-purpose nodes that will be either workstation or server type. Nodes are assumed to be PC compatible devices. System workstation nodes provide the interface for image capture, storing, retrieving, viewing and enhancement of images. System server nodes provide services that can be shared by all the workstations, such as database management, file serving, output and gateway functions.

The STI Facility's DDS Revised Work Plan of October 11, 1989, specifically excludes the following system requirements from being incorporated within the Pilot Production System functionality:

a. Direct interface of hardware or software with NASA/RECON.

b. Enhanced (that is, full-text) search capability.

c. A footnote capability to jump to the text of footnotes.

d. The capability to store, reproduce, or transmit color images.

e. Replacement of current microfiche media and methods for meeting distribution needs.

The DDS Revised Work Plan, however, has no specific exclusion of a link or gateway to the STI Facility's mainframes to obtain information and status of documents from existing files or databases. In addition, there is no exclusion of the use of optical character recognition (OCR) for an appropriate function, such as converting Table of Contents images to text for report subpart access, even though it is understood that full-text recognition during the image capture and storage processes is not required.

2.2.2   System Description

In lieu of a functional description based on a requirements analysis effort, the DDS project staff has assumed a level of functionality for the DDS Pilot Production System in the following sections. The DDS workstations to support the functions (described in section 2.2, *Functional Description of the System*) are considered physical subsystems in that each workstation, to a large extent, provides distributed processing in a stand-alone fashion. Document images are captured page by page in the document capture subsystem via the primary document scanner. When a batch of pages, a partial or complete document, is released to the quality control subsystem, there will be verification against the original hard-copy pages to ensure completeness. Image enhancement, rescanning, or rejection of specific images may occur prior to release of the pages for temporary storage on the rewritable optical disk at the quality control workstation. Figure 2-1, the DDS component functions, show the subsystem functions of the Pilot Production System.

When a group of documents has been reviewed, they will be released for permanent storage in the document archival subsystem. The document reproduction subsystem will retrieve page images for the requested document in the correct sequence for printing on the high-speed laser printer. The remote-access function uses communications equipment in the document archival subsystem to transmit information to and from the remote-access retrieval subsystem that is located at the remote site in the office of NASA Code NTT.

Figure 2-1. *DDS component functions.*

Image Scanning — Image Preview — Enhancement

Accession Vertification — Document Transmission — Communications Management

IMAGE CAPTURE

REMOTE ACCESS

Document Preview — Document Storage — Document Indexing

DOCUMENT ARCHIVAL

Table Of Contents Processing — OCR Processing — Database Management

QUALITY CONTROL

DOCUMENT REPRO–DUCTION

Image Inspection — Page Rescanning — Gray Scale Processing — Final Enhancement

Printer Control — Print Job Scheduling — Queue Management — Document Retrival

2.2.2.1   Document Capture Subsystem

The document capture workstation serves as the front-end station of the digital imaging system. Its primary function is to convert hard-copy NASA Technical Reports into an electronic, digitized form that subsequently can be maintained, stored, displayed, and printed by operators on the other workstations.

The document capture function is supported by hardware and software components integrated together around an 80386-based microcomputer to perform key document capture activities. Subfunctions to be performed by the document capture subsystem are:

a. Image scanning

b. Previewing the captured image

c. Control of the document capture workstation

2.2.2.1.1   Image Scanning

The image scanning subfunction is the process whereby a hard-copy document is scanned by a hardware device and the image is converted to digital form. The Pilot Production System is required to have the capability of processing 5,000 documents per year with an average size of 50 pages per document, where a document equates to a NASA Technical Report accession in the STIMS database.

Although a detailed document characterization study has not been authorized by NASA, initial analysis by the STI Facility staff indicates that an appropriate scanning capability must incorporate the following characteristics:

a. Control of the scanning process using a variable scan resolution up to 300 dots per inch (dpi).

b. A scanner configuration capable of handling bound and unbound documents, landscape and portrait orientations, dithering, automatic paper feed, and a 50- to 100-sheet capacity is essential to handle the input document variation.

c. Capability of providing acceptable quality image capture of the high proportion of halftone photographs prevalent in NASA Technical Reports.

2.2.2.1.2   Previewing the Captured Image

The operator controlling the input processing functions will have available a 19-inch high resolution monitor (with a minimum resolution of 120 dpi) that will provide a means of previewing the scanned image and interfacing with the software that controls the scanning process via menu driven selection screens.

The monitor will be capable of displaying the entire scanned page on the screen at one time. Applicable commands, options, scanning parameters, etc. will be displayed simultaneously on a display window side-by-side with the image. Zoom capability will be available to allow the operator to display the full resolution of the image as captured by the scanner.

2.2.2.1.3   Control of the Document Capture Workstation

The high-resolution monitor, associated keyboard and mouse device located at the document capture workstation will be the primary interface mechanism through which the operator will control all document capture functions. At this workstation, an operator will use a user-friendly, menu-driven interface that can be easily mastered by clerical personnel with no prior knowledge or experience in computer operations. Formal training will be required to prepare the operator for the document capture function. The interface will be sufficiently simple so that operator requirements can be mastered with a minimum of hands-on training.

The following is an exemplary, but not exhaustive, list of control functions that will be provided:

a. Specification of scan control parameters (scan resolution, dithering, etc.)

b. Initiation of scan processing

c. Display and manipulation of scanned image

d. Rescan initiation

e. Initiation of Table of Contents processing sequence

f. Windowing control functions

g. Storage and retrieval of scanned image in document capture queue

h. Input of document characterizing variables

i. Flagging to system that a document has been captured and should go to the quality control workstation for further processing

2.2.2.2   Quality Control Subsystem

The quality control workstation requires the same functionality as the document capture workstation but at much higher resolutions and shades of gray. Additionally, the quality control workstation provides the need or opportunity to inspect, verify, dither, and enhance the images of documents before they are forwarded to be archived.

The following list give additional quality control subfunctions that will be provided but were not stated in detail previously:

a. Initiation of quality control processing

b. Display and manipulation of scanned image

c. Windowing control functions

d. Storage and retrieval of scanned image in quality control processing queue

e. Input and checking of document characterizing variables

f. Flagging to system that a document has completed quality control processing and should go to document archival for further processing

2.2.2.3   Document Archival Subsystem

The document archival subsystem consists of the following subfunctions:

* Checking of document descriptive information

* OCR processing

* Table of Contents indexing

2.2.2.3.1   Checking of Document Descriptive Information

It is anticipated that the Pilot Production System will have electronic retrieval of NASA/RECON surrogate records with read-only access for validations of reproduction requests in terms of user profile and document limitations. On a periodic basis, a temporary file of accession numbers will be provided to NASA/RECON by DDS staff indicating that the digitized form of the NASA Technical Report is available in the electronic document archive. These newly acquired document accessions could be used to indicate their availability in electronic form for ordering via NASA/RECON by way of setting a flag in the appropriate STIMS record. Also, newly acquired hard-copy documents within the Input Processing System (IPS) of the current system, could be listed for use by DDS operators.

These document control files will not only allow look-ahead management control, but also provide the ability to automate much of the document management process. The operator will be required to input into the DDS document control files certain additional descriptive textual information to identify and characterize the document that is going into the document archive. Examples of textual information that might be captured are:

a. Accession number
b. Document title
c. NASA document number
d. Document date
e. DDS archival processing date
f. DDS operator's initials
g. OCR processing of DDS image page portions
h. Captured document image for previewing pages
i. Table of Contents
j. Additional document identification, tag, and description

2.2.2.3.2   OCR Processing

The Optical Character Recognition (OCR) subfunction scans the input document to convert characters into digital form. NASA requires this capability to capture the document Table of Contents (if one exists) so that direct, nonsequential access to a subsection of the document can be provided. OCR processing will also display to the operator any characters that cannot be deciphered and present an opportunity for the operator to resolve manually any discrepancies.

2.2.2.3.3   Table of Contents Indexing

NASA requires that for those documents that contain a Table of Contents page, information must be captured that will allow a user to point directly to any section of the document referenced in the Table of Contents. This will comprise the nonsequential access capability of the Pilot Production System for jumping into the body of a document without paging sequentially through its entire length.

2.2.2.4   *Document Reproduction Subsystem*

This subsystem will have control of the DDS printers located at the STI Facility, the print queue, and the printing process. It will have total management control over the sequence of print jobs including access and priority functions. It will automatically notify the operator of printer status and action steps that need to be taken. Jobs will be able to be dynamically stopped, started, and requeued.

2.2.2.5   *Remote-Access Retrieval Subsystem*

The remote user at NASA Headquarters Code NTT will be able to request either entire documents by accession number or their subparts by a Table of Contents lookup. Once these images are received, they may be either viewed on the remote workstation monitor or directed to be printed locally. This will be an automated process requiring no previous training to operate the subsystem or special skills to navigate for access. NASA Technical Reports with limited document distribution attributes (that is, 1X series reports) will not be transmitted remotely as a precaution against unauthorized access or viewing. Figure 2-2, the DDS remote workstation, shows the components necessary for remote-access retrieval of digitally stored document images.

The remote workstation provides the user with electronic images of NASA Technical Reports for display, manipulation, storage and printing. There are two postulated modes of operation at the remote workstation: batch/deferred or interactive processing. In batch/deferred mode, documents are transferred, at a specified time, from the document archive to the local storage medium (hard disk, rewritable disk, or tape drive) for later processing. In interactive mode, the remote user will request a specific document by accession number and resolution level (low for display only and high for printing letter-quality pages).

If the desired document is available within the DDS document archive, then the first page image will be displayed on the remote workstation screen. If the requested accession number is invalid within DDS, then an appropriate warning message will be displayed on the remote user's screen. The simplest form of interactive viewing is the sequential browsing of images in page sequence using the cursor keys or the page up or

Figure 2-2. *DDS remote workstation.*
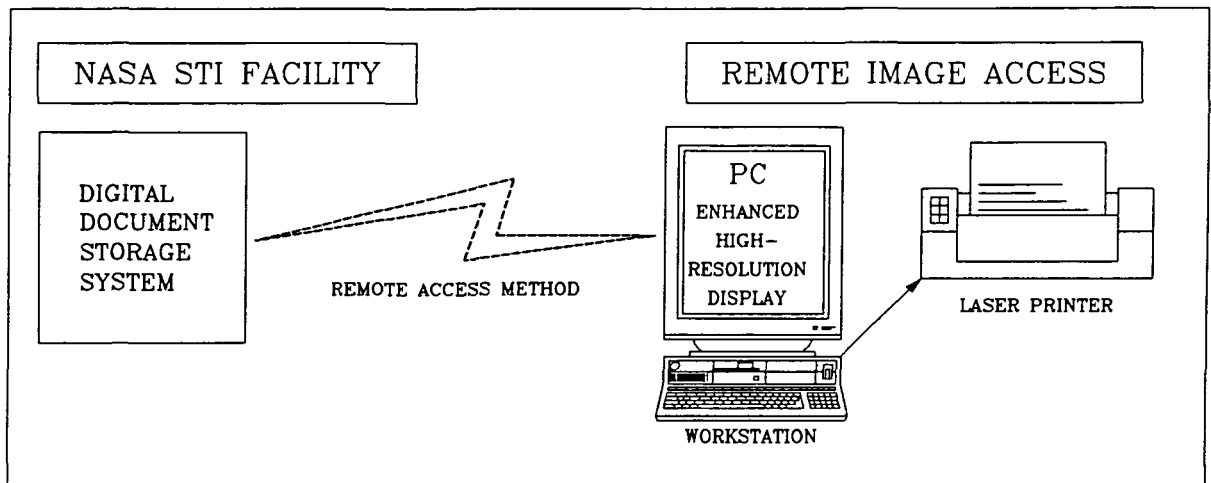
page down keys. Context sensitive help is available at any point in the remote retrieval session by selecting the F1 function key. See appendix C–*Remote-Access Retrieval Description*, for a more detailed description of a remote-access workstation session.

2.3 Environment

The proposed DDS Pilot Production implementation is, with few exceptions, designed to operate as a totally independent automated system with no interfaces to existing application systems or document processing workflows. Because the DDS platform will use stand-alone, special-purpose, PC-based workstations to be procured specifically for that purpose, hardware and operating system compatibilities with other, existing systems are not, for the most part, a consideration.

An exception to this is the potential need for compatibility with the existing communications environment for implementing the remote-access retrieval capability. See section 4.3, *Alternative Approach 1 —Mainframe Communications Support*, for a more detailed description of the anticipated communications configuration requirements.

The other notable exception will be the need to coordinate DDS document request processing with the existing STI Facility document request workflow. A detailed process definition effort will be necessary to establish the best method of interrupting the current workflow to divert appropriate DD492 requests to the DDS system for processing.

Additionally, consideration must be given to developing new procedures for validating document requests, determine the limitations of the requestor's user profile, and enforcing the dis-

tribution constraints on each document to be reproduced by DDS. It is anticipated that these details will be resolved in the first six months of the DDS Pilot Production System as part of the system analysis effort referred to as the process definition task.

For the purposes of this Cost/Benefit Analysis, it is assumed that these requirements can be met through existing mechanisms used for microfiche blowback and minimal effort will be necessary to tailor those procedures for DDS reproduction. No consideration has been given in this analysis to software development efforts to automate a DDS–NASA/RECON–STIMS interface to access user profile and document distribution limitations for DDS document blowback. Consideration should be given, however, to such an automated interface before a full-scale system configuration is finalized.

3–APPROACH

The previous section dealt with background information such as the scope of this Cost/Benefit Analysis and a description of the DDS Pilot Production System from a functional viewpoint. This next section identifies a number of critical assumptions upon which the functional description of this system is based. Also, assumptions and constraints pertaining to this analysis effort are provided. These assumptions and constraints pertain to:

* DDS Pilot Production System in general
* Document characteristics and capture volumes
* Electronic reproduction volume
* Labor requirements
* Remote-access characteristics and retrieval volumes
* Local communications traffic
* Access control and quality control requirements
* Evaluated alternatives
* Cost and benefit characteristics

Finally, the methodology for performing this Cost/Benefit Analysis is discussed at the end of this section.

3.1 Assumptions and Constraints

Due to the absence of a requirements analysis of the DDS functionality at the STI Facility and remote sites, a number of assumptions were made in order to derive a cost/benefit profile of the Pilot Production System implementation. Additionally, critical system characteristics and labor skill-level information is unavailable until the DDS Prototype System is acquired and evaluated. The following narrative highlights critical aspects underlying this Cost/Benefit Analysis that were based upon minimal information and data sources. Any change in the following assumptions could affect this Cost/Benefit Analysis, and would require additional analysis.

3.1.1 System Constraints

The Pilot Production System life cycle is five years. Although it is highly unlikely that this amount of time would be required to fulfill the Pilot Production System objectives as stated in section 1, this Cost/Benefit Analysis was developed under the premise of a Pilot Production System five-year life cycle. The Pilot Production System will provide all of the functionality that is required in a full-scale system with the following single exception:

Only a single remote site will be supported at NASA Headquarters Code NTT; communications equipment and STI Facility central-processing capabilities are sized for only 1 remote link rather than the minimum of 16 links that would be required in a full-scale system.

DDS is designed to provide centralized electronic capture and storage of a maximum of 5,000 NASA Technical Reports yearly and approximates 90 percent of the NASA Technical Reports acquired annually. (This document capture volume could be increased with additional resources and planning.) All document capture is based on availability of original hard-copy reports from a day-forward viewpoint; neither back-file conversion nor microform scanning has been considered in the Pilot Production System. Centralized document reproduction from the DDS document archive will be by way of local electronic access from the WORM optical disk storage media and use of a laser printer. It is assumed that this will be accomplished in a shorter time frame than current methods of microfiche blowback and at higher-quality levels.

3.1.2   System Configuration

The proposed DDS Pilot Production System configuration is comprised of equipment at the central processing site (located at the STI Facility) and one remote workstation with accessories (located at NASA Headquarters Code NTT). A graphic representation of the Pilot Production System is provided in Figure 3-1, the Pilot Production System configuration. The major hardware and software components required at both locations are listed in appendix A–*Assumed Pilot Production System Configuration*. The equipment list varies according to three alternatives, as indicated in appendix A. The guidelines for the Pilot Production System configuration and system acquisition strategy are as outlined in the Digital Imaging Technology Assessment report. Additionally, solely for this Cost/Benefit Analysis, it was assumed that the implementation strategy will be an unbundled, component-level procurement with system integration performed at the STI Facility and customization for the NASA environment. The open architecture design for the Pilot Production System will enable the insertion of new technology in the future that could facilitate a quicker transition into a full-scale system before the end of the five-year life cycle of the Pilot Production System.

Differences between functionality described in the Digital Imaging Technology Assessment report and later NASA Headquarters Code NTT guidance involve a scaling down of mainframe-level integration with NASA/RECON and the elimination of full-text capture, search, and retrieval at this time. Remote workstation functionality details are based on materials presented at the *May 1989 NASA STI Conference* and the assumed functional capabilities discussed in section 2.2.1, *General Description of the Pilot Production System*, of this Cost/Benefit Analysis.

Figure 3-1. *Pilot Production System configuration.*
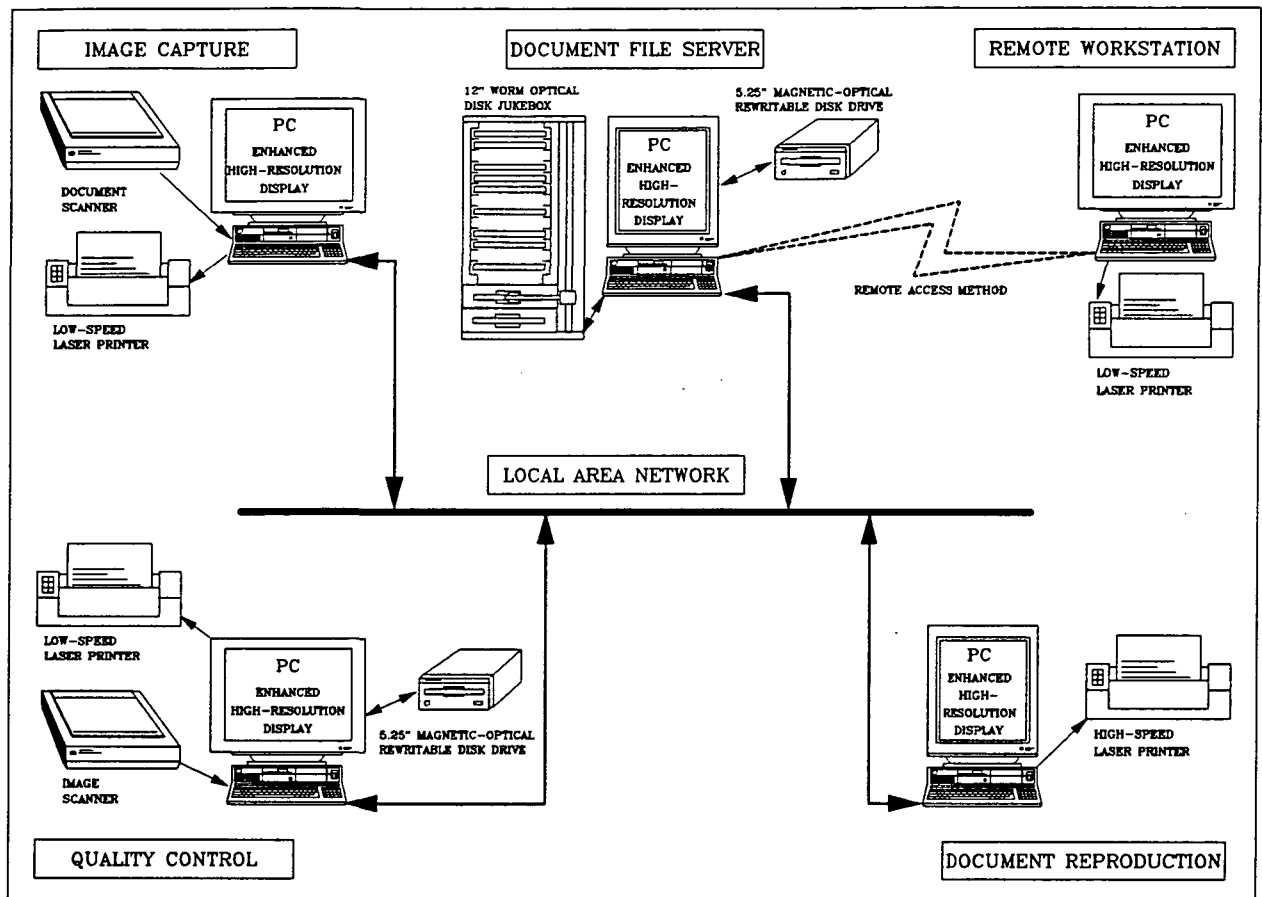
There are numerous technical issues that are normally addressed during a requirements analysis effort. Research over the last 20 years indicates that the costs associated with errors made in the early stages of the system life cycle are much cheaper to fix and have less implementation impact than errors made during the later stages (for example, it is better to fix a design problem or omission on paper than after a system has been developed and/or is in operation). Vital information affecting system sizing, development and operational personnel, user requirements and security issues have not been discussed with NASA Headquarters staff or any other potential DDS users. Quantitative and qualitative characteristics were assumed in the following sections corresponding to many of the subjects often documented in a requirements analysis study.

3.1.3   Document Characteristics

Specifics of the types of documents to be captured and stored in the proposed system can greatly affect the scanning, quality control, and image enhancement tasks in addition to the

skill level required to accomplish those tasks. Volume projections for the entire Pilot Production System life cycle have their basis in assumptions about the average page size per acquisitioned document. Also, other system design considerations (such as access limitation) are impacted by document characteristics.

The salient document characteristics are the following:

* Page specifications for document scanning are:
    * must be 8.5-by-11-inch size paper
    * conforms to scanner's operational thresholds (range of paper thickness and texture
* Scanned pages will be stored as bilevel (black-and-white)
* The average number of pages per document accession is 50
* No classified or limited distribution documents will be transmitted to the remote site
* Estimated percentage of pages requiring reprocessing is 10 percent
* Estimated percentage of pages to be image-enhanced is 5 percent
* A document is defined as a Scientific and Technical Information Modular System (STIMS) database accession and is equated with a database surrogate record. Due to the procedure for creating database accessions/records, a single printed NASA Technical Report may result in the creation of multiple database accessions/records. In all instances in this report where the term "document" is used, it is used to refer to a STIMS database accession/record.

3.1.4   Document Acquisition

Document acquisition for the DDS Pilot Production System is envisioned to occur after the current microfiche capture procedures are completed. This will minimize the operational impact on existing document accessioning efforts. Figure 3-2, the NASA Technical Reports yearly accessions, gives the number of accessions per year for the past 21 years.

Figure 3-2. *NASA Technical Reports yearly accessions.*

NUMBER OF ACCESSIONS
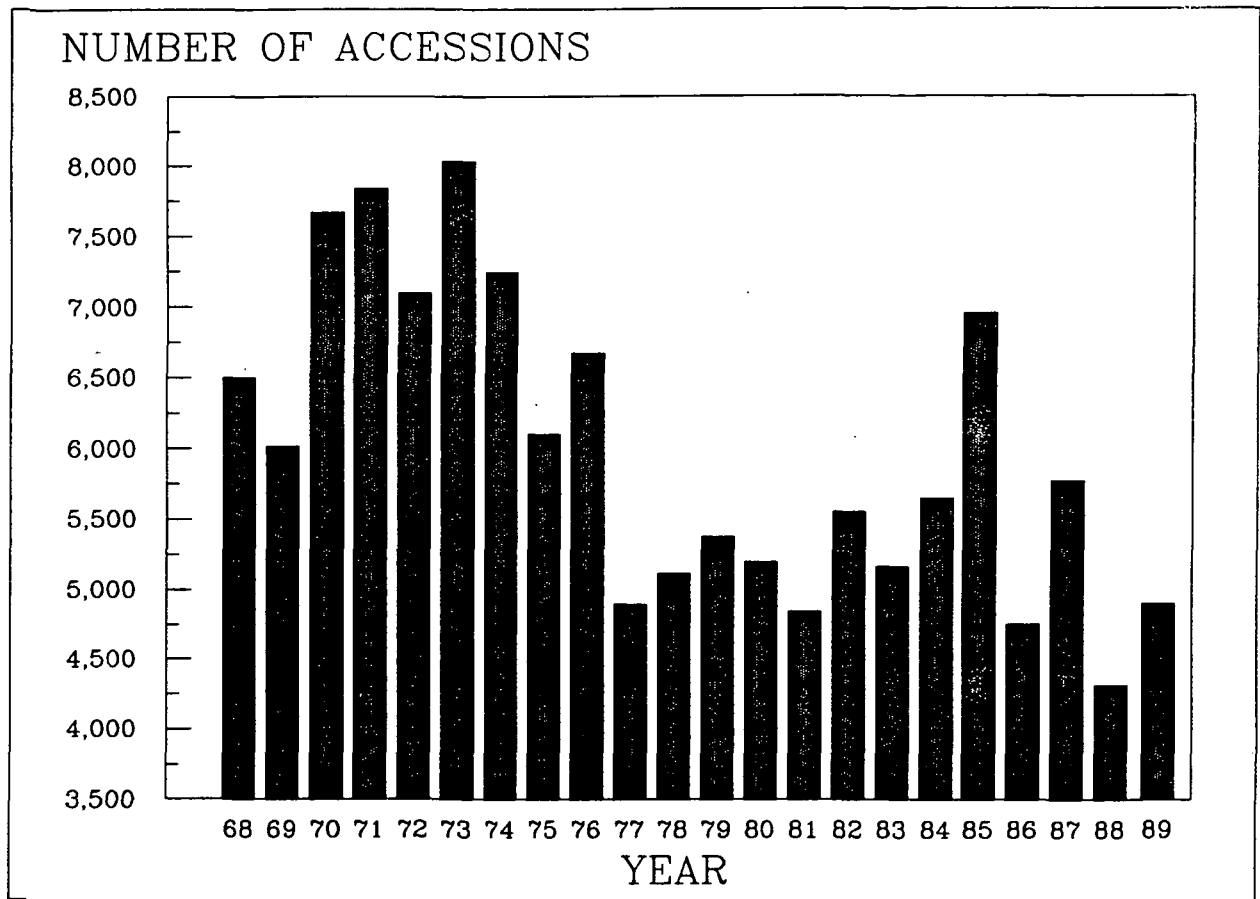
The estimated volume of image pages, 1,000 pages per day, is derived by multiplying the current number of documents per year (5,000) by the average number of pages per acquired document (50) and the dividing by the number of workdays in a year (250) as shown below:

$$\frac{5,000\,documents\ per\ year \times 50\,pages\ per\ document}{250\,days\ per\ year} = 1,000\,pages\ per\ day$$

Table 3-1, the document acquisition volume, provides a breakdown of the estimated annual volume of scanned documents, average daily volumes, and the size of the DDS document archives by operational year. The operational year starting month is the first time document images are captured in production volume and starts at Month 7 of the Pilot Production System life cycle base year.

TABLE 3-1. *Document acquisition volume.*

OPERA-TIONAL YEAR[a]	ANNUAL VOLUME (DOC.)	AVG. DAILY VOLUME (PAGES)	ARCHIVE SIZE (DOC.)	ARCHIVE SIZE (PAGES)
One	5,000	1,000	5,000	250,000
Two	5,000	1,000	10,000	500,000
Three	5,000	1,000	15,000	750,000
Four	5,000	1,000	20,000	1,000,000
Five	5,000	1,000	25,000	1,250,000

[a]   *Operational year starts at Month 7 of the Pilot Production System life cycle base year.*

3.1.5   Reproduction Workload

Estimated centralized reproduction volume of all NASA Technical Reports, which was broken down by month in the DDS Alternative Media Reproduction Volume (Blowback) Report (dated February 28, 1989), is depicted in Figure 3-3, the projected number of pages printed during the Pilot Production System life cycle.

The projected volume of pages by operational year and the maximum daily volume is presented in Table 3-2, the estimated reproduction volume. The maximum daily volume is useful in assessing equipment capability and performance for peak system activity. The numbers used in Table 3-2 were extracted from appendix D–*Monthly Reproduction Workload.* See Figure 3-4, the number of NASA Technical Report pages printed per month, for a graphic representation of the reproduction volume.

Figure 3-3. *Projected number of pages printed during the Pilot Production System life cycle.*

NUMBER OF PAGES PRINTED

DDS PILOT PRODUCTION SYSTEM LIFE CYCLE (YEARS)
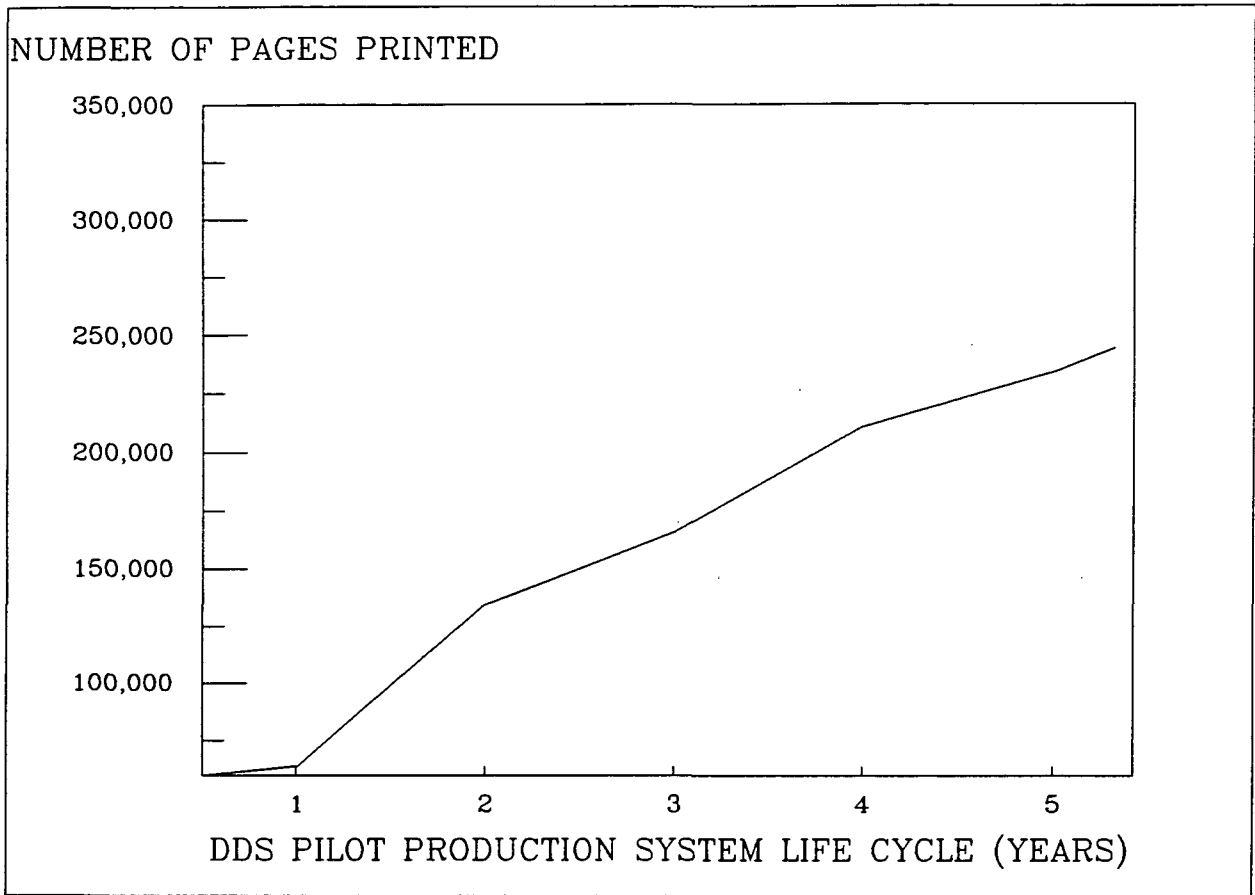
Table 3-2. *Estimated reproduction volume.*

OPERATIONAL YEAR[a]	ANNUAL VOLUME (PAGES)	MAXIMUM DAILY VOLUME (PAGES)
One	63,331	441
Two	134,236	550
Three	165,318	705
Four	210,718	868
Five	233,936	894

[a] *Operational year starts at Month 7 of the Pilot Production System life cycle base year.*

Figure 3-4. *Number of NASA Technical Report pages printed per month.*

NUMBER OF PAGES PRINTED
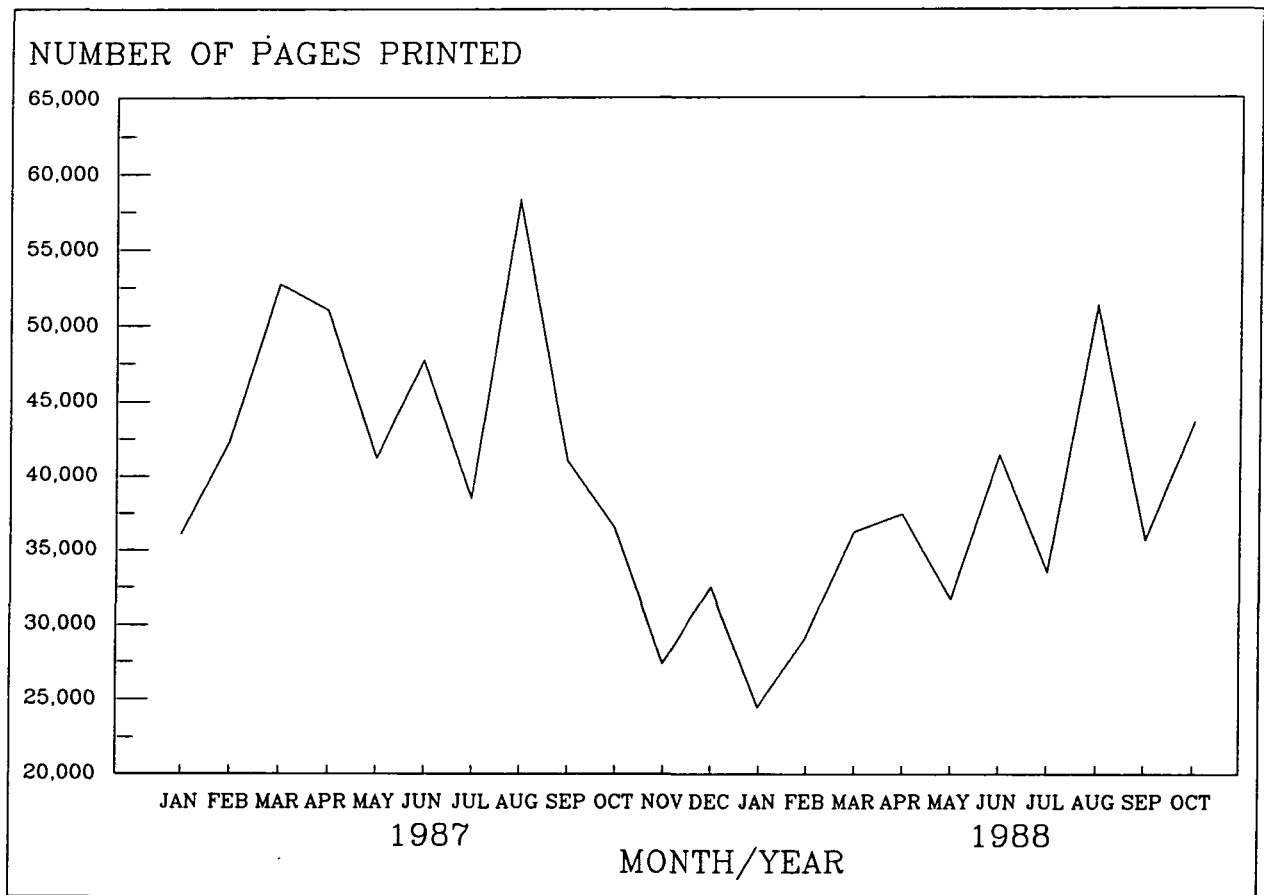
The maximum daily volume column represents the peak daily volume at the end of the year and is based on the data from appendix D. It is assumed that the full-time staff will easily handle the cyclical reproduction volumes within the STI Facility service windows and manage the workload of lower priority tasks accordingly without the need for any overtime.

3.1.6   Labor Requirements

The DDS Pilot Production System primarily requires document scanning quality control and reproduction labor skills at different levels throughout the Pilot Production System life cycle. Labor requirements for the DDS Pilot Production System begin at 1.5 full-time equivalent (FTE) staff at the STI Facility in the first year and increase to 2 FTE staff by the fifth year. The DDS labor requirement is in addition to current operational personnel. There are no additional FTE labor requirements at the remote site, although the designated NASA System Administrator will have ongoing responsibilities that may affect collat-

eral duties. The remote site System Administrator will coordinate access control, the maintenance and distribution of passwords, manage local document storage and perform other remote workstation control duties.

The labor skill levels at the STI Facility vary from the medium- to supervisory-level clerical categories with personal computer experience. The medium-level position, Document Imaging Specialist, is responsible for document preparation, the primary scanner workflow and document reproduction. This position requires training and experience in the operation of modern reprographics equipment such as large copying machines and laser printers.

The Senior Document Imaging Specialist, acting as a working supervisor, will be cross-trained in the Document Imaging Specialist duties and also perform quality control reviews and image enhancement. A background in computer graphics and micrographic quality assurance procedures is desirable for this role in addition to the Document Imaging Specialist job experience. The Senior Document Imaging Specialist will serve as the DDS Supervisor, managing the documentation clerical staff and serving as the DDS System Administrator including LAN management responsibilities.

Although the average daily document capture volume will remain constant at 20, the overall workload is expected to increase with additional reproduction requests and other increasing system-management responsibilities. The total staffing level is represented as the number of FTE personnel assigned to the DDS Pilot Production System at the end of each year. Refer to Table 3-3, the estimated labor requirements in FTE, for staffing levels during implementation of the DDS Pilot Production System.

The amount of supervision task FTE is assumed to be one-half due to administrative and management report responsibilities in addition to ongoing operational duties. The document capture FTE is also constant due to the anticipated constant document acquisition volumes. The amount of document reproduction is a function of the size of the digital document database archive from which reproduction requests can be satisfied. This amount starts at a low figure and gradually increases throughout the Pilot Production System life cycle.

Table 3-3. *Estimated labor requirements in full-time equivalents (FTE).*

OPERATIONAL YEAR[a]	SUPERVISOR	DOCUMENT CAPTURE	DOCUMENT REPRODUCTION	TOTAL LABOR
One	0.50	1.00	0.16	1.66
Two	0.50	1.00	0.31	1.81
Three	0.50	1.00	0.37	1.87
Four	0.50	1.00	0.45	1.95
Five	0.50	1.00	0.50	2.00

a Operational year starts at Month 7 of the Pilot Production System life cycle base year.

3.1.7 Remote Access

The remote-access delivery volume—either by transmission or physical distribution—is assumed to be identical to the calculated number of document pages ordered by Code NTT during calendar year 1988 and ignores the possibility of significantly increased demand due to availability of electronic access in a convenient manner. It is assumed that an equivalent number of remote-access pages will be delivered as those resulting from existing request procedures. This results in an anticipated increase in delivery of twice the number of pages delivered to a typical remote site, including both the blowback and remote-access volumes, and therefore represents a conservative estimate.

Table 3-4, the number of processed requests, shows the requests from NASA (including all NASA Centers). The maximum daily volume calculation was performed by multiplying the annual volume of reproduction pages, by the percentage of reproduction requests in 1987 and 1988 from NASA Centers, which is 85 percent. See Figure 3-5, the number of requests by type of requestor, for the breakdown of NASA and non-NASA requests.

Table 3-4. *Number of processed requests.*

TYPE OF REQUESTOR	NUMBER OF PROCESSED REQUESTS			
	1987	1988	TOTAL	PERCENT
NASA and NASA contractors	3,024	3,318	6,342	85
All others	526	688	1,214	15
GRAND TOTAL	3,550	4,006	7,556	100

Figure 3-5. *Number of requests by type of requestor.*
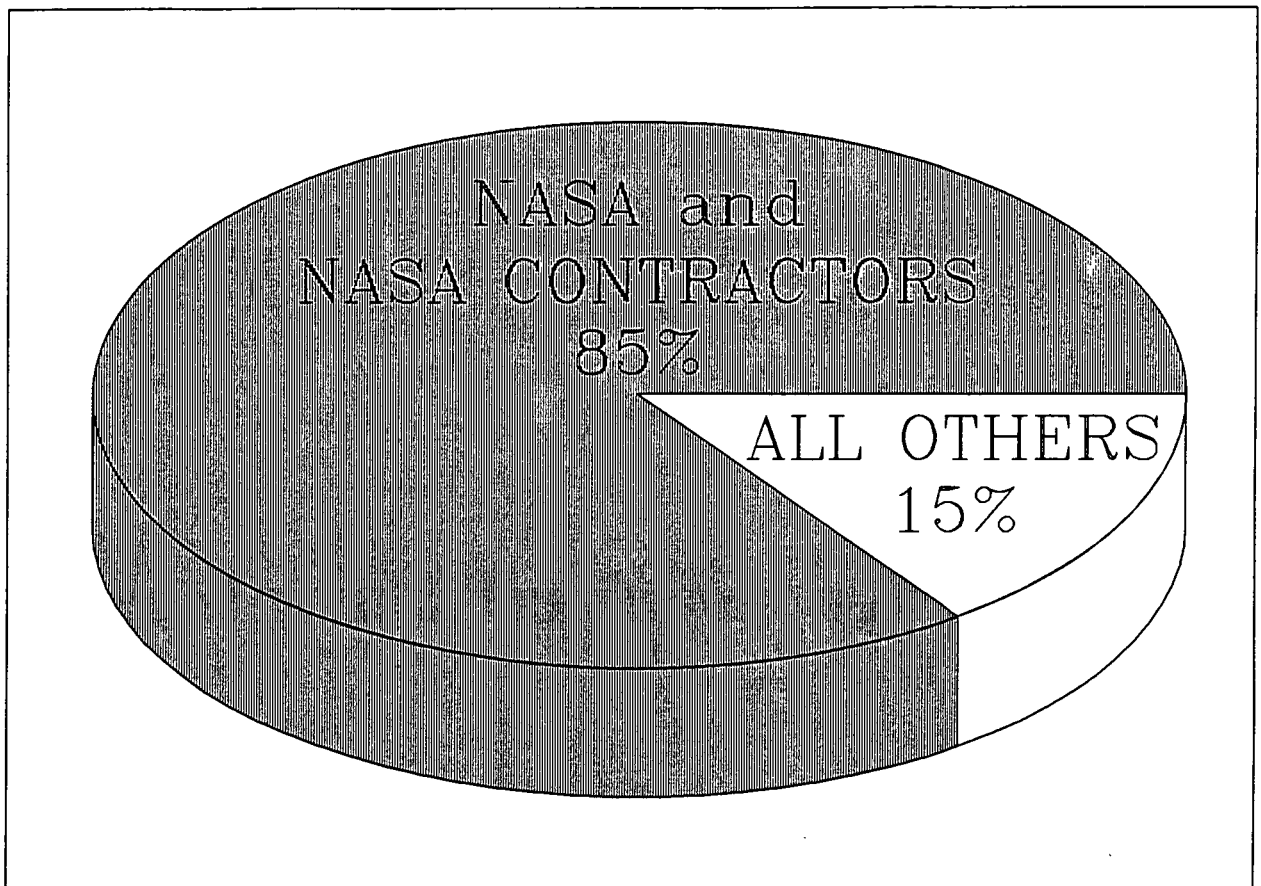
As shown in the equation below, the product of the number of NASA and non-NASA requests is divided by the number of NASA Centers plus Code NTT, which is 16, and further divided by the number of work days per year, which is 250. Refer to appendix A-5 in the Alternative-Media Reproduction Volume (Blowback) Report for the source data used to calculate the average percentage of NASA reproduction requests for 1987 and 1988.

$$\frac{annual\ volume\ of\ reproduced\ pages \times .85}{16\ remote\ sites \times 250\ days\ per\ year} = maximum\ daily\ volume$$

Each year an increasing percentage of requests will be filled via DDS due to the constant addition of NASA Technical Reports to the document archives. The number of pages printed at the remote site is assumed to be the same as the number of delivered pages per operational year as listed below in Table 3-5, the estimated remote-site printing volume.

Table 3-5. *Estimated remote-site printing volume.*

OPERATIONAL YEAR[a]	ANNUAL VOLUME (PAGES)	MAXIMUM DAILY VOLUME (PAGES)
One	3,364	13
Two	7,131	29
Three	8,783	35
Four	11,194	45
Five	12,428	50

[a] *Operational year starts at Month 7 of the Pilot Production System life cycle base year.*

An important objective is to minimize the cost involved in delivering the document images to the remote site to encourage the use of this new service. Other solutions to the remote-access method must be sought to provide the best service possible at the least cost. Primary benefits to processing and maintaining a digitized document database centrally are the consolidated services, access capability, minimizing of media handling, and coordination with NASA/RECON.

3.1.8   Local Communications Traffic

No local area communications bottleneck is expected within the STI Facility DDS Pilot Production System due to image-capture traffic and retrieval requests because of the temporary image-buffering design using a magneto-optical (M-O) drive at the quality control workstation. This buffering minimizes image traffic in all cases, which should reduce the chance of collision on the LAN. Also, the remote-access retrieval traffic is expected to be infrequent, intense, and of limited duration (less than one hour). Coordination of local and remote traffic will be accomplished by way of file management access priorities. Workload smoothing will play an increasingly important role in providing a high level of service in the later years of the Pilot Production System.

3.1.9   Access Control

The only access to DDS is by entering a valid STIMS database accession number. Since classified documents will not be stored in the Pilot Production System, no additional security is required. Limited distribution documents (that is, the 1X Series) will not be available remotely through DDS.

3.1.10 Quality Control

The STI Facility will use the current micrographics quality control procedures as the baseline for the scope and level of effort required in the DDS Pilot Production System quality control workstation. These procedures will be supplemented by the guidelines set for the American National Standards Institute/Association for Information and Image Management (ANSI/AIIM) MS44, Scanner Test Targets.

3.1.11 Alternatives

The selection of alternatives for cost and benefits comparison was determined by the most sensitive cost element, the remote-access document delivery method. A wide variety of approaches and methods was considered, but by no means have all alternatives been identified.

3.1.12 Costs

Although a detailed cost analysis was not performed, most of the significant cost items are assumed to have been addressed in section 5, *Costs*. Most cost items had either insignificant or no recurring costs. The value of equipment salvaged at the end of the Pilot Production System five-year life cycle was not included since it is not a determining factor in the comparison of alternatives and probably would not be resold due to its low residual value. Also, labor costs are based on the STI Facility contractor's current labor rates remaining constant.

3.1.13 Benefits

The two benefits that have been quantified, reproduction request servicing turnaround time and image reproduction quality, were assigned a range of values rather a single assumed value. Although the assignment of benefit values is a subjective process, it is assumed that the value of improved image quality and faster turnaround time are both at least $.56 per page.

3.2 Methodology

This Cost/Benefit Analysis was conducted using established methods based on standard discounted cash-flow techniques for determining the present value of the pertinent cost and benefit items for each alternative.

Figure 3-6, a cost/benefit quantitative model, presents a schematic representation of the modeling process used to support the Cost/Benefits Analysis of the DDS Pilot Production System.

Figure 3-6. *Cost/benefit quantitative model.*
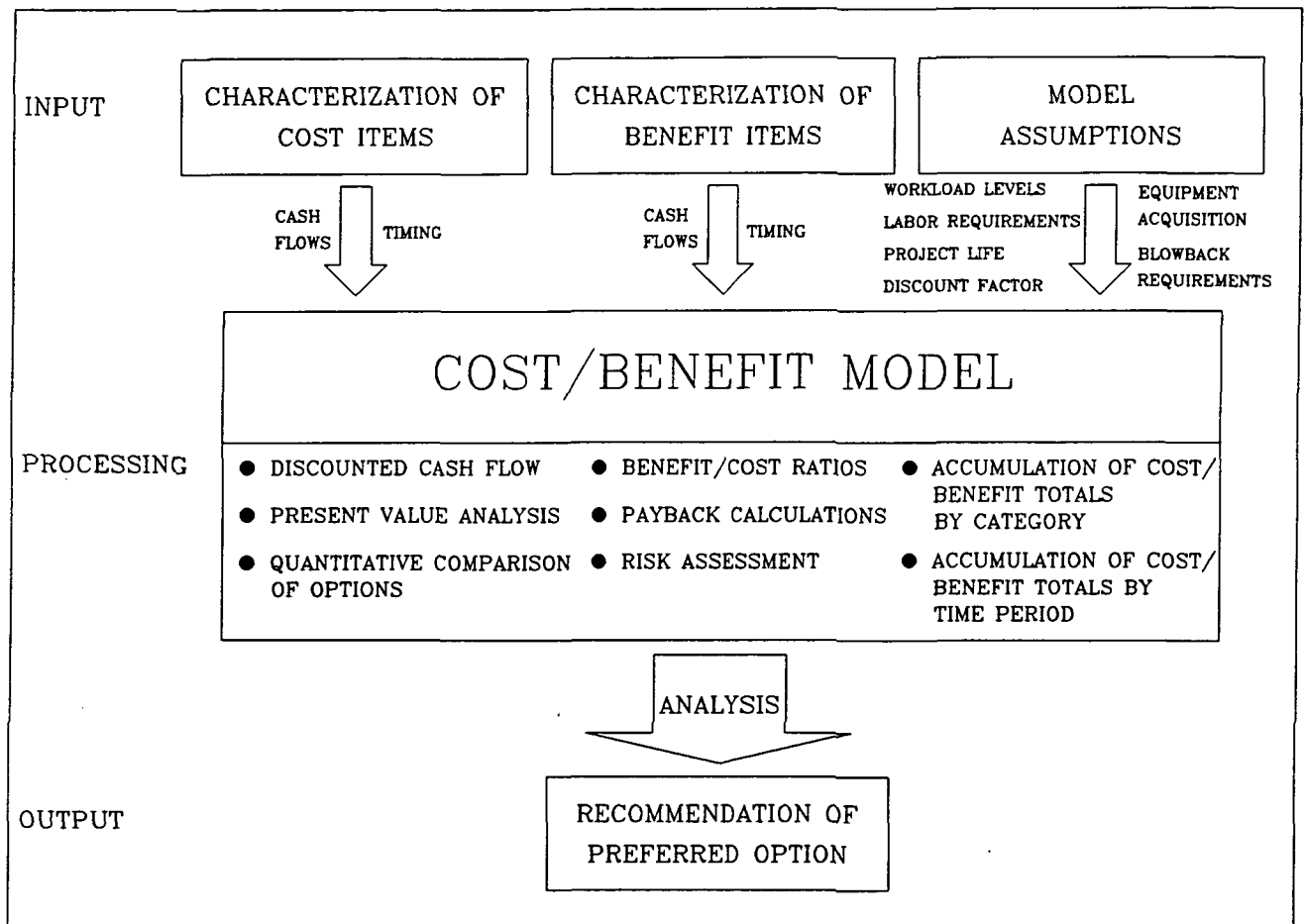
Discounted cash-flow analysis is a modern approach to judging the relative merits of alternative implementation strategies by characterizing all cash inflow (benefits) and outflows (cost) associated with each alternative over the proposed system life. The timing of those inflows and outflows must be defined relative to the start of the project.

Discounted cash-flow techniques recognize the inherent time value of money. That is, money received earlier has a greater value than money received at a later time. To reflect this, all cash inflows and outflows are discounted with an appropriate discount factor to convert them to an equivalent time frame—the start of the Pilot Production System. This discounted value for the cash flow is called the "present value" of the future cash flow.

The sum of all of the present value cash flows for an alternative is the net present value (NPV) of all cost and benefits for that alternative. If the NPV is positive for an alternative, its time-valued benefits outweigh its costs and it is viable from a cash-flow standpoint. If the NPV for

an alternative is negative, its costs exceed its benefits over the life of the project. In comparing alternative strategies, the alternative with the highest NPV returns the highest level of benefits for the costs incurred over the life of the Pilot Production Systems.

In accordance with AIM Cost/Benefit guidelines, this study also presents the traditional measures—total nondiscounted cost, total nondiscounted benefit, cost/benefit ratios, and payback periods—for each of the three alternatives. The cost/benefit ratio is simply the total benefit divided by total cost in discounted terms for a given alternative. The payback period for an alternative is the length of time required for the stream of cash proceeds generated by the investment to equal the original cash outlay.

The following costing assumptions have provided the basis for performing the Cost/Benefit Analysis of remote-access alternatives for the Pilot Production System:

a. All cash flows are stated in terms relative to the cost/benefit ratios that would derive if the current document handling methods were continued over the life of the Pilot Production System. In other words, all costs are incremental costs and all benefits are incremental benefits for the DDS treatment as compared with the comparable cost or benefit that would be achieved if no changes were made to the current micrographics-based treatment.

b. A discount rate of 10 percent is assumed for purposes of present value calculations for all future cash inflows and outflows.

c. The DDS pilot project under evaluation is assumed to have a system life of five years. The DDS equipment is assumed to have little or no residual value at the end of the five-year period for each of the three alternatives examined.

d. All cash flows are time-phased in one-month intervals with each cash inflow or outflow assumed to take place at the end of the period in which it falls.

e. The implementation phase of the Pilot Production System is assumed to require a six-month period, during which time equipment will be installed, tested, and integrated. Also assumed to take place during that six-month time frame is software customization, procedural definition, and operator training necessary to support production operations.

f. The capture of production document images will begin at the start of Month 7 once the implementation phase of the Pilot Production System is completed.

g. DDS document capture will proceed in parallel with the current micrographics-based input processing function over the entire five-year project period. No replacement of the current microfiche input processing function is assumed insofar as document capture or storage is concerned.

h. Processing of production document order requests for DDS-stored documents will begin at the start of Month 7 once the pilot implementation phase is complete.

i. Since all documents captured in the DDS Pilot Production System will also be filmed using current micrographics procedures, a hard-copy request could be satisfied by either medium. It is assumed that all hard-copy requests that can be accommodated by the DDS Pilot Production System will be processed there. This implies that insofar as requests for hard-copy reproductions are satisfied by the DDS Pilot Production System rather than microfiche, there will be a corresponding reduction in the microfiche blowback workload. Therefore, DDS document reproduction activities will constitute a replacement for a portion of the microfiche blowback workload.

j. No labor savings in the input processing function will be achieved by DDS pilot implementation since no replacement of microfiche input processing will take place.

k. No storage media or storage facilities savings will be achieved by the DDS pilot implementation since all documents stored in the DDS system will also be stored on microfiche.

l. Any performance benefits attributable to the DDS Pilot Production System (improved workflow, faster turnaround, and so on) will be limited to the document reproduction function of DDS.

m. All DDS document capture and storage activities, regardless of efficiency or cost effectiveness, result in an incremental cost increase over the current microfiche treatment since no replacement of microfiche is involved.

The mechanics of the cost/benefit calculations have been accommodated by developing a spreadsheet model that provides a handy means of assigning cost/benefit items to the period in which they will be realized. Lotus Symphony spreadsheet facilities include built-in functions for calculating the present value of a stream of cash flows (cost/benefit), which will automatically generate the desired NPV, cost/benefit ratios, and payback periods resulting from the cost/benefit figures input to the model. Refer to appendix E–*Cost/Benefit Model Financial Detail*, for the printed reports from the spreadsheets for the three alternatives.

4-DESCRIPTION OF ALTERNATIVES

In the previous section, pertinent assumptions and constraints were identified in addition .o an explanation of the methodology of this Cost/Benefit Analysis. In this section, the current system is described based on existing input processing and reproduction using microfilm technology. Then, three remote-access method alternatives for electronic document delivery are presented in terms of advantages and disadvantages in meeting the assumed NASA-specific requirements.

4.1 Current System Description

The STI Facility currently has a well-defined process for handling NASA requirements for document receipt, surrogate record processing, document characterization, microfilming storage, retrieval, reproduction, and distribution. Before the potential benefits of the proposed DDS alternatives can be assessed, the current document processing treatment must be understood.

The STI Facility regularly processes a wide variety of technical and aerospace related documents: domestic and foreign, classified and unclassified, NASA and non-NASA, government and private sector. Since the DDS Pilot Production System is limited to the handling of NASA Technical Reports categorized as STAR (1N series) and LSTAR (1X series) we will detail current processing steps specific to these documents only. These steps include:

a. *Document receipt.* Documents that arrive at the STI Facility are separated, logged in, and have a case file made for each one.

b. *Input processing.* After a document's suitability for NASA/RECON has been determined, input processing workflow is automated with the Input Processing System (IPS). A surrogate record is created and a database accession number is assigned.

c. *Microfilming.* Documents are filmed to produce 24:1 microfiche. They are developed on-site and then checked for quality.

d. *Initial distribution.* Subscribers to the STI Facility's service receive a diazo microfiche copy.

e. *Archival storage.* A silver microfiche master is kept both on- and off-site. Stock copies from initial printing of NASA Technical Reports are also kept on-site.

f. *Secondary distribution.* Requests are filled for stock copy, microfiche, and reproductions from microfiche as well as copies from originals. These requests arrive through NASA/RECON electronic requests, phone orders, and the mail.

An overview of the document processing function of the STI Facility is presented in Figure 4-1, the current document processing overview. Appendix B-*Current System Functional Description*, provides a more detailed analysis of the document flow at the STI Facility.

Figure 4-1. *Current document processing overview.*
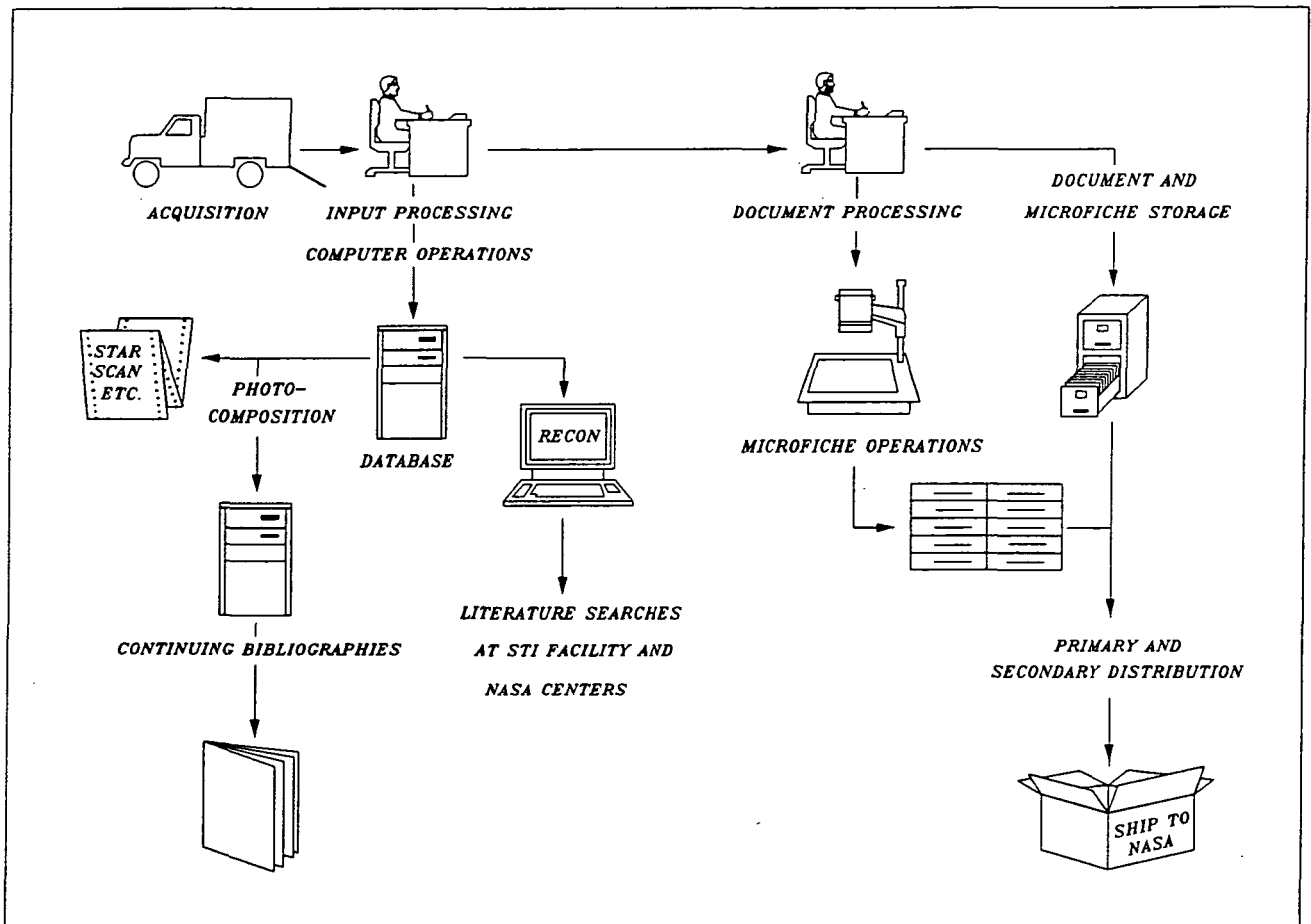
4.2 Introduction to Remote-Access Retrieval Alternatives

Vendor equipment differences are not being used as a variable in the Cost/Benefit Analysis. It is the judgment of the DDS staff that the variations are not meaningful enough to produce significant cost/benefit effects. This is particularly true now that the Pilot Production System has been scaled back to a nonsearch configuration.

All equipment (hardware and most software) to be used is commercially available with little fat to be pared by the astute buyer. This leaves most buying decisions for the base system to be mechanical in nature, if a requirements analysis has been performed. This area is a low-risk concern and does not warrant a Cost/Benefit Analysis. The anticipated competitive procurement of the Pilot Production System will most likely specify equipment in terms of functionality and requirements and not specific vendor products.

With these points in mind, it is more desirable and advantageous to orient the Cost/Benefit Analysis to an important and pressing concern that previously has not been considered in detail. Remote access and electronic document delivery alternatives will have meaningful benefits to be weighed as well as costs to be incurred. The Digital Imaging Technology Assessment report did not deal with the specifics of a remote-access implementation. This last major subsystem remains largely undetermined, unconstrained, and unevaluated.

The DDS Pilot Production System has one component that must be viewed as a moderate risk factor, the remote-access delivery method including the online request and electronic transfer of specific documents. Remote-access methodologies can be characterized in various communications techniques employed between the DDS LAN system configuration and the remote site at NASA Code NTT. Of the three alternatives presented, the first two represent electronic communications configurations (either using or bypassing the STI Facility mainframes). The third method eliminates all long-distance electronic communication by way of physically distributing the digitized document database on an optical disk for local access at the remote site.

The actual merits and costs of circuit types (such as satellite, T1 service, fiber optic, or microwave) and the public or private service options will not be discussed here because they are beyond the scope of this Cost/Benefit Analysis. An in-depth communications analysis is required for that purpose. Note that none of the alternatives discussed here will affect the quality of the images. Digitization largely removes the possibility of image degradation. Figure 4-2, the electronic document delivery methods for the three alternatives, contains diagrams of the three alternatives discussed below.

Figure 4-2. *Electronic document delivery methods for the three alternatives.*
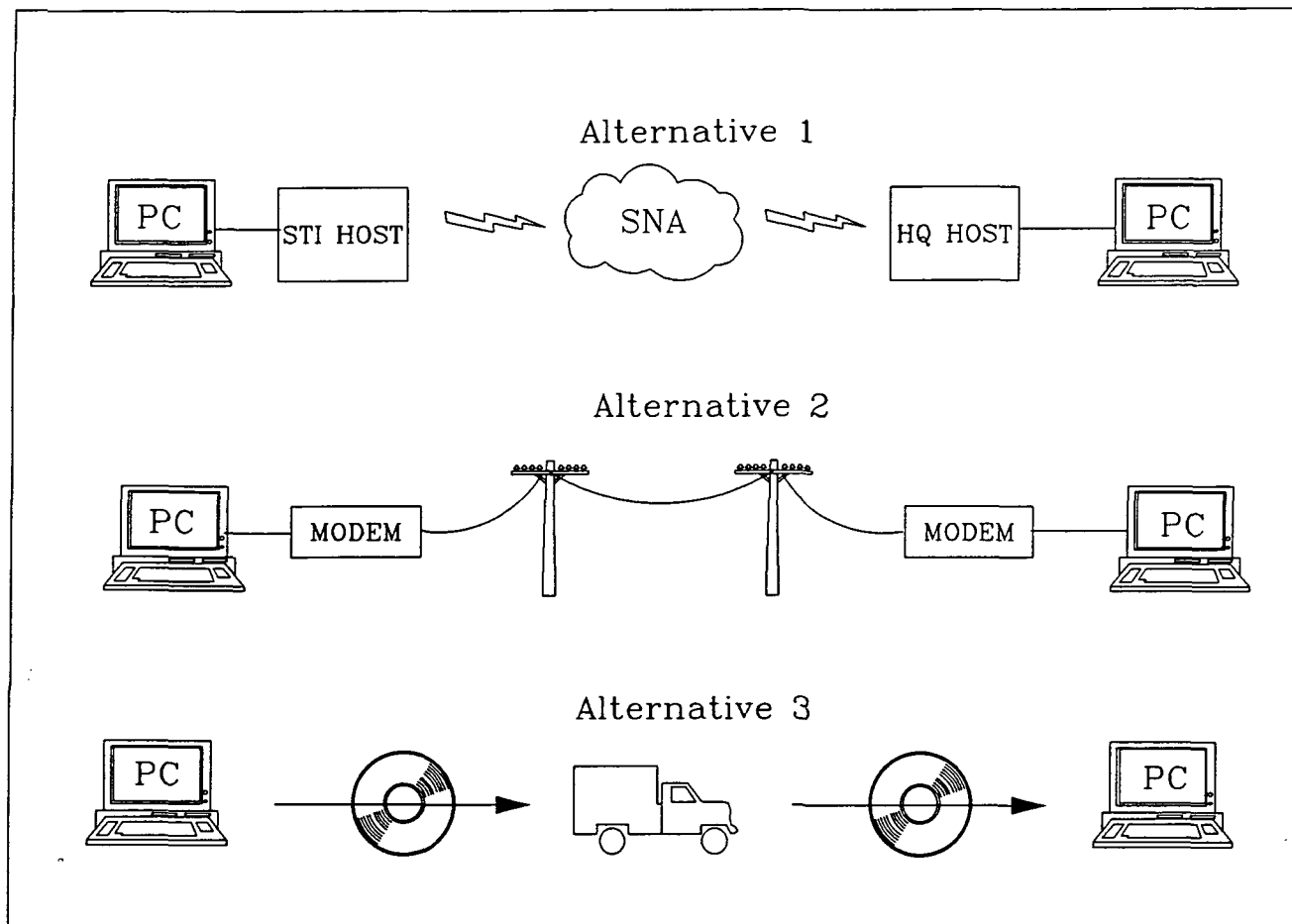
4.3   Alternative Approach 1—Mainframe Communications Support

There are primarily two methods of remote access delivery using the STI Facility mainframes. The first employs the mainframes in an active sense using a special-purpose, mainframe communications software application. The second uses the mainframes in a passive manner, strictly as a pathway with no application software necessary at the mainframe level.

4.3.1   Mainframe Alternative Introduction

Various mainframe schemes involve the existing IBM 4381 computers at the STI Facility, the NASA Headquarter's computer and their communications systems for providing on-demand, remote electronic access. For the initial implementation of the DDS system, there will be no direct use or modification of existing application systems at the STI Facility, such as NASA/RECON or NASA/ARIN to help accomplish the objectives of the Pilot Production System.

4.3.2   Host Application to Remote Host

Nevertheless, it is entirely possible to have a separate mainframe application under the virtual telecommunication access method (VTAM) executing under IBM's Customer Information Control System (CICS) or time-share option (TSO) to accomplish file transfers of page images from the DDS Pilot Production System to the remote site. This method takes advantage of existing STI Facility systems (mainframe hardware, software and communications) even though it is undesirable to share existing networks or communications lines due to the large file sizes required to transfer multiple pages within a document.

Another advantage of this approach is the foundation that could be set for integration with NASA/RECON. This integration appears to be the best way to verify a remote user's access level and the current document limitations for the requested transactions. The drawbacks include burdening of the DDS document archival/file server subsystem with many layers of software and systems that are not warranted. It could easily develop into a level of complexity that would diminish the anticipated benefits.

4.3.3   SNA/LU 6.2 Upgrade *(Candidate Alternative 1)*

This mainframe approach, considered for the Cost/Benefit Analysis as Alternative 1, consists of using advanced IBM system software to allow a remote workstation, either on a LAN or stand-alone, to communicate directly with the Pilot Production System LAN. System Network Architecture (SNA) Logical Unit–to–Logical Unit (LU-to-LU) level of communications would facilitate a PC File Server to directly send files to and from a remote site PC via existing mainframe software, Network Data Mover. Unlike the host-to-remote, the mainframe is merely a flow-through mechanism and is not directly involved with access on an application level but only on a communications level. LU-to-LU file-transfer capability currently does not exist and is not planned for the near future. Such software would help establish an ideal Wide Area Network (WAN) for many NASA Headquarters or STI Facility applications as well.

4.4   Alternative Approach 2—PC-to-PC Communications

The second alternative approach for electronic delivery is comprised of the following two methods for PC-to-PC communications access:

* Dedicated line
* Common carrier phone system (dial up)

4.4.1   Direct PC-to-PC Introduction

PC-to-PC communication schemes deliver images with electronic communications via a communications server on the DDS Pilot LAN directly in control of the remote access with

no involvement of the mainframe communications systems. There are several variations that would have little effect on the functionality or operation of a session but are worthy of note for their effect on the costs. A transmission rate of 9.6 Kbps will work in a low-volume (Pilot Production System) application or low-resolution image and provides an excellent low cost demonstration capability. If variable density transmissions are implemented, transmission speed can be increased as the square of the bit-image density reduction ratio.

To transmit an image page for display purposes, 75-dpi resolution would require only one-sixteenth of the transmission time that a 300-dpi image requires. Full-scale implementation at 16 sites will require much higher transmission rates or multiple communication lines.

The following points provide a summary of advantages to this method of PC-to-PC remote access:

a. Relatively low-cost, remote-access solution using minimal hardware and software components, such as serial ports, standard dial-up modems, and single software

b. Simple to operate and troubleshoot

c. No special communication service, networks or lines are required

d. Automatic, off-peak, batch transmissions of selected documents for remote printing

e. Easily modifiable for customization and prototyping

4.4.2 Dedicated Lines

As with the STI Facility mainframes, dedicated lines (unshared and no dial-up required) work equally well as a mainframe communications line when connected to a communications server that is directly attached to and controlled by a PC workstation. A commercially available 9.6Kb dedicated line costs $400 per month after a one time fee of $1,000. T1 service is available commercially from $1,500 to $2,000 per month within a 50-mile radius. This high-volume throughput capability at 1.544Mbps is potentially capable of sub-second per image page transfer rates to provide a high level of service. Chiefly, what is purchased is very high bandwidth. The wider the bandwidth of a dedicated line, the faster the response time and the higher the cost. While an image transmission is a heavy demand for any line, overall the Pilot Production System can be characterized as low-volume, and the cost to test application functionality is not warranted.

4.4.3 Dial-Up Access *(Candidate Alternative 2)*

For a very modest increase in time to initiate a remote-access, dial-up service is attractive for the following reasons:

a. The Pilot Production System is expected to have low-volume remote usage (one hour per day or less)

b. There will be no ongoing communications charges at the STI Facility because NASA Code NTT will always use its own connect time using its existing phone service

c. Sophisticated software is available at excellent price/performance ratios

Even for full-scale implementation, PC LAN-compatible dial-in servers are available at PC workstation prices or on a printed circuit board (add-on card for a PC). This proven technology has a low initial cost, can be easily expanded, and can be upgraded to dedicated lines if and when they may be needed.

4.5 Alternative Approach 3—Distributed Replicated Database

This third alternative approach for remote access for the Pilot Production System is characterized by a physical distribution to the remote site of the media containing the document images. No electronic communications is required for document distribution and retrieval even though on-line access to the centralized document database may have other justification, such as access to newly acquired documents not yet available in the distribution cycle.

The remote site duplicates the file-management, search-and-retrieval, display, and output-server functions within a single-user workstation. Whatever archival storage equipment used for DDS at the STI Facility, a compatible storage device must reside at NASA Code NTT. The archival storage equipment is likely to be one to four 12-inch, 6GB (gigabyte) WORM optical disk drives to hold several years of digitized NASA Technical Reports at the remote site.

On a periodic basis, a reusable medium will be sent by the STI Facility shuttle service or other delivery service to NASA Headquarters Code NTT to update their local WORM system with the latest documents that were processed at the STI Facility. All of the reasons that make WORM the preferred archival storage media at the STI Facility apply to the remote site, such as permanency, low cost per megabyte, and ruggedness. Any change in the medium at the remote site that is different from the medium at the STI Facility will substantially increase costs of both remote workstation hardware and software. This decentralized approach has some significant advantages, although it does complicate the Cost/Benefit Analysis in that the STI Facility configuration cannot be held a fixed variable, as in electronic communications alternatives.

Advantages of this approach include:

a. A single 12-inch WORM controller and drive could eliminate all recurring remote-access costs

b. As long as the document is on the disk in the WORM controller, computer bus retrieval rates can be provided with no reduction in communications transfer rates

c. Reliability of the remote system is increased because neither remote communications nor the DDS system at the STI Facility need to be to be activated for an access; the central DDS system is no longer a single point of system failure

d. Near-linear costs to make the system operational at additional NASA sites

e. Custom or restricted collections can be provided for particular sites

f. Multiple document database archival copies can be distributed off-site automatically

The major disadvantages of the distributed, replicated database approach are:

a. The cost of the remote workstation configuration may be doubled or tripled

b. The costs of handling and storing additional media on an ongoing basis

c. The complexities introduced as a result of periodic document archive updates and remote workstation database maintenance

The media described in sections 4.5.1 through 4.5.6 have potential for a distributed system and are the basis for determining the specific candidate alternative within the third approach.

4.5.1   Rewritable Optical Disk

Rewritable optical, or magneto-optical (M-O), disk is ideal and recommended for the update medium particularly considering it is already planned for use in the DDS system. When compared with WORM, the M-O disk is not as well suited as an archival medium because it is more expensive, has less storage capacity, and is not a permanent medium (it can be erased like a magnetic disk).

4.5.2   Tape

Magnetic tape, or digital audio tape (DAT), has a good price/storage ratio but is not a direct-access device. This makes it a medium that does not meet the functional requirements of the remote-access application due to slow access time because of the sequential access nature of all tape medium. Still, DAT is a good candidate for the update medium in the distributed database approach.

4.5.3   CD-ROM

CD-ROM has two major shortcomings, slow access speeds and high unit costs in mastering low volumes, such as the single copy for NASA Code NTT (in the Pilot Production System)

or the 16 copies for all DDS remote sites (in a full-scale implementation). CD-ROM is nei-
ther reusable nor currently producible at the STI Facility in a mass production environ-
ment. Producing CD-ROM at the STI Facility would require an expenditure of at least
one-hundred thousand dollars for a low-volume premastering workstation and a single disk
mastering device.

4.5.4   Digital Paper

Digital paper holds much promise for the future because this easily distributed medium will
likely have attractive price/performance ratios. This projected low-cost form of nondisk
WORM should be evaluated when it becomes commercially available as expected in the
1991–1992 time frame.

4.5.5   Magnetic Disk

This magnetic medium is still prohibitively expensive for mass storage of many gigabytes of
information. It also is disqualified from the requirement for archival permanency. As a
reusable medium, it is cost effective, but only for smaller storage capacities. Removable
hard disks hold promise for the future, when storage capacities should increase, but are
fragile and currently have a high cost per megabyte ratio.

4.5.6   WORM *(Candidate Alternative 3)*

The distributed replicated database approach selected for the Cost/Benefit Analysis as
Candidate Alternative 3 is WORM optical disk. WORM is the ideal candidate for the
remote-access archival storage for the same reasons it is appropriate for the Pilot Produc-
tion System at STI Facility. It is not a reusable medium and therefore not recommended as
the update medium. Storage capacities of current generation 12-inch WORM disks range
from 5 to 6 GB and have the lowest cost per megabyte of any random access device that is
rewritable. An M-O device at the remote workstation will provide the rewritable, recycl-
able update medium for central DDS document updates to be incorporated periodically
into the local WORM archive.

The following three candidate alternatives are compared in this Cost/Benefit Analysis:

Candidate Alternative 1—Mainframe communications support by way of an SNA/LU 6.2
    upgrade
Candidate Alternative 2—PC-to-PC communications using a dial-up capability
Candidate Alternative 3—Distributed, replicated database using WORM disks

5-COSTS

In section 4, three candidate alternatives were described for the purpose of comparing their characteristics. In this section, these alternatives are discussed in terms of nondiscounted, nonrecurring, and recurring costs by various categories of expenditures.

5.1 Description of Costs

Costs for the Pilot Production System are broken down into the following categories:

* capital investment costs
* nonrecurring labor costs
* recurring labor costs
* supply costs (and other direct charges)

5.1.1 Capital Investment Costs

Initial cost outlays for equipment for the DDS Pilot Production System constitute the primary capital investment cost for all three alternatives examined in this Cost/Benefit Analysis. No investment in additional communications equipment is anticipated to support any of the alternatives other than communications servers or boards configured with the DDS LAN. These costs are included with the LAN equipment configuration. Equipment costs are assumed to be incurred at the start of Month 1 of the Pilot Production System life cycle. All of these costs are summarized in section 5.2, *Tabulation Summary of Cost Elements for Each Alternative*.

5.1.2 Nonrecurring Labor Costs

All three alternatives require a one-time expenditure of labor to complete the initial installation, testing, and systems integration of the DDS Pilot Production System equipment. In this Cost/Benefit Analysis, this expenditure will be referred to as the systems installation cost. Furthermore, there is a one-time cost of software engineering to be performed by the STI Facility's management contractor to develop customized software to meet NASA-specific requirements and test the significant functional elements. In this Cost/Benefit Analysis, this expenditure is referred to as the software integration and testing cost.

Also, effort must be expended to define the production processing workflow for DDS document capture, storage, and reproduction and to document that workflow in a detailed form. In this Cost/Benefit Analysis, this effort is referred to as process definition cost. Finally, there will be a one-time cost to develop a training program and conduct training for the operators who will use the DDS equipment. In this Cost/Benefit Analysis, this cost is

referred to as the training cost. Refer to appendix E–*Cost/Benefit Model Financial Detail*, for the summary tables for each alternative that was derived from the Pilot Production System Cost/Benefit model spreadsheet.

Nonrecurring system installation and integration costs are assumed to be distributed evenly over the first six months of the Pilot Production System. Process definition is costed for Months 3 and 4 only. Training labor will be expended in Months 5 and 6. See Table 5-1, the total nonrecurring labor costs (in dollars), for the costs by category for all three alternatives.

In all instances in this Cost/Benefit Analysis in which STI Facility labor and labor rates are cited, current Contract Year Five rates have been applied with no provision for escalation. Furthermore, these labor cost estimates represent fully burdened cost under the STI Facility services contract (NASW-4070). None of these labor estimates include labor for general project management or general administration.

Table 5-1. *Total nonrecurring labor costs (in dollars).*

(PERSON DAYS) COST CATEGORY[a]	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
System Installation	(30 days) 8,400	(30 days) 8,400	(50 days) 14,000
System Integration and Testing	(370 days) 103,600	(370 days) 103,600	(420 days) 117,600
Process Definition	(30 days) 8,400	(30 days) 8,400	(30 days) 8,400
Training	(120 days) 33,600	(120 days) 33,600	(120 days) 33,600
TOTAL DAYS	(550 days)	(550 days)	(620 days)
TOTAL COSTS	154,000	154,000	173,600

[a]   *All labor costs are estimated at $35 per hour, fully burdened, for an eight-hour day.*

5.1.3   Recurring Labor Costs

All three alternatives will involve document capture costs associated with document preparation, scanning, quality assurance, and image-management efforts. The document capture workload is assumed to be a constant at 1,000 pages per day (20 documents at 50 pages per

document) beginning in Month 7. If document capture proceeds at the rate of two pages per minute, one full-time operator, the Document Imaging Specialist, will be kept busy processing the projected volume of NASA Technical Reports.

This relatively low document capture rate is not due to equipment processing limitations (for example, the scan rate), but rather due to the expected extensive quality checking and image-enhancement steps expected to be required for documents containing line art, graphics, and supporting photographs.

If the hourly labor cost for the Document Imaging Specialist, with approximately one extra day overtime per month, is assumed to be $15 per hour, fully burdened, and the number of hours worked per year is 2,000, then document capture labor cost is projected to average $2,600 per month as shown in the equation below (where FTE stands for full-time equivalent labor unit).

$$\frac{1.04 FTE \times \$15\,per\,hour \times 2,000\,hours\,per\,year}{12\,months\,per\,year} = \$2,600\,per\,month$$

This is the estimated document capture labor cost. It is expected to be the same for all three alternatives since the document capture process is the same for each.

Document reproduction costs are a function of the volume of document order requests processed by DDS and the rate at which requests can be processed. These costs are expected to grow over the five-year period as the DDS image database builds. Appendix D–*Monthly Reproduction Workload*, presents the anticipated monthly reproduction workload for the five-year life of the DDS Pilot Production System. This assumed growth in monthly activity has been extrapolated from data presented in the DDS Reproduction Volume (Blowback) Report. The maximum level of activity is expected to be on the order of 1,000 pages per day in the last month of the Pilot Production System life cycle. At an average reproduction request processing rate of four pages per minute, this workload would eventually require an additional 0.5 FTE, to handle reproduction processing. This task can be performed by either the Senior Document Imaging Specialist or the Document Imaging Specialist.

An additional labor requirement exists to handle additional administrative responsibilities associated with LAN management and DDS supervisory tasks, requiring another one-half FTE. These supervisory tasks can be performed by the Senior Document Imaging Specialist and are assumed to remain constant for the duration of the Pilot Production System operation. If the hourly labor cost is assumed to be $15 per hour and the number of hours worked per year is 2,000, this requirement is projected to average $1,250 per month as shown in the equation below.

$$\frac{0.5\,FTE \times \$15\,per\ hour \times 2,000\,hours\ per\ year}{12\,months\ per\ year} = \$1,250\,per\ month$$

Because of the varying level of labor required to handle document request processing during the Pilot Production System life cycle, total recurring labor levels will start at 1.5 FTE beginning in Month 6 and grow steadily to reach 2.0 FTE by Month 60. Some operator availability in Month 5 is included in the cost/benefit financial model to allow for training and familiarization prior to commencement of production processing in Month 7.

Alternative 3 will incur an additional labor cost to support the generation, distribution and management of one 5.25-inch M-O disk every two weeks. This effort is expected to be accommodated by the two full-time DDS operators already proposed for the STI Facility DDS configuration. It is assumed that the additional complexity of Alternative 3 will require an additional one person-day per week of labor at the remote site for media handling and system management. This equates to approximately $1,000 per month (66 person-hours per month at $15 per hour). Refer to Table 5-2, the total recurring labor costs (in dollars), for the cost figures associated with the three alternatives.

Table 5-2. *Total recurring labor costs (in dollars).*

(PERSON DAYS) COST CATEGORY[a]	ALTERNATIVES 1, 2, AND 3
Administrative tasks	(605 days) 72,600
Reproduction tasks	(362 days)[b] 43,473
Document capture and quality control tasks	(1,235 days) 148,200
TOTAL DAYS	(2,202 days)
TOTAL COSTS	264,273

a   All labor costs are estimated at $15 per hour, fully burdened, for an eight-hour day.
b   An additional fraction of one day (0.275) has been added to this task to allow for rounding errors in the recurring labor costs.

In all instances of this Cost/Benefit Analysis in which STI Facility labor and labor rates are cited, current Contract Year Five rates are applied with no provision for escalation. Furthermore, these labor cost estimates represent fully burdened cost under the STI Facility services contract (NASW-4070). None of these labor estimates include labor for general project management or general administration.

5.1.4   Recurring Supply Costs

Supplies necessary to support the DDS document capture and reproduction activities are assumed to be minimal and insignificant to this Cost/Benefit Analysis with the single exception of additional expenses incurred under Alternative 3 for media costs. It is assumed that three 5.25-inch M-O disks will be used to distribute the DDS database to the remote location. One will be prepared and sent to Code NTT every two weeks. The three disks will allow the remote site to have two distribution disks on hand at any given time and one recycled back to STI Facility for the next distribution.

To maintain the distributed DDS database in permanent archival form, the remote work-station will require two 12-inch WORM disks, each with a 5 to 6 GB capacity, each year for the entire five-year period. At $500 per WORM disk, these two disks will require an additional cost of $1,000 per year for Alternative 3. For the purposes of this Cost/Benefit Analysis, Alternative 3 will expend for this media $500 every six months beginning in Month 1 for the duration of the Pilot Production System life cycle for a total of $5,000 over the five-year period. All optical disks and magnetic media will be backed up on redundant and duplicate media for data security purposes.

5.2   Tabulation Summary of Cost Elements for Each Alternative

Table 5-3, the summary of cost elements (in dollars) for each alternative, is a tabular listing of the pertinent recurring and nonrecurring cost items for each alternative included in the model used for this Cost/Benefit Analysis.

Table 5-3. *Summary of cost elements (in dollars) for each alternative.*

COSTS	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
NONRECURRING COSTS[a]			
Capital:			
Central site equipment	175,957	176,307	175,858
Remote site equipment	18,841	18,841	18,841
Telecommunications	1,000	-0-	-0-
Labor:			
System installation	8,400	8,400	14,000
System integration	103,600	103,600	117,600
Process definition	8,400	8,400	8,400
Training	33,600	33,600	33,600
SUBTOTAL	349,798	349,148	368,299
RECURRING COSTS[b]			
Media	16,000	16,000	27,000
Communications	27,500	-0-	-0-
DDS operational labor	264,273	264,273	264,273
SUBTOTAL	307,773	280,273	291,273
TOTAL COSTS	*657,571*	*629,421*	*659,572*
PRESENT VALUE COST	**579,955**	**558,211**	**586,192**

[a] All labor costs are estimated at $35 per hour, fully burdened, for an eight-hour day.

[b] All recurring labor costs are estimated at $15 per hour, fully burdened, for an eight-hour day.

6-BENEFITS

In the previous section, nonrecurring costs were broken down by cost categories, such as capital investment, labor, and supplies. In this section, benefits are described in lesser detail due to the lack of user feedback that is typically received during a requirements analysis.

6.1 Description of Benefits

The two major benefits of the Pilot Production System that have been identified for this Cost/Benefits Analysis are improved reproduction quality and faster service times for reproduction requests (turnaround times) as described in section 6.1.2, *Recurring Benefits.*

6.1.1   Nonrecurring Benefits

There are no nonrecurring benefits expected for any of the three alternatives under examination in this Cost/Benefit Analysis.

6.1.2   Recurring Benefits

Digital document storage and retrieval technology usually results in significant savings due to reduction in document capture and storage costs. Additionally, for a digital imaging system that replaces a more labor-intensive treatment, major recurring labor savings are realized. Since the proposed NASA DDS project does not involve replacement of current document capture facilities, these usual savings will not accrue for the Pilot Production System.

The primary benefits to be achieved by the DDS Pilot Production System are an improvement in the servicing of document reproduction requests and an improvement in the quality of the image that can be reproduced. It is expected that DDS will reduce the current centralized document request turnaround time from five days to two days. DDS is also expected to provide enhanced blowback quality over the current microfiche treatment, especially for documents with halftone photographs, line art, complex graphical representations. Quantifying the value of improved turnaround and blowback quality precisely is impossible without having performed a requirements analysis. Experience gained from the DDS Prototype System will better characterize the benefits that reasonably may be expected by NASA.

By subjectively assigning a valuation to such intangibles as turnaround time and quality, little meaning could be derived from this analysis. To avoid such arbitrary valuations, solely for the purposes of this Cost/Benefit Analysis, DDS staff considered the value that NASA places on improved quality and reduced turnaround time as independent variables that are not precisely established. A range of plausible values for both benefit variables was determined for this Cost/Benefit Analysis. The variables turnaround improvement value and

quality improvement value, both expressed in dollars per page processed, are used in the model to represent these valuations for the iterative calculations of various costs and benefits. Turnaround improvement value and quality improvement value are used in this analysis to represent NASA's valuation of blowback turnaround and quality.

The cost/benefit model allowed the value of each of these two variables to float between zero dollars per page and two dollars per page and to assess the effect of changing their values on the calculated benefits expected from the DDS. The benefits that those two variables generate are inherently a function of the reproduction volume accommodated by the DDS Pilot Production System. These benefits grow over the five years of the project life as DDS digital document database and blowback volume increases. These are the only benefits explicitly quantified in this Cost/Benefit Analysis.

6.1.3   Other Intangible Benefits

In addition to the turnaround and quality benefits quantified for the Cost/Benefit Analysis, there are numerous additional intangible benefits that are expected to generate long-term, significant returns to NASA. However, these are virtually impossible to quantify without performing a requirements analysis. These intangible benefits should be considered by NASA when judging the merits of implementing the Pilot Production System.

The intangible benefits include:

a. Establishment of a technology base from which to support future digital imaging capabilities at the NASA STI Facility. For instance, Facility products and services involving NASA Technical Reports could be issued in electronic form (for example, NASA Technical Reports on CD-ROM).

b. Creation of a base capability that will allow each of the NASA Center libraries and others appropriately equipped to perform on-demand, remote access to the DDS document images. This capability will give the NASA Centers rapid retrieval capability for NASA technical documents, a capability that currently does not exist. Once widespread remote access is made available, the labor savings potential for the end user is expected to be significant.

c. Potential for long-term replacement of less optimal microfiche treatment and the substantial savings that such replacement entails.

d. If DDS reproduction achieves sufficient economies, centralized inventorying of shelf copies to satisfy hard-copy requests might be found unnecessary. If inventory-carrying costs exceed the cost of reproducing the document from DDS and the quality is sufficiently high, it would be cost effective to satisfy all hard-copy requests from DDS.

e. Establishment of digital imaging capture, storage, and retrieval mechanisms at the STI Facility could potentially provide the capability for a highly efficient document acquisition function whereby documents are transmitted electronically from the source to the STI Facility archives in digitized form.

7–COMPARISON OF ALTERNATIVES

The prior sections contain an assessment of the evaluated costs and benefits, both nonrecurring and recurring. This section contains a comparison of the overall cost/benefit totals for each of the three alternatives. Classic comparison techniques are used here, such as dividing the total benefits by the total costs (benefit/cost ratios) and determining the point in time in which the benefits offset the cost (payback period). The more meaningful and widely accepted method of discounted data comparison is also employed, referred to as the net present value (NPV) comparison. Present value cost analysis is the most widely accepted technique used in modern capital budgeting and management accounting.

7.1 Cost Comparison

Summarized in Tables 7-1 and 7-2, respectively, are the pertinent nonrecurring and recurring cost figures for the three alternatives under evaluation. Both the nondiscounted and discounted (that is, present value) totals are presented for the entire 60-month span of the Pilot Production System.

Table 7-1. *Nonrecurring cost summary (in dollars) by cost category.*

ALTER-NATIVE	CENTRAL SITE EQUIPMENT	REMOTE SITE EQUIPMENT	COMMUNI-CATIONS UPGRADE	SYSTEM INSTALLATION LABOR	SYSTEM INTEGRATION LABOR	PROCESS DEFINITION LABOR	TRAINING LABOR	TOTAL NON-RECURRING COST
NONDISCOUNTED								
1	175,957	18,841	1,000	8,400	103,600	8,400	33,600	349,798
2	176,307	18,841	–0–	8,400	103,600	8,400	33,600	349,148
3	175,858	18,841	–0–	14,000	117,600	8,400	33,600	368,299
DISCOUNTED TO PRESENT VALUE								
1	175,957	18,841	1,000	8,331	100,644	8,160	32,101	345,034
2	176,307	18,841	–0–	8,331	100,644	8,160	32,101	344,384
3	175,858	18,841	–0–	13,884	114,245	8,160	32,101	363,089

The nonrecurring cost items—central- and remote-site equipment—reflect the estimated initial purchase cost, respectively, of DDS equipment installed at the STI Facility and the remote NTT site. The required communications upgrade item reflects the up-front cost of upgrading communications facilities to accommodate the remote-access treatment in each case.

Only Alternative 1 incurs a communications upgrade cost to conform to projected communications requirements. It necessitates an upgrade to the COMTEN Network Control Program

Table 7-2. *Recurring cost summary (in dollars) by cost category.*

ALTER-NATIVE	MEDIA COST	COMMUNI-CATION AND COST	DDS OPERATING LABOR	TOTAL RECURRING COST
NONDISCOUNTED				
1	16,000	27,500	264,273	307,773
2	16,000	-0-	264,273	280,273
3	27,000	-0-	264,273	229,273
DISCOUNTED TO PRESENT VALUE				
1	13,413	21,094	200,414	234,921
2	13,413	-0-	200,414	213,827
3	22,689	-0-	200,414	223,103

(NCP) software at the STI Facility site to accommodate remote access via the existing VTAM/SNA network. This involves a one-time charge of $1,000 (nonrecurring cost item) and an ongoing licensing fee of $500 a month (recurring cost item).

The nonrecurring cost items—system installation labor and system integration labor—reflect the cost of the level of effort associated with installing all necessary hardware and software items, component testing, systems integration, problem analysis and troubleshooting, and final checkout and systems testing. Also included in system integration is the estimated cost of performing local software customization to tailor user interfaces and workflow logic to NASA requirements. All of these labor costs are based upon current, Contract Year Five, labor rates and include no escalation factor.

Alternative 3 reflects a higher system integration labor component. This is based upon the proposed distributed database concept and associated mechanisms for ongoing creation and distribution of periodic database updates which will require a higher level of effort.

The nonrecurring item, process definition labor, is the cost associated with developing a detailed description of the specific operational steps that DDS operators will take in the processing of documents into and out of the DDS system. Included is the identification of those points in the current document processing workflow where DDS processing can take place. The end result of this effort will be a detailed operations manual that details each action to take in capturing and reproducing DDS documents. Training labor is the one-time cost of developing and conducting training classes for the DDS operators. All of these labor costs are based upon current, Contract Year Five, labor rates and include no escalation factor.

The media cost item reflects the cost of optical media to support each of the alternative approaches. The additional $12,000 recurring cost for optical media for Alternative 3 reflects the additional cost associated with storing a distributed replicated database at the remote NTT workstation and supporting periodic updates to this database.

DDS operating labor reflects the ongoing labor cost associated with DDS document capture and blowback. A component for DDS operational administration and supervision is also reflected in the figure. Labor to accommodate document capture and operational administration/supervision is assumed to be level over the life of the project. Labor to support document blowback requirements grows over the life of the project as the document reproduction workload increases. No significant cost differential in operating labor between the three alternatives is expected. All of these labor costs are based upon current, Contract Year Five, labor rates and include no escalation factor.

Table 7-3 gives the recurring benefits (in dollars) by benefit category, for the three alternatives. Total costs for all three alternatives are presented in the table contained in section 7.2, Benefits Comparison. As shown, Alternative 2 is the least-cost case of the approaches examined, followed by Alternative 1, and then Alternative 3.

Table 7-3. *Recurring benefits (in dollars) by benefit category.*

(Turnaround Value and Quality Value = $.56/page)			
ALTERNATIVE	TURNAROUND IMPROVEMENT BENEFIT	QUALITY IMPROVEMENT BENEFIT	TOTAL RECURRING BENEFIT
NONDISCOUNTED			
1	386,834	386,834	773,668
2	386,834	386,834	773,668
3	386,834	386,834	773,668
DISCOUNTED TO PRESENT VALUE			
1	280,674	280,674	561,347
2	280,674	280,674	561,347
3	280,674	280,674	561,347

7.2 Benefits Comparison

Presented in Table 7-3 are the pertinent amounts of recurring benefits associated with each of the three alternatives examined. For the purposes of this Cost/Benefit Analysis, quantified benefits derive from two sources, turnaround improvement benefits and quality improvement benefits. The calculated dollar value of the benefit derived is a function of the valuation that NASA chooses to assign to improving document request turnaround and to enhancing the quality of the reproductions provided. It is also a function of the number of documents reproduced in each period of the project life span.

The benefit values summarized in Table 7-3 are for a representative valuation of turnaround improvement and quality improvement of $.56 per reproduced page. This happens to be the break-even point for the least-cost alternative and, therefore, is illustrative of the pertinent benefit relationships.

Since the turnaround and quality valuations are independent of the remote-access method used and all three cases will process the same document reproduction workload, there are no benefits variations between the three alternatives examined. The expected total recurring benefits figure is identical for all three alternatives.

Total benefits for the three alternatives are presented along with the associated total costs in Table 7-4, the cost/benefit summary (in dollars) after five years. Since the total benefits are the same for each of the three cases examined, the least-cost alternative is also the approach with the most advantageous net benefit (that is, total benefits minus total costs). Alternative 2 has the highest net benefit of the three alternatives at $144,247 (nondiscounted) over the project life at a turnaround/quality valuation of $.56 per page. At these benefit levels, Alternatives 1 and 3 also exhibit benefits that outweigh the costs of implementation and operation when present value considerations are ignored.

Table 7-4. *Cost/benefit summary (in dollars) after five years.*

(Turnaround Value and Quality Value = $.56/page)			
ALTERNATIVE	TOTAL PROJECT COST (C)	TOTAL PROJECT BENEFIT (B)	NET PROJECT BENEFIT (B – C)
NONDISCOUNTED			
1	657,571	773,668	116,097
2	629,421	773,668	144,247
3	659,572	773,668	114,096
DISCOUNTED TO PRESENT VALUE			
1	579,955	561,347	-18,607
2	558,211	561,347	3,137
3	586,192	561,347	-24,845

7.3   Discounted Data Comparison

In addition, Tables 7-1 through 7-4 contain the associated present values for all costs and benefits when a 10-percent discount factor is applied to all cash inflows and outflows. Alternative 2 is the least-cost option when discounting is applied.

Examination of Table 7-4 reveals that, when discounted cost/benefit ratios are calculated, costs exceed benefits for all but Alternative 2 and the discounted net project benefit (that is, NPV) of Alternatives 1 and 3 are negative. Alternative 2 enjoys a positive NPV of $3,137 for a valuation of $.56 per page. This is just over the break-even point for the projected cash flows.

8-RISK ASSESSMENT/SENSITIVITY ANALYSIS

In section 7, all three alternatives were compared according to various financial analysis techniques. In this section, risk factors are identified and assessed in terms of high, medium, or low impact upon implementation risk. Next, the sensitivity analysis that was performed by DDS staff is discussed.

8.1 Assessment of Risk Factors

A formal risk analysis was not conducted, however, while analyzing costs and benefits, some of the following major risk factors were identified:

* remote-access delivery method
* assumed functional description of system
* system performance with ill-defined workload levels

The DDS Pilot Production System implementation at the STI Facility and at the remote site in NASA Code NTT are low-risk factors in terms of technical feasibility.

Numerous assumptions have been made in modeling the costs/benefit ratios expected for the three alternatives examined in this study. Some of the assumptions made are very solid, others are highly speculative. All are deemed to represent the best estimate that can be made at present, based on available information and current understanding of the DDS project objectives and the underlying technology.

It is appropriate at this juncture to identify those assumptions that are most uncertain and to attempt to isolate those assumptions. If found to be invalid, those assumptions have the highest potential for altering the findings of this study.

Table 8-1, a summary of risk factors for key elements of analysis, contains a list of factors that impact the cost/benefit ratios developed in the model. Two ratings are presented for each. One is a subjective assignment—high, medium, or low—of the confidence level associated with each factor. High indicates the assumptions made are based on considerable knowledge and available supporting documentation for the area in question, and model assumptions in that area may be expected to have relatively high certainty of being valid. Factors assigned a low confidence level indicate an area where incomplete information or ambiguous requirements necessitate the adoption of highly subjective cost/benefit assumptions. Next to the confidence level is a second subjective assignment—also high, medium, or low—to indicate impact potential for each factor listed. A high impact potential indicates that assumptions made in this area, if found to be invalid, have the potential to radically alter the validity of conclusions and recommendations made by the analysis. Low indicates a low potential for such impacts.

Table 8-1. *Summary of risk factors for key elements of analysis.*

Analysis Item	Confidence Level[a]	Impact Potential[b]
Equipment configuration	High	High
Equipment acquisition cost	High	Medium
Communications configuration	Low	High
Communications cost	Low	High
Document capture rate	Low	High
Document blowback rate	Low	High
Document capture workload	Medium	Medium
Document blowback workload	Medium	High
System installation/integration labor	Medium	High
Remote-access demand level	Low	High
Ongoing DDS operator labor	Low	Medium
Optical media cost	High	Low
Training cost	Medium	Low
Process definition cost	Medium	Medium
Document characteristics	Low	High
Turnaround improvement expectations	Low	High
Quality improvement expectations	Low	High
Turnaround improvement benefit value	Low	High
Quality improvement benefit value	Low	High

[a] *Subjective evaluation of confidence level associated with assumptions made in each area.*
[b] *Subjective evaluation of potential impact this item has on findings if assumptions in this area prove invalid.*

Of particular interest are those items in Table 8-1 that have an assigned confidence level of low and a corresponding impact potential of high. These are items for which judgments made in constructing the model are highly subjective and uncertain. At the same time, these items have the potential to alter radically the conclusions reached.

For example, the study has assumed that turnaround improvement expectations warrant a reduction in the STI Facility's turnaround of document requests from five days to two days. This is a highly subjective judgment that cannot be substantiated until a working prototype is implemented and realistic processing times can be validated. If, in fact, turnaround improvements of this order of magnitude cannot be achieved, a major component of expected benefits is negated and the findings of the Cost/Benefit Analysis could be invalidated.

Notably, the areas with a low confidence level and a high impact potential include assumptions about:

a. Communications requirements and costs
b. Document processing times and workloads
c. The value of improving document quality and document request turnaround
d. The characteristics of the documents to be captured and the ability to capture high-quality digital images
e. The level of demand for remote access of digitized documents on demand and the associated application-level impacts

Since each of these items entails a high degree of uncertainty and have the potential to markedly impact the direction of the DDS project, priority should be given by NASA to investigate these areas further. Early attention should be given to validating the assumptions made in these areas and to developing a further understanding of their impact on the DDS project.

Many large computer system development projects are initiated by a requirements analysis that characterizes and evaluates many of the risk factors included in Table 8-1. Aside from the functional specifications that a requirements analysis would provide, the DDS Pilot Production System requires a completed characterization of all communications issues involved in remote electronic delivery (access) and the critical document characteristics specific to NASA Technical Reports.

8.2 Sensitivity Analysis

The model parameters that entail the greatest level of uncertainty are the turnaround improvement value and the quality improvement value. These are highly subjective and are an attempt to reflect NASA's judgment as to the quantitative value of improving turnaround of document requests and improving document reproduction quality via the DDS implementation. The assumed benefit values of $.56 per page is not a NASA assumption, but rather it is an RMS Associates assumption made solely for the purposes of this Cost/Benefit Analysis.

Because of the high degree of uncertainty surrounding the appropriate value to assign to these two parameters, they were chosen for the conduct of sensitivity analysis to assess the response of the model as their values are varied. As the net present value (NPV) break-even point for the preferred alternative was found to be at the point where both variables assume a value of approximately $.56 per page, it was decided to vary each variable across a range that brackets this break-even condition. Therefore, turnaround improvement value and quality improvement value were each varied between $.35 per page and $.75 per page with the NPV, cost/benefit ratio, and payback period calculated for each alternative with each iteration.

The results of this exercise are summarized in Tables 8-2 through 8-4. These tables represent NPV, cost/benefit ratio, and payback period, respectively, for each alternative as a function of the independent variables—turnaround improvement value (X) and quality improvement value (Y). In the first two tables, bold type has been used to highlight those values of X and Y where benefits exceed costs. In Table 8-4, payback periods of greater than five years (that is, longer than the system life) are left blank as payback is unlikely within the Pilot Production System life cycle for these cases.

Of primary concern in the sensitivity analysis is the effect of X and Y on the NPV. Table 8-2, the discounted net present value (NPV) in dollars by alternative as function of turnaround (X) and quality (Y) benefit value variables in terms of benefit value per page after five years, demonstrates that Alternative 2 remains the preferred alternative over the entire range of X–Y values examined at the end of five years. Further, the calculated NPV for Alternative 2 is found to vary over a wide range, swinging from a low of minus $207,369 for $Y=X=$ $.35 to a high of positive $193,594 for $Y=X=$ $.75. Valuations of X and Y below $.35 and above $.75 will exhibit proportionally higher orders of magnitude changes in the NPV respectively.

Table 8-2. *Discounted net present value (NPV) in dollars by alternative as function of turn-around (X) and quality (Y) benefit value variables in terms of benefit value per page after five years.*

NPV$_1^a$ NPV$_2$ NPV$_3$		TURNAROUND VALUE (X)			
	$ .35	$ .45	$ .55	$ .65	$ .75
Q $ .35	-230,936	-180,816	-130,695	-80,575	-30,455
	-207,369	-157,248	-107,128	-57,008	-6,887^b
	-235,350	-185,229	-135,109	-84,989	-34,868
U					
A $ .45	-180,816	-130,695	-80,575	-30,455	**19,666**
L	-157,248	-107,128	-57,008	-6,887^b	**43,733**
I	-185,229	-135,109	-84,989	-34,868	**15,257**
T					
Y $ .55	-130,695	-80,575	-30,455	**19,666**	**69,786**
	-107,128	-57,008	-6,887^b	**43,733**	**93,353**
V	-135,109	-84,989	-34,868	**15,257**	**65,372**
A					
L $ .65	-80,575	-30,455	**19,666**	**69,786**	**119,906**
U	-57,008	-6,887^b	**43,733**	**93,353**	**143,474**
E	-84,989	-34,868	**15,257**	**65,372**	**115,493**
(Y) $ .75	-30,455	**19,666**	**69,786**	**119,906**	**170,193**
	-6,887^b	**43,733**	**93,353**	**143,474**	**193,594**
	-34,868	**15,257**	**65,372**	**115,493**	**165,613**

^{a} For each quality value (Y) in dollars per page, there are three rows, one for each alternative, in each column of turnaround value (X) in dollars per page.

^{b} This value designates the approximate break-even point for the maximum quality and turnaround matching values —actually closer to Y = X = $.56 per page —for Alternative 2, which results in an NPV of $3,137. Note that since this table is a right-diagonally symmetrical matrix, break-even points exist for Y = .66, X = .46; Y = .46, X = .66; and so on.

Clearly, the model is highly sensitive to the values assigned to turnaround value and quality improvement value. Should NASA determine its' subjective valuation of these parameters correspond with X–Y combinations exhibiting a positive NPV (in boldface), it can expect discounted benefits deriving from the Pilot Production System to exceed discounted costs. If, on the other hand, NASA decided X and Y should be valued somewhat lower, at a point where

the NPV is negative, it can expect discounted costs deriving from the Pilot Production System to exceed discounted benefits. In this case, the predominance of costs will have to be justified in terms of nonquantifiable, less tangible benefits if the Pilot Production System is to be considered cost effective.

Similar conclusions may be reached in assessing Table 8-3, the nondiscounted benefit/cost (B/C) ratio by alternative as function of turnaround (*X*) and quality (*Y*) benefit value variables in terms of benefit value per page after five years, and Table 8-4, the payback period (in years) by alternative as function of turnaround (*X*) and quality benefit (*Y*) value multipliers, if NASA chooses to consider the nondiscounted measures—cost/benefit ratio and payback period—as meaningful measures of system return.

Table 8-3. *Nondiscounted benefit/cost (B/C) ratio by alternative as function of turn-around (X) and quality (Y) benefit value variables in terms of benefit value per page after five years.*

$B/C_1{}^a$ B/C_2 B/C_3	TURNAROUND VALUE (X)				
	$ .35	$ .45	$ .55	$ .65	$ .75
Q $ .35	0.73	0.84	0.94	1.05	1.15
U	0.77	0.88	0.99^b	1.10	1.21
	0.73	0.84	0.94	1.05	1.15
A					
L $ .45	0.84	0.94	1.05	1.15	1.25
I	0.88	0.99^b	1.10	1.21	1.32
T	0.84	0.94	1.05	1.15	1.26
Y					
V $ .55	0.94	1.05	1.15	1.25	1.36
A	0.99^b	1.10	1.21	1.32	1.43
	0.94	1.05	1.15	1.26	1.36
L					
U $ .65	1.05	1.15	1.25	1.36	1.46
E	1.10	1.21	1.32	1.43	1.54
	1.05	1.15	1.26	1.36	1.47
(Y)					
$ .75	1.15	1.25	1.36	1.46	1.57
	1.21	1.32	1.43	1.54	1.65
	1.15	1.26	1.36	1.47	1.57

^{a} *For each quality value (Y) in dollars per page, there are three rows, one for each alternative, in each column of turnaround value (X) in dollars per page.*

^{c} *This ratio designates the approximate break-even point for the maximum quality and turnaround matching values—actually closer to Y = X = $.46 per page—for Alternative 2, which results in a benefit/cost ratio of 1.01. These variables are lower than the break-even variables for Table 8-2 because they are based on nondiscounted amounts; the net present calculation factors result in the discounted amounts in Table 8-2 (although the NPV in dollars is actually -97,104). Note that since this table is a right-diagonally symmetrical matrix, break-even points exist for Y = .56, X = .36; Y = .36, X = .56; and so on.*

Table 8-4. *Payback period (in years) by alternative as function of turnaround (X) and quality (Y) benefit value multipliers.*

Payback Yr$_1$[a] Payback Yr$_2$ Payback Yr$_3$	TURNAROUND VALUE (X)				
	$ .35	$ .45	$ .55	$ .65	$ .75
Q $ .35	—	—	—	4.83	4.50
	—	—	—	4.67	4.43
	—	—	—	4.83	4.50
U					
A $.45	—	—	4.83	4.50	4.25
L	—	—	4.67	4.33	4.08
I	—	—	4.83	4.50	4.25
T					
Y $ .55	—	4.83	4.50	4.25	3.92
	—	4.67	4.33	4.08	3.83
V	—	4.83	4.50	4.25	4.00
A					
L $ .65	4.83	4.50	4.25	3.92	3.75
U	4.67	4.33	4.08	3.83	3.67
E	4.83	4.50	4.25	4.00	3.75
(Y) $ .75	4.50	4.25	3.92	3.75	3.58
	4.33	4.08	3.83	3.67	3.50[b]
	4.50	4.25	4.00	3.75	3.58

[a] For each quality value (Y), there are three rows, one for each alternative, of turnaround value (X) columns.

[b] This number represents the earliest payback duration using the highest charted benefit values for Alternative 2. Note this table is also a right diagonally symmetrical matrix.

9-ANALYSIS OF FINDINGS

In section 8, risk factors were described in terms of implementation risk level. By performing a sensitivity analysis, DDS staff identified the affects of specific cost/benefit variables on this Cost/Benefit Analysis. In this section, findings that represent the major conclusions derived from this Cost/Benefit Analysis are presented.

FINDINGS
1. Alternative Approach 2 Provides the Most Favorable Cost/Benefit Ratio 2. Layers of Assumptions Present Risk 3. Cost/Benefit Variables are Sensitive

9.1 Alternative Approach 2 Provides the Most Favorable Cost/Benefit Ratio

In analyzing the costs, benefits, and risks associated with alternative approaches to providing NASA Headquarters Code NTT with remote, on-demand access to digitized NASA Technical Reports, DDS staff compared three approaches:

* mainframe communications
* PC-to-PC communications
* distributed replicated database

As described in section 4, within each of these approaches, a variety of methods or media exist to satisfy the technical requirements of the approach. In this analysis DDS staff selected a specific method, which was labeled as candidate, within each approach. Within the mainframe communications approach, the DDS staff selected the SNA/LU 6.2 upgrade method; within the PC-to-PC communications approach, the DDS staff selected the dial-up access method; and, within the distributed, replicated database approach, the DDS staff selected the WORM optical disk method.

Based upon this evaluation of costs and benefits, the DDS staff finds that the second candidate alternative approach—PC-to-PC communications using dial-up access—provides the most favorable cost/benefit ratio for the Pilot Production System. Additionally, it is a flexible method that will be relatively easy to use and augment in the future. While the first candidate alternative approach—mainframe communications using SNA/LU 6.2—may be cost effective for full-scale implementation of the DDS system, it is not cost effective for the Pilot Production System under which remote access is required from a single NASA site. The third alternative approach—the distributed, replicated database using WORM optical disks—is also less attractive when access from only a single remote site is required. Although physically distributing media initially looks very attractive, for a single remote site, it is costly and may include unwieldy media management requirements.

In evaluating communications services required to support the full-scale implementation of the DDS system, an entirely different conclusion about the most cost-effective approach to meeting the relatively high demands of expected document image traffic may be reached. Both the first and the third alternative approaches considered for satisfying the demands of the Pilot Production System are sensitive to the number of remote sites requiring support. Additionally, data communications technology is an area that is experiencing rapid change. A careful analysis of the risks is required to obtain good price/performance results.

9.2 Layers of Assumptions Present Risk

All descriptions of user functionality and system description are based on the hypothetical assumptions stated in section 3.1, *Assumptions and Constraints*. There are a number of critical assumptions forming various dependent layers of the cost/benefit elements. Figure 9-1, the cumulative effect of layers of assumptions, depicts the lowering of confidence levels as a result of these assumptions. The greater the number of layers of dependent assumptions, the less confidence there is in the conclusion. This point should be emphasized with respect to the Pilot Production System implementation. Either a systems analysis effort or a Prototype System evaluation is required to raise the confidence level by converting critical assumptions into firm information.

Among these layers of assumptions is a set of assumptions about the presence, frequency, and distribution of specific document characteristics in the NASA Technical Reports. If this set of assumptions varies from actual NASA document characteristics, estimates used for the following might be changed:

* document capture effective throughput rate
* operational labor requirements (skill and staffing levels)
* quality improvement related benefits
* remote transmission requirements
* Pilot Production System configuration
* document database sizing

Although the DDS project staff has conducted a top-level review of document characteristics, the number of interrelated assumptions based on detailed document characteristics alone present risks to the conclusions reached in this Cost/Benefit Analysis.

Figure 9-1. *Cumulative effect of layers of assumptions.*
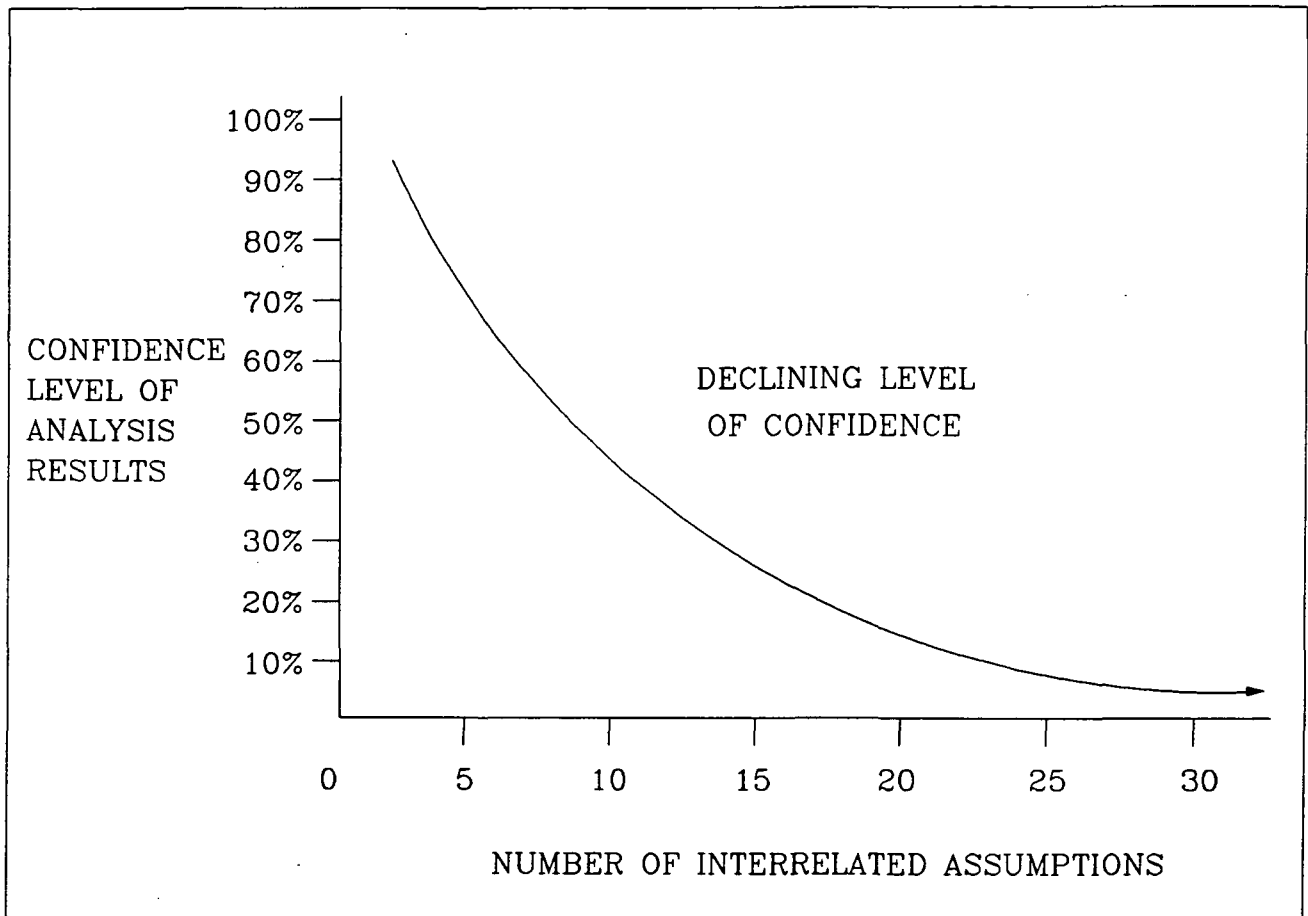
9.3 Cost/Benefit Variables are Sensitive

The sensitivity of the cost/benefit variables is high. Changes to a relatively small number of the variables can greatly affect the summary comparison and the net present value (NPV). For example, lowering the assumed document capture rate from 2 pages per minute (ppm) to 1 ppm could double the labor requirements for related tasks, such as document preparation, document scanning, quality control, and administration. Secondly, raising the centralized reproduction rate from 4 ppm to 8 ppm would reduce the staff level for that task. Combinations of adjustments to these assumptions could affect the entire operating staff plan. This indicates the importance of testing critical assumptions before proceeding with the Pilot Production System. This testing can be accomplished using the proposed DDS Prototype System.

10-RECOMMENDATIONS

In the previous section, major findings were presented as a result of the comparison of alterna-
tives. In this final section, recommendations outlining a suggested course of action for NASA
to capitalize on the results of this Cost/Benefit Analysis are presented.

RECOMMENDATIONS
1. Proceed with DDS Prototype System 2. Perform Communications Requirements Analysis 3. Proceed with Pilot Production System after Testing Assumptions and Adjusting Cost Estimates 4. Consider Selected Back-File Conversion 5. Implement Full-Scale System within Two Years of Pilot Production System Implementation 6. Develop Electronic Document Delivery Strategic Plan

10.1 Proceed with DDS Prototype System

STI Facility staff recommends an expeditious procurement of the DDS Prototype System as
specified in the DDS Prototype Acquisition Plan of December 29, 1989. The primary objective
of the Prototype System is to assess the labor skill levels required to operate the DDS Pilot
Production System. Other objectives that should be included to maximize the benefits of the
prototype include the following:

* validate and/or refine assumptions used in the assessment of the DDS Pilot Production
  System
* simulate the remote-access application
* analyze the electronic document acquisition workflow required to support DDS
* benchmark image capture time per page and reproduction time per page

10.2 Perform Communications Requirements Analysis

The criticality of the remote-access delivery method was described in prior sections of this
report. Additionally, a series of assumptions rather than actual facts were used in this Cost/Be-
nefit Analysis. Although the Impact Analysis Report (required by NASA for delivery in March,
1990) will assess communications services required to support full-scale implementation of the
DDS system at 16 DDS remote sites, it will be prepared using assumptions about remote-user
traffic requirements. A detailed communications requirements analysis for the full-scale sys-
tem is recommended to minimize the implementation cost and adequately explore alternative

approaches described in section 4 of this Cost/Benefit Analysis. This recommended analysis may be performed in conjunction with the prototype assessment. The results of this analysis are essential to increasing the probabilities of satisfactory remote-access turnaround time.

10.3 Proceed with Pilot Production System after Testing Assumptions and Adjusting Cost Estimates

The DDS project staff recommends that Pilot Production System acquisition and procurement plans be developed to enable procurement of the DDS Pilot Production System shortly after the completion of the Prototype System evaluation period. During the preparation of these plans, the DDS project staff's efforts should be focused on using the Prototype System to test the critical assumptions contained in this Cost/Benefit Analysis. Revisiting key portions of the cost/benefit comparison may be necessary based on updated assumptions or facts resulting from the evaluation of the Prototype System. Additionally, even if current assumptions parallel test results, cost estimates for development and implementation of the Pilot Production System should be reviewed and adjusted. This adjustment is needed in order to reflect a suitable escalation factor for STI Facility mangement contractor labor for the anticipated new contract, as well as any other cost impacts.

10.4 Consider Selected Back-File Conversion

The conversion of previously accessioned NASA Technical Report documents was not discussed in this Cost/Benefit Analysis. STI Facility staff proposes that selected prior documents be converted as they are requested for reproduction through the microfiche blowback procedure. This selective DDS document acquisition criteria produces back-file conversion of the most recently referenced documents.

10.5 Implement Full-Scale System within Two Years of Pilot Production System Implementation

DDS project staff suggests that the Pilot Production System operate for less than the five years discussed in this Cost/Benefit Analysis. Two years of system operation should be sufficient for evaluation of the Pilot Production System. During those two years, either a plan should be developed for the full-scale implementation at the 16 DDS remote sites or, if the evaluation indicates, a revised system approach should be developed.

10.6 Develop Electronic Document Delivery Strategic Plan

A 5- or 10-year plan should be developed to exploit the proposed electronic imaging technology to its fullest. A strategic planning document will provide the forum for exchanging long-

range planning information with NASA technical and administrative managers. It is important to begin the assessment of the level of future remote-access of documents in their electronic form by users outside of the designated 16 DDS remote sites. Analysis of other critical NASA documents to be made available electronically in the future, from the STI Facility and other sources, should be considered during a strategic planning effort. Also, the use of electronic media as a form of initial document acquisition should be considered and evaluated.

11-APPENDIXES

A–Assumed Pilot Production System Configuration
B–Current System Functional Description
C–Remote-Access Retrieval Description
D–Monthly Reproduction Workload
E–Cost/Benefit Model Financial Detail
F–References
G–Glossary of Terms

A-Assumed Pilot Production System Configuration

Subsystem/Component
(Remote-Access Alternative)

A. IMAGE CAPTURE SUBSYSTEM
1. PC workstation
2. Landscape imaging monitor
3. Scanner with document feeder
4. Image-processing board
5. Optical character recognition board
6. Image display interface board
7. Scanner interface board
8. Serial hand-held scanner
9. Serial trackball
10. Power organizer
11. Computer desk and table
12. Scanner table
13. Text-capture software
14. SCSI adapter board

B. QUALITY CONTROL SUBSYSTEM
1. PC workstation
2. Gray-scale imaging display
3. Optical character recognition board
4. Image display board
5. Image printer board
6. Image printer video board
7. Image-enhancement board
8. High-resolution scanner
9. 5.25-inch rewritable optical disk
10. Low-speed laser printer
11. Serial trackball
12. Power organizer
13. Computer desk and table
14. Printer and scanner table
15. SCSI adapter board
16. Image-capture software
17. Image-enhancement software

C. DOCUMENT FILE SERVER
1. PC workstation
2. Portrait imaging display
3. 12-inch WORM with controller
4. 12-inch WORM
5. 12-inch WORM jukebox
6. 5.25-inch rewritable optical disk
7. Display board
8. Display monitor
9. 3270 emulation board
10. 3270 emulation software
11. Remote-access image software
12. High-speed modem
13. Power organizer
14. Computer desk and table
15. Laser printer table
16. External tape backup
17. SCSI adapter board
18. CD-ROM drive
19. Image file-server software
20. Data analysis software
21. Software integration tools

D. DOCUMENT REPRODUCTION SUBSYSTEM
1. PC workstation
2. Serial trackball
3. Image display board
4. Image printer board
5. Laser printer
6. Image printer video cable
7. Power organizer
8. Computer desk and table
9. Laser printer table
10. LAN printer control software

E. REMOTE-ACCESS RETRIEVAL SUBSYSTEM
1. PC 386/25 base unit
2. Portrait imaging display
3. 12-inch WORM with controller
4. 12-inch WORM
5. 5.25-inch rewritable optical disk
6. Image display board
7. Serial trackball
8. Laser printer
9. High-speed modem
10. Power organizer
11. Computer desk and table
12. Laser printer table

F. LOCAL AREA NETWORK
1. LAN boards for four workstations
2. LAN software

B-Current System Functional Description

As discussed in section 4.1, *Current System Description*, it is important to understand the existing procedures at the STI Facility in order to compare the three candidate alternatives. This appendix provides a more detailed description of the document acquisition, image capture and storage, and reproduction of NASA Technical Reports. The following steps provide an overview of the current system procedures.

CURRENT PROCESSING STEPS
1. Document Receipt
2. Input Processing
3. Filming
4. Initial Distribution
5. Archival and Storage
6. Secondary Distribution

Each of these steps will be described briefly to provide some perspective on document handling requirements at the STI Facility. Since the DDS Pilot Production System is proposed as a supplementary capability for providing secondary distribution of NASA Technical Reports, this step will be described in more detail than the others.

B.1. Document Receipt

The Digital Imaging Technology Assessment report established that the STI Facility received over 75,000 documents during contract year four (July 1, 1988—June 30, 1989), 33,000 of which were accepted into the current database. NASA documents account for approximately one-third of all accepted documents and approximately 70 percent of all documents received into the STI Facility are categorized as STAR (1N Series). For Fiscal Year 1988, this resulted in monthly average accepted volumes of 2,399 documents for STAR and 57 documents for LSTAR with annual totals of 23,223 and 679, respectively.

These documents are received at the STI Facility, primarily via U.S. Mail, from Langley Research Center and various commercial printers. Large shipments are sometimes sent in bulk via commercial carrier. Documents are separated, logged in, and a case file is constructed for each. The case file is used to transport the document and associated materials through the various input processing steps.

The STI Facility currently receives a small portion of its accessioned documents in electronic form via magnetic tape. Currently, however, these tapes are used to transmit surrogate entries only, not full documents, to the RECON/STIMS database. They do not, therefore, play any part in satisfying document blowback requests.

B.2. Input Processing

A new document received at the Facility must be examined, paginated, cataloged, duplicate checked, abstracted, and indexed. A surrogate record (text only) is entered into the STIMS database for NASA/RECON search and retrieval. Selected cataloging information is extracted from STIMS and reformatted into a descriptive masthead. This masthead is driven through a Linotronic photocomposition machine to generate a hard-copy masthead, which in turn, is mated with the document for microfiche filming. Input processing workflow is automated and tracked via the Input Processing System (IPS), a mainframe application written in ADABAS/NATURAL that supplements and facilitates manual document handling.

The STI Facility often receives multiple copies of the documents it processes into the STIMS database. The number of copies received varies from report to report. NASA Technical Reports usually arrive with 10 to 15 copies. Once the case file has been created to support input processing, any additional copies are sent to Document Storage as stock copies to be made available to satisfy document requests for stock copies.

Most stock inventory copies arrive at the STI Facility after the case-file copy has been processed and a permanent database accession number has been assigned. Such items are stamped with the accession number and physically arranged in Document Storage in accession number order. If the extra copies arrive before input processing is complete, they are temporarily stored by their NASA report number until a database accession number can be assigned.

Orders for as many as five copies of a document are satisfied from stock as long as the copies are in the inventory and there is no requirement from NASA for a reserve to be maintained for the document.

B.3. Filming

Once input processing of surrogate records into the STIMS database is complete, the case file containing the original hard-copy document is forwarded to Micrographics for filming. The material to be filmed is determined according to the standard set forth in NASA Specification 20 (a description of which is contained in the Statement of Work). A masthead (as described above in section B.2., *Input Processing*) containing necessary descriptive information is joined to the document and each page is photographed with a 24:1 reduction onto microfiche film.

The film is developed on site at STI Facility to produce a silver master microfiche and carefully quality checked to ensure adherence with National Micrographics Association (NMA) standards and NASA specifications. A 100-percent inspection is made of the filmed images, and page count, orientation, resolution, and density are checked by skilled technicians.

If the microfiche does not pass the quality checks, the document is returned for refilming. If the operator judges that refilming cannot improve the image, the operator may elect to stamp the document as "Best Available Copy" and continue processing the microfiche as is. Once a good silver master microfiche has been produced, one silver microfiche duplicate is created to be sent to the Government Printing Office (GPO). This copy is used by GPO to satisfy their document requests and also acts as an additional archival mechanism.

B.4. Initial Distribution

Once filming is completed, initial distribution to regular subscribers is accomplished by making diazo microfiche duplicates on one of three machines installed at STI Facility. The microfiche is collated and packaged according to subscription requirements (some subscribers receive only a subset of the total documents available) and forwarded via U.S. Mail.

B.5. Archival and Storage

The silver microfiche master and one diazo microfiche copy are filed to satisfy archival requirements and secondary distribution requests for hard-copy blowbacks. The 4-by-6-inch microfiche sheets are stored in steel filing cabinets by accession number within accession year. Approximately two cabinets are required to hold the microfiche for each accession year.

B.6. Secondary Distribution

In addition to the automatic primary distribution of documents on microfiche, STI Facility provides secondary distribution of documents on a request basis. An analysis was conducted by RMS Associates to characterize this secondary distribution workload and the results were documented in the DDS Alternative Media Reproduction Volume (Blowback) Report issued in February of 1989.

During 1987 and 1988, the STI Facility received 17,409 reproduction requests for NASA Technical Reports. Of these, 2.6 percent (459) could not be filled because of document unavailability, access limitations, or policy restrictions, leaving 16,950 requests that were actually processed.

The STI Facility fills document reproduction requests by providing stock copy originals, microfiche, 24:1 reproductions, 20:1 reproductions, and 1:1 copies made from hard-copy originals on a duplicating machine. Stock copy originals, microfiche, and reproduction (24:1, 20:1, and 1:1 reproductions collectively) accounted for 51.8, 8.1, and 40.1 percent, respectively, of the request volume over the referenced two-year period.

The portion of the workload that resulted in paper reproduction (namely 24:1, 20:1, and 1:1 reproductions) represented 8,119 requests (7,520 actual requests adjusted for multicopy activity). The 8,119 requests resulted in the generation of 1,079,008 pages at an average of 133 pages per requested NASA Technical Report. On an annual basis this equates to an average of 4,059 requests and 539,504 pages per year of printed paper reproduction volume. It is this paper reproduction workload that can alternatively be accommodated via the DDS system.

Requests for NASA Technical Reports are received via three mechanisms: by phone, by mail, and by online request through NASA/RECON. The ORDER command in NASA/RECON is by far the principle means of ordering documents. The largest component of the request volume is that of NASA Center libraries ordering documents for their patrons. NASA standards require that most document requests be satisfied within five days of order receipt. The current process for filling a document request at the STI Facility is presented in Figure 4-1.

Online requests for documents are queued up during the day and passed through an overnight batch program that prints FF492 forms (Document Request Forms). These are merged with any FF492 forms that have been received by mail or prepared in response to a telephone request. The Registration and Product Control System (RPCS) file is checked to determine the requestor's registration characteristics, and the STIMS database is checked to determine the document type and access restrictions on the materials requested. All requests for classified materials, invalid requests, orders for copyrighted items, and requests for more than five copies are referred to supervisory personnel for review.

The requestor may specify the requested item be provided as:

a. Hard copy (may be filled from stock or blowback)

b. Microfiche (microfiche reproduction required)

c. Stock copy (no reproductions, must fill from stock)

d. Microfiche and hard copy (both reproduced microfiche and either stock copy or hard-copy blowback)

e. Microfiche or hard copy (STI Facility provides hard copy or microfiche at its option)

Requests that can be satisfied from inventory stock are processed by Document Storage. In some cases, NASA requires that a specified number of copies be reserved in inventory. In the case that a document request would reduce the on-hand stock inventory below the reserve level, NASA must approve filling the order from stock. Hard-copy orders that cannot be filled from stock are forwarded to the reprographics department for blowback from microfiche.

The desired document must be manually located in the microfiche storage room, pulled from the file, taken to the duplicating room, and copied on a Tameran 1970 microfiche-to-paper printer. If the order is for only one or two copies, both are produced on the Tameran. If

numerous copies are required, only the first is produced on the Tameran and Xerox copies are then produced on a Xerox 5090. The microfiche is then refiled and the document forwarded to the mailroom for distribution.

The orders are validated before the copying process and again before binding. A final quality-assurance review is performed prior to packaging and mailing.

C–Remote-Access Retrieval Description

This appendix is a brief summary of the display, manipulation, and printing functionality that will be provided in the remote workstation at Code NTT in the DDS Pilot Production System.

C.1. Viewing

The retrieved images can be displayed not only at their full-scale size, but also at zoom magnification (with panning) for an enhanced view of image detail. From within any retrieved document or document subpart, a user at the remote station will be able to execute the following page functions:

* Print this page
* Print this screen
* Get next page
* Get previous page
* Go to first page of document
* Go to the last page of document
* Rotate this page
* Inverse video this page

C.2. Printing

Printing will be available on a document or subpart basis without having to first view the document. The document will have to be retrieved. Printing will be accomplished as a secondary task. A user at the remote workstation will be able to retrieve or view a document while a different document is in the process of printing.

C.3. Retrieving

Retrieving will be made as automatic a function as is possible. The workstation will always check its resident storage first when seeking to retrieve a document. If it is not available, the system will ask if the user wants to retrieve the document electronically from the STI Facility. If the user does want the document, the system will automatically initiate the transaction and inform the user if the request could not be fulfilled. A fulfilled request will result in the viewing of the first page of the retrieved document. It is anticipated that the local storage at the remote workstation will be adequate to hold several hundred pages at a minimum.

C.4. A Remote-Access Scenario

The following is a simulated procedure to retrieve, view and print a document. Not all contingencies or possibilities will be covered. This is only an attempt to give the flavor of the look and feel of what will be involved.

a. Power on the workstation by pushing one switch.

b. After the power-on procedures have finished, the digital document access screen will appear with several options.

c. Items on menu screens will be selected by either a mouse or use of arrow keys to highlight desired subselections. The default function is to view/retrieve, so all a user needs to do is press the Enter key on the keyboard to bring up the next screen to make a selection.

d. The view/seek function will allow the user to type in the accession number of the document they want. This field will be edit checked to ensure that it is in the range of possible accession numbers that are available on optical storage to help minimize false inquires. This screen will additionally allow one to request the Table of Contents page only, a particular page number or a range of page numbers. Pressing the Escape key will always allow one to return to the previous screen.

e. After typing in the accession number and pressing the Enter key, three outcomes are possible. If the document is available locally, the first page will appear with a side bar menu giving the functionality described in the above section, viewing. If the document is not available locally one will be prompted to ascertain if one wants to initiate a remote retrieval. If the document is found at DDS it will be transmitted to the remote workstation and the first page will appear on the screen. If the document is not available anywhere on the DDS system A message will appear on the view/seek indicating so and asking one to make an alternative selection.

f. Assuming there is a successful retrieval, the user can either view the retrieved pages, quit the application, or initiate a printing of part or the entire document. The user can simultaneously print and view the same document. Because the documents will be stored locally in a disk buffer, turning off the computer (workstation) will not result in a loss of the document. Documents can be retrieved one day, viewed another and printed on yet another day.

g. Alternatively, the user will be able to select a document subpart from a Table of Contents function instead of retrieving an entire document. If selected as an option on the view/seek screen, and the document is available, a menu will appear listing the available subparts for the selected document. Using the arrow keys or moving an input locator, such as a mouse, will move a highlighted bar to indicate a sub-selection. Once the desired subpart is indicated, the user need only press the Enter key and the system will retrieve the subpart for

viewing and the system will work as in the previous step. Pressing the Escape key will return the user to the Table of Contents menu where an additional subpart may be selected. Pressing the Escape key once again will provide a return to view/seek screen.

h. Termination of the session can be accomplished by selecting the quit function or pressing the Escape key until the first screen appears, whereby the user can then turn the work-station off.

D–Monthly Reproduction Workload

The numbers contained in the two tables in this appendix represent the estimated monthly reproduction volumes in number of pages that were derived from the DDS Alternative-Media Reproduction Volume (Blowback) Report. The monthly volume numbers were calculated using standard mathematical projections involving integral calculus and straight-line estimation techniques.

Table D-1, the reproduction volume by operational year, provides the estimated number of document pages to be printed from the DDS Pilot Production System from the beginning of document capture time (operational year), which starts in Month 7 of the first project year. The same estimates were allocated to the project year framework in Table D-2, the reproduction volume by project year, which results in different annual reproduction volumes when compared with Table D-1.

Table D-1. *Reproduction volume by operational year.*

YEAR 1 (MONTH)	VOLUME (PAGES)
1	800
2	1,600
3	2,400
4	3,200
5	4,100
6	4,900
7	5,700
8	6,500
9	7,200
10	8,100
11	8,900
12	9,700
Subtotal	*63,100*

YEAR 3 (MONTH)	VOLUME IN PAGES
1	12,200
2	12,500
3	12,800
4	13,100
5	13,400
6	13,700
7	14,000
8	14,300
9	14,600
10	14,900
11	15,200
12	15,500
Subtotal	*166,200*

YEAR 5 (MONTH)	VOLUME (PAGES)
1	19,400
2	19,425
3	19,450
4	19,475
5	19,500
6	19,525
7	19,550
8	19,575
9	19,600
10	19,625
11	19,650
12	19,675
Subtotal	*234,450*

YEAR 2 (MONTH)	VOLUME (PAGES)
1	10,450
2	10,600
3	10,750
4	10,900
5	11,050
6	11,200
7	11,350
8	11,500
9	11,650
10	11,800
11	11,950
12	21,100
Subtotal	*144,300*

YEAR 4 (MONTH)	VOLUME (PAGES)
1	15,800
2	16,100
3	16,400
4	16,700
5	17,000
6	17,300
7	17,600
8	17,900
9	18,200
10	18,500
11	18,800
12	19,100
Subtotal	*209,400*

GRAND TOTAL	817,450

Table D-2. *Reproduction volume by project year.*

YEAR 1 (MONTH)	VOLUME (PAGES)
1	N/A
2	N/A
3	N/A
4	N/A
5	N/A
6	N/A
7	800
8	1,600
9	2,400
10	3,200
11	4,100
12	4,900
Subtotal	*17,000*

YEAR 3 (MONTH)	VOLUME IN PAGES
1	11,350
2	11,500
3	11,650
4	11,800
5	11,950
6	12,100
7	12,200
8	12,500
9	12,800
10	13,100
11	13,400
12	13,700
Subtotal	*148,050*

YEAR 5 (MONTH)	VOLUME (PAGES)
1	17,600
2	17,900
3	18,200
4	18,500
5	18,800
6	19,100
7	19,400
8	19,425
9	19,450
10	19,475
11	19,500
12	19,525
Subtotal	*226,875*

YEAR 2 (MONTH)	VOLUME (PAGES)
1	5,700
2	6,500
3	7,200
4	8,100
5	8,900
6	9,700
7	10,450
8	10,600
9	10,750
10	10,900
11	11,050
12	11,200
Subtotal	*111,050*

YEAR 4 (MONTH)	VOLUME (PAGES)
1	14,000
2	14,300
3	14,600
4	14,900
5	15,200
6	15,500
7	15,800
8	16,100
9	16,400
10	16,700
11	17,000
12	17,300
Subtotal	*187,800*

GRAND TOTAL	690,775

E–Cost/Benefit Model Financial Detail

This appendix contains three summary spreadsheet presentations—Tables E-1, E-2, and E-3)—for Alternatives 1, 2, and 3, respectively. These tables provide a detailed description of cost figures and benefit values by category for each of the 60 months in the Pilot Production System life cycle (Months 1 through 54 in the operational life cycle). The cost/benefit model is designed to support this Costs/Benefit Analysis and subsequent decision-support applications for the DDS Pilot Production System.

TABLE: E-1   Cost/Benefit Model Financial Detail for Alternative 1

| | COSTS | | | | | | | | | | | | | BENEFITS | | | | | COST/BENEFIT | |
| | NON-RECURRING | | | | | | | | RECURRING | | | ALL | NON-RECUR | RECURRING | | | ALL | ALL | |
PER IOD	CENTRAL SITE EQUIP	REMOTE SITE EQUIP	COMMUNI-CATIONS UPGRADE	SYST INSTALL LABOR	SYST INTEG LABOR	PROCESS DEFINE LABOR	TRAIN-ING LABOR	TOTAL NON-RECUR COST	MEDIA COST	COMMUNI-CATIONS COST	DDS OPER LABOR	TOTAL RECUR COST	TOTAL ALL COSTS	TOTAL NON-RECUR BENEFITS	TURN AROUND BENEFIT	QUAL IMPROVE BENEFIT	TOTAL RECUR BENEFITS	TOTAL ALL BENEFITS	SUM OF ALL COSTS & ALL BENEFITS	PER IOD
0	-175957	-18841	-1000					-195798	-4000			-4000	-199798	0	0	0	0	0	(199,798)	0
1				-8400	-17267			-25667		0	0	0	-25667	0	0	0	0	0	(25,667)	1
2					-17267			-17267		0	0	0	-17267	0	0	0	0	0	(17,267)	2
3					-17267	-4200		-21467		0	0	0	-21467	0	0	0	0	0	(21,467)	3
4					-17267	-4200		-21467		0	0	0	-21467	0	0	0	0	0	(21,467)	4
5					-17267		-16800	-34067		0	0	0	-34067	0	0	0	0	0	(34,067)	5
6					-17267		-16800	-34067		-500	-1320	-1820	-35887	0	0	0	0	0	(35,887)	6
7								0		-500	-4120	-4620	-4620	0	448	448	896	896	(3,724)	7
8								0		-500	-4170	-4670	-4670	0	896	896	1792	1792	(2,878)	8
9								0		-500	-4220	-4720	-4720	0	1344	1344	2688	2688	(2,032)	9
10								0		-500	-4270	-4770	-4770	0	1792	1792	3584	3584	(1,186)	10
11								0		-500	-4326	-4826	-4826	0	2296	2296	4592	4592	(234)	11
12								0	-3000	-500	-4376	-7876	-7876	0	2744	2744	5488	5488	(2,388)	12
13								0		-500	-4426	-4926	-4926	0	3192	3192	6384	6384	1,458	13
14								0		-500	-4476	-4976	-4976	0	3640	3640	7280	7280	2,304	14
15								0		-500	-4520	-5020	-5020	0	4032	4032	8064	8064	3,044	15
16								0		-500	-4576	-5076	-5076	0	4536	4536	9072	9072	3,996	16
17								0		-500	-4626	-5126	-5126	0	4984	4984	9968	9968	4,842	17
18								0		-500	-4676	-5176	-5176	0	5432	5432	10864	10864	5,688	18
19								0		-500	-4723	-5223	-5223	0	5852	5852	11704	11704	6,481	19
20								0		-500	-4733	-5233	-5233	0	5936	5936	11872	11872	6,640	20
21								0		-500	-4742	-5242	-5242	0	6020	6020	12040	12040	6,798	21
22								0		-500	-4751	-5251	-5251	0	6104	6104	12208	12208	6,957	22
23								0		-500	-4761	-5261	-5261	0	6188	6188	12376	12376	7,115	23
24								0	-3000	-500	-4770	-8270	-8270	0	6272	6272	12544	12544	4,274	24
25								0		-500	-4779	-5279	-5279	0	6356	6356	12712	12712	7,433	25
26								0		-500	-4789	-5289	-5289	0	6440	6440	12880	12880	7,591	26
27								0		-500	-4798	-5298	-5298	0	6524	6524	13048	13048	7,750	27
28								0		-500	-4808	-5308	-5308	0	6608	6608	13216	13216	7,909	28
29								0		-500	-4817	-5317	-5317	0	6692	6692	13384	13384	8,067	29
30								0		-500	-4826	-5326	-5326	0	6776	6776	13552	13552	8,226	30
31								0		-500	-4833	-5333	-5333	0	6832	6832	13664	13664	8,332	31
32								0		-500	-4851	-5351	-5351	0	7000	7000	14000	14000	8,649	32
33								0		-500	-4870	-5370	-5370	0	7168	7168	14336	14336	8,966	33
34								0		-500	-4889	-5389	-5389	0	7336	7336	14672	14672	9,283	34
35								0		-500	-4908	-5408	-5408	0	7504	7504	15008	15008	9,601	35
36								0	-3000	-500	-4926	-8426	-8426	0	7672	7672	15344	15344	6,918	36
37								0		-500	-4945	-5445	-5445	0	7840	7840	15680	15680	10,235	37
38								0		-500	-4964	-5464	-5464	0	8008	8008	16016	16016	10,552	38
39								0		-500	-4983	-5483	-5483	0	8176	8176	16352	16352	10,870	39
40								0		-500	-5001	-5501	-5501	0	8344	8344	16688	16688	11,187	40
41								0		-500	-5020	-5520	-5520	0	8512	8512	17024	17024	11,504	41
42								0		-500	-5039	-5539	-5539	0	8680	8680	17360	17360	11,821	42
43								0		-500	-5058	-5558	-5558	0	8848	8848	17696	17696	12,139	43
44								0		-500	-5076	-5576	-5576	0	9016	9016	18032	18032	12,456	44
45								0		-500	-5095	-5595	-5595	0	9184	9184	18368	18368	12,773	45
46								0		-500	-5114	-5614	-5614	0	9352	9352	18704	18704	13,090	46
47								0		-500	-5133	-5633	-5633	0	9520	9520	19040	19040	13,408	47
48								0	-3000	-500	-5151	-8651	-8651	0	9688	9688	19376	19376	10,725	48
49								0		-500	-5170	-5670	-5670	0	9856	9856	19712	19712	14,042	49
50								0		-500	-5189	-5689	-5689	0	10024	10024	20048	20048	14,359	50
51								0		-500	-5208	-5708	-5708	0	10192	10192	20384	20384	14,677	51
52								0		-500	-5226	-5726	-5726	0	10360	10360	20720	20720	14,994	52
53								0		-500	-5245	-5745	-5745	0	10528	10528	21056	21056	15,311	53
54								0		-500	-5264	-5764	-5764	0	10696	10696	21392	21392	15,628	54
55								0		-500	-5283	-5783	-5783	0	10864	10864	21728	21728	15,946	55
56								0		-500	-5284	-5784	-5784	0	10878	10878	21756	21756	15,972	56
57								0		-500	-5286	-5786	-5786	0	10892	10892	21784	21784	15,998	57
58								0		-500	-5287	-5787	-5787	0	10906	10906	21812	21812	16,025	58
59								0		-500	-5289	-5789	-5789	0	10920	10920	21840	21840	16,051	59
60								0		-500	-5290	-5790	-5790	0	10934	10934	21868	21868	16,078	60
TOT	-175957	-18841	-1000	-8400	-103600	-8400	-33600	-349798	-16000	-27500	-264273	-307773	-657571	0	386834	386834	773668	773668	116,097	TOT
PV TOT	-175957	-18841	-1000	-8331	-100644	-8160	-32101	-345034	-13413	-21094	-200414	-234921	-579955	0	280674	280674	561347	561347	(18,607)	PV TOT

Quality Improvement = $0.56/page   Turnover Improvement = $0.56/page

TABLE: E-2   Cost/Benefit Model Financial Detail for Alternative 2

PERIOD	CENTRAL SITE EQUIP	REMOTE SITE EQUIP	COMMUNI-CATIONS UPGRADE	SYST INSTALL LABOR	SYST INTEG LABOR	PROCESS DEFINE LABOR	TRAIN-ING LABOR	TOTAL NON-RECUR COST	MEDIA COST	COMMUNI-CATIONS COST	DDS OPER LABOR	TOTAL RECUR COST	TOTAL ALL COSTS	TOTAL NON-RECUR BENEFITS	TURN AROUND BENEFIT	QUAL IMPROVE BENEFIT	TOTAL RECUR BENEFITS	TOTAL ALL BENEFITS	SUM OF ALL COSTS & ALL BENEFITS	PERIOD
0	-178307	-16841	0					-195148	-4000			-4000	-199148	0	0	0	0	0	(199,148)	0
1				-8400	-17267			-25667		0	0	0	-25667	0	0	0	0	0	(25,667)	1
2					-17267			-17267		0	0	0	-17267	0	0	0	0	0	(17,267)	2
3					-17267	-4200		-21467		0	0	0	-21467	0	0	0	0	0	(21,467)	3
4					-17267	-4200		-21467		0	0	0	-21467	0	0	0	0	0	(21,467)	4
5					-17267		-16800	-34067		0	0	0	-34067	0	0	0	0	0	(34,067)	5
6					-17267		-16800	-34067		0	-1320	-1320	-35387	0	0	0	0	0	(35,387)	6
7								0		0	-4120	-4120	-4120	0	448	448	896	896	(3,224)	7
8								0		0	-4170	-4170	-4170	0	896	896	1792	1792	(2,378)	8
9								0		0	-4220	-4220	-4220	0	1344	1344	2688	2688	(1,532)	9
10								0		0	-4270	-4270	-4270	0	1792	1792	3584	3584	(686)	10
11								0		0	-4325	-4325	-4325	0	2296	2296	4592	4592	268	11
12								0	-3000	0	-4375	-7375	-7375	0	2744	2744	5488	5488	(1,888)	12
13								0		0	-4425	-4425	-4425	0	3192	3192	6384	6384	1,958	13
14								0		0	-4475	-4475	-4475	0	3640	3640	7280	7280	2,804	14
15								0		0	-4520	-4520	-4520	0	4032	4032	8064	8064	3,544	15
16								0		0	-4576	-4576	-4576	0	4536	4536	9072	9072	4,496	16
17								0		0	-4626	-4626	-4626	0	4984	4984	9968	9968	5,342	17
18								0		0	-4676	-4676	-4676	0	5432	5432	10864	10864	6,188	18
19								0		0	-4723	-4723	-4723	0	5852	5852	11704	11704	6,981	19
20								0		0	-4733	-4733	-4733	0	5936	5936	11872	11872	7,140	20
21								0		0	-4742	-4742	-4742	0	6020	6020	12040	12040	7,298	21
22								0		0	-4751	-4751	-4751	0	6104	6104	12208	12208	7,457	22
23								0		0	-4761	-4761	-4761	0	6188	6188	12376	12376	7,615	23
24								0	-3000	0	-4770	-7770	-7770	0	6272	6272	12544	12544	4,774	24
25								0		0	-4779	-4779	-4779	0	6356	6356	12712	12712	7,933	25
26								0		0	-4789	-4789	-4789	0	6440	6440	12880	12880	8,091	26
27								0		0	-4798	-4798	-4798	0	6524	6524	13048	13048	8,250	27
28								0		0	-4808	-4808	-4808	0	6608	6608	13216	13216	8,409	28
29								0		0	-4817	-4817	-4817	0	6692	6692	13384	13384	8,567	29
30								0		0	-4826	-4826	-4826	0	6776	6776	13552	13552	8,726	30
31								0		0	-4833	-4833	-4833	0	6832	6832	13664	13664	8,832	31
32								0		0	-4851	-4851	-4851	0	7000	7000	14000	14000	9,149	32
33								0		0	-4870	-4870	-4870	0	7168	7168	14336	14336	9,466	33
34								0		0	-4889	-4889	-4889	0	7336	7336	14672	14672	9,783	34
35								0		0	-4908	-4908	-4908	0	7504	7504	15008	15008	10,101	35
36								0	-3000	0	-4928	-7928	-7928	0	7672	7672	15344	15344	7,416	36
37								0		0	-4945	-4945	-4945	0	7840	7840	15680	15680	10,735	37
38								0		0	-4964	-4964	-4964	0	8008	8008	16016	16016	11,052	38
39								0		0	-4983	-4983	-4983	0	8176	8176	16352	16352	11,370	39
40								0		0	-5001	-5001	-5001	0	8344	8344	16688	16688	11,687	40
41								0		0	-5020	-5020	-5020	0	8512	8512	17024	17024	12,004	41
42								0		0	-5039	-5039	-5039	0	8680	8680	17360	17360	12,321	42
43								0		0	-5058	-5058	-5058	0	8848	8848	17696	17696	12,639	43
44								0		0	-5076	-5076	-5076	0	9016	9016	18032	18032	12,956	44
45								0		0	-5095	-5095	-5095	0	9184	9184	18368	18368	13,273	45
46								0		0	-5114	-5114	-5114	0	9352	9352	18704	18704	13,590	46
47								0		0	-5133	-5133	-5133	0	9520	9520	19040	19040	13,908	47
48								0	-3000	0	-5151	-8151	-8151	0	9688	9688	19376	19376	11,225	48
49								0		0	-5170	-5170	-5170	0	9856	9856	19712	19712	14,542	49
50								0		0	-5189	-5189	-5189	0	10024	10024	20048	20048	14,859	50
51								0		0	-5208	-5208	-5208	0	10192	10192	20384	20384	15,177	51
52								0		0	-5226	-5226	-5226	0	10360	10360	20720	20720	15,494	52
53								0		0	-5245	-5245	-5245	0	10528	10528	21056	21056	15,811	53
54								0		0	-5264	-5264	-5264	0	10696	10696	21392	21392	16,128	54
55								0		0	-5283	-5283	-5283	0	10864	10864	21728	21728	16,446	55
56								0		0	-5284	-5284	-5284	0	10878	10878	21756	21756	16,472	56
57								0		0	-5286	-5286	-5286	0	10892	10892	21784	21784	16,498	57
58								0		0	-5287	-5287	-5287	0	10906	10906	21812	21812	16,525	58
59								0		0	-5289	-5289	-5289	0	10920	10920	21840	21840	16,551	59
60								0	0	0	-5290	-5290	-5290	0	10934	10934	21868	21868	16,578	60
TOT	-176307	-16841	0	-8400	-103600	-8400	-33600	-349148	-16000	0	-264273	-280273	-629421	0	386834	386834	773668	773668	144,247	TOT
PV TOT	-176307	-16841	0	-8331	-100644	-8160	-32101	-344384	-13413	0	-200414	-213827	-558211	0	280674	280674	561347	561347	3,137	PV TOT

Quality Improvement = $0.56/page   Turnover Improvement = $0.56/page

TABLE: E-3   Cost/Benefit Model Financial Detail for Alternative 3

P E R I O D	CENTRAL SITE EQUIP	REMOTE SITE EQUIP	COMMUNI-CATIONS UPGRADE	SYST INSTALL LABOR	SYST INTEG LABOR	PROCESS DEFINE LABOR	TRAIN-ING LABOR	TOTAL NON-RECUR COST	MEDIA COST	COMMUNI-CATIONS COST	DDS OPER LABOR	TOTAL RECUR COST	TOTAL ALL COSTS	NON-RECUR TOTAL NON-RECUR BENEFITS	TURN AROUND BENEFIT	QUAL IMPROVE BENEFIT	TOTAL RECUR BENEFITS	TOTAL ALL BENEFITS	SUM OF ALL COSTS & ALL BENEFITS	P E R I O D
COSTS — NON-RECURRING									**RECURRING**				**ALL**	**NON-RECUR**	**RECURRING**			**ALL**	**COST/BENEFIT ALL**	
0	-175858	-18841	0					-194699	-7000			-7000	-201699	0	0	0	0	0	(201,699)	0
1				-14000	-19600			-33600		0	0	0	-33600	0	0	0	0	0	(33,600)	1
2					-19600			-19600		0	0	0	-19600	0	0	0	0	0	(19,600)	2
3					-19600	-4200		-23800		0	0	0	-23800	0	0	0	0	0	(23,800)	3
4					-19600	-4200		-23800		0	0	0	-23800	0	0	0	0	0	(23,800)	4
5					-19600		-16800	-36400		0	0	0	-36400	0	0	0	0	0	(36,400)	5
6					-19600		-16800	-36400		0	-1320	-1320	-37720	0	0	0	0	0	(37,720)	6
7								0		0	-4120	-4120	-4120	0	448	448	896	896	(3,224)	7
8								0		0	-4170	-4170	-4170	0	896	896	1792	1792	(2,378)	8
9								0		0	-4220	-4220	-4220	0	1344	1344	2688	2688	(1,532)	9
10								0		0	-4270	-4270	-4270	0	1792	1792	3584	3584	(686)	10
11								0		0	-4326	-4326	-4326	0	2296	2296	4592	4592	266	11
12								0	-5000	0	-4376	-9376	-9376	0	2744	2744	5488	5488	(3,888)	12
13								0		0	-4426	-4426	-4426	0	3192	3192	6384	6384	1,958	13
14								0		0	-4476	-4476	-4476	0	3640	3640	7280	7280	2,804	14
15								0		0	-4520	-4520	-4520	0	4032	4032	8064	8064	3,544	15
16								0		0	-4576	-4576	-4576	0	4536	4536	9072	9072	4,496	16
17								0		0	-4626	-4626	-4626	0	4984	4984	9968	9968	5,342	17
18								0		0	-4676	-4676	-4676	0	5432	5432	10864	10864	6,188	18
19								0		0	-4723	-4723	-4723	0	5852	5852	11704	11704	6,981	19
20								0		0	-4733	-4733	-4733	0	5936	5936	11872	11872	7,140	20
21								0		0	-4742	-4742	-4742	0	6020	6020	12040	12040	7,298	21
22								0		0	-4751	-4751	-4751	0	6104	6104	12208	12208	7,457	22
23								0		0	-4761	-4761	-4761	0	6188	6188	12376	12376	7,615	23
24								0	-5000	0	-4770	-9770	-9770	0	6272	6272	12544	12544	2,774	24
25								0		0	-4779	-4779	-4779	0	6356	6356	12712	12712	7,933	25
26								0		0	-4789	-4789	-4789	0	6440	6440	12880	12880	8,091	26
27								0		0	-4798	-4798	-4798	0	6524	6524	13048	13048	8,250	27
28								0		0	-4808	-4808	-4808	0	6608	6608	13216	13216	8,408	28
29								0		0	-4817	-4817	-4817	0	6692	6692	13384	13384	8,567	29
30								0		0	-4826	-4826	-4826	0	6776	6776	13552	13552	8,726	30
31								0		0	-4833	-4833	-4833	0	6832	6832	13664	13664	8,832	31
32								0		0	-4851	-4851	-4851	0	7000	7000	14000	14000	9,149	32
33								0		0	-4870	-4870	-4870	0	7168	7168	14336	14336	9,466	33
34								0		0	-4889	-4889	-4889	0	7336	7336	14672	14672	9,783	34
35								0		0	-4908	-4908	-4908	0	7504	7504	15008	15008	10,101	35
36								0	-5000	0	-4926	-9926	-9926	0	7672	7672	15344	15344	5,418	36
37								0		0	-4945	-4945	-4945	0	7840	7840	15680	15680	10,735	37
38								0		0	-4964	-4964	-4964	0	8008	8008	16016	16016	11,052	38
39								0		0	-4983	-4983	-4983	0	8176	8176	16352	16352	11,370	39
40								0		0	-5001	-5001	-5001	0	8344	8344	16688	16688	11,687	40
41								0		0	-5020	-5020	-5020	0	8512	8512	17024	17024	12,004	41
42								0		0	-5039	-5039	-5039	0	8680	8680	17360	17360	12,321	42
43								0		0	-5058	-5058	-5058	0	8848	8848	17696	17696	12,639	43
44								0		0	-5076	-5076	-5076	0	9016	9016	18032	18032	12,956	44
45								0		0	-5095	-5095	-5095	0	9184	9184	18368	18368	13,273	45
46								0		0	-5114	-5114	-5114	0	9352	9352	18704	18704	13,590	46
47								0		0	-5133	-5133	-5133	0	9520	9520	19040	19040	13,908	47
48								0	-5000	0	-5151	-10151	-10151	0	9688	9688	19376	19376	9,225	48
49								0		0	-5170	-5170	-5170	0	9856	9856	19712	19712	14,542	49
50								0		0	-5189	-5189	-5189	0	10024	10024	20048	20048	14,859	50
51								0		0	-5208	-5208	-5208	0	10192	10192	20384	20384	15,177	51
52								0		0	-5226	-5226	-5226	0	10360	10360	20720	20720	15,494	52
53								0		0	-5245	-5245	-5245	0	10528	10528	21056	21056	15,811	53
54								0		0	-5264	-5264	-5264	0	10696	10696	21392	21392	16,128	54
55								0		0	-5283	-5283	-5283	0	10864	10864	21728	21728	16,446	55
56								0		0	-5284	-5284	-5284	0	10878	10878	21756	21756	16,472	56
57								0		0	-5286	-5286	-5286	0	10892	10892	21784	21784	16,498	57
58								0		0	-5287	-5287	-5287	0	10906	10906	21812	21812	16,525	58
59								0		0	-5289	-5289	-5289	0	10920	10920	21840	21840	16,551	59
60								0	0	0	-5290	-5290	-5290	0	10934	10934	21868	21868	16,578	60
TOT	-175858	-18841	0	-14000	-117600	-8400	-33600	-368299	-27000	0	-264273	-291273	-659572	0	386834	386834	773668	773668	114,096	**TOT**
PV TOT	-175858	-18841	0	-13884	-114245	-8160	-32101	-363089	-22689	0	-200414	-223103	-586192	0	280674	280674	561347	561347	(24,844)	**PV TOT**

Quality Improvement = $0.56/page   Turnover Improvement = $0.56/page

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G–Glossary of Terms

1:1 reproduction: This is an exact-size reproduction of an original document; for example, an 8.5-by-11-inch copy made from an 8.5-by-11-inch original document.

20:1 and 24:1 reproduction: These terms represent the amount of magnification (20 and 24 times, respectively) that is necessary to produce an 8.5-by-11-inch paper copy of an image stored on microfiche.

Access Time: The time required to gain entry to a specific location on a memory device.

Accession: This term indicates a surrogate record that identifies a document or a part of a document (analytic).

Address: The physical or logical location in a computer's memory of a quantity of data.

ADP: Automated data processing.

AGA: Advanced Graphic Applications Inc.

AIIM: Association for Information and Image Management.

AIM: NASA's Automated Information Management.

Analytic: This term refers to the logical concept of dividing a document, such as conference proceedings, into parts. Each part is known as an analytic, which is assigned an accession number. When a document is divided into analytics, the document and its analytics form a parent/child or primary/subsidiary relationship.

ANSI: American National Standards Institute.

Archival: This term, when used for media, means that it is readable (and sometimes writable) for a long time; "long" means anywhere from 5 to 100 years or more depending on who is speaking.

ASCII: American Standard Code for Information Interchange.

Aspect Ratio: The relationship between the length and width of a two-dimensional area.

AT: Advanced Technology.

ATL: Automated Tape Library.

b: Abbreviation for "bit."

B: Abbreviation for "byte."

Back-up: A copy of stored data.

Bandwidth: The range of frequencies that can be passed through a channel.

BER: Bit error rate.

Bit: Short for "binary digit, " a bit is a unit of computer information that can be represented by an electrical impulse, a magnetized spot, or a hole whose presence or absence indicates data.

Block: An amount of data move or addressed as a single unit.

Blowback: In micrographics, when a reduced image is projected back to its original size.

bpi: Bits per inch.

Broadband: A device that can accept a wide range of frequencies. Same as "wide band"; see "bandwidth."

Buffer: (Noun) A relatively small portion of memory in which data is kept briefly between or during steps of processing of that data. (Verb) The use of a buffer to store data.

Byte: A group of adjacent binary bits, often shorter than a word, that a computer processes as a unit, for example, an 8-bit byte.

Cache: Generally, temporary storage for data to which access must be very quick.

CALS: Computer-aided Logistics Support. A U.S. Department of Defense (DOD) initiative to provide a standardized method of exchanging text and images among multiple computer hardware and software platforms. CALS is actually a superset of existing standards governing format s for computer graphics files, document typesetting tags, and storing scanned images. See "CGM," "SGML," and "TIFF."

CAR: Computer-assisted retrieval.

Cartridge: In optical technology, an enclosure, generally of plastic in which an optical medium is kept for protection, also called a cassette.

CAV: Constant angular velocity. Describes a disk that always spins at the same rotation rate.

CCD: Charge coupled device.

CCITT: The International Telegraph and Telephone Consultative Committee

CD-ROM: Compact Disc–read only memory. A version of the audio Compact Disc intended to store general-purpose memory.

CD: Compact Disc, the trademarked name for the laser-read digital audio disk, 12 centimeters in diameter, developed jointly by Philips and Sony; see "CD-ROM."

CGM: Computer graphics metafile. A standard file format for electronically stored images.

CICS: IBM's Customer Information Control System.

CLV: Constant linear velocity. Describes a disk that rotates more slowly when outer radii are being scanned.

COM: Computer output microfilm. A system in which digital data is converted into an image on dry processed microfilm; see "CD-ROM."

Compression: An encoding technique that save space by eliminating gaps, empty fields, redundancy, or unnecessary data.

Compression algorithms: The formulae according to which digital data sets representing images are compressed.

DAT: Digital audio tape.

Data rate: The rate at which data moves through, out of or into a device; frequently modified by "peak," "burst," "instantaneous," "sustained," "average," or other indicators of the conditions of measurement.

Database: A collection of information; computer methods for organizing and manipulating databases are called "database management systems."

DBMS: Database management system

DDS: Digital Document Storage

Decompression: A decoding technique that is a reverses compression to convert what was compressed to the original data.

Defect: An irregularity in a medium that disturbs its ability to store recorded data.

Digital image management system: This is a system designed to convert documents into binary (digital) code representing an image of the document and to store that code onto optical media. The digitized image can be reproduced as a paper copy of the original document or displayed as an image of the original document upon request.

Digital Paper: A relatively new optical storage flexible media that has a storage capacity of one gigabyte on a single-sided 5.25-inch optical disk.

Disk: A medium for randomly addressable data storage.

Disk Partitioning: The division of one large disk area into smaller user-defined storage blocks.

Document: This is the physical, paper copy, of a NASA Technical Report. Any document referenced in a RECON/STIMS database and retained at the STI Facility is assigned an accession number.

DOR: Digital optical recorder.

DOS: Disk Operating System. The operating system for computers that manages the physical resources of a computer such as disks, memory, displays, etc. UNIX, MS-DOS, OS/2 and VMS are examples.

dpi: Dots per inch.

DRAW: Direct read after write.

Drive: A machine for reading and, when possible, writing a data storage medium (disk, tape, card, or otherwise); can be optical, magnetic, etc.

DTR: Data transfer rate

EDRAW: Erasable DRAW.

Erasable: Rewritable. See also "M-O."

ESA: European Space Agency

fax: (Noun) Facsimile machine; the electronic transmission of a document page image by a facsimile machine; or the hard-copy output produced by a facsimile machine. (Verb) To send document page images via a facsimile machine.

fax board: An add-in board that enables a PC workstation to send or receive a facsimile (fax) transmission. A received fax can be output on a printer connected to the PC.

FIFO: First-in, first-out. A queue for storage of commands or data.

File server: A special PC where shared software resources are stored, including the network software that monitors network operation. The file server software manages access to a shared disk and the data on it. File server software is designed specifically for networking and is built to handle the sharing of files in a multiuser environment.

FIPS: Federal Information Processing Standard.

Firmware: Software stored in read-only memory (ROM).

Formatting: The physical format of an optical disk. The preparation of a storage medium with guidance information and a structure for keeping or collecting information for a directory. This collection of material placed on the disk before user data is written is called a "format."

Frequency: The number of cycles per second of a periodic phenomenon; unit is hertz (Hz); see "wave."

FTE: Full-time equivalent.

G: Abbreviation for "giga."

Gb: Gigabit; one billion (2^{30}) bites.

GB: Gigabyte; one billion (2^{30}) bytes.

GEM: Graphics Environment Manager from Digital Research Inc.

Giga: Prefix meaning one billion.

GPO: U.S. Government Printing Office.

Handling zone: The part of a disk that may be touched by a handling mechanism (For example, in a jukebox).

Hertz: A unit of frequency equal to one cycle per second.

Hierarchy: An arrangement of memory device types connected to form a series with increasing values of one parameter (e.g., accessibility) and decreasing values of another parameter (e.g., cost per bit).

Huffman code: A code used for one-dimensional data compression in the CCITT Group III digital facsimile standard.

Hz: Abbreviation for "hertz."

IBM: International Business Machines Inc.

IEEE: Institute of Electrical and Electronics Engineers.

IMG: An image file format created by Digital Research Inc. for its GEM Paint program.

Import/Export Slot: The slot used to add disks to or remove disks from a jukebox; also referred to as an exchange slot or mailbox.

IPL: Intelligent Peripheral Interface.

IPS: Input Processing System.

ISO: International Standards Organization.

Jukebox: An automatic media handler for optical disks and drives; also called a library.

k: The abbreviation for "kilo."

Kb: kilobits; 1,024 (2^{10}) bits.

KB: Kilobytes; 1,024 (2^{10}) bytes.

Kbps: Kilobits per second.

C-2

Kilo: Prefix meaning one thousand.

KIPP: Kofax Image Processing Platform.

LAN: Local Area Network.

Library: See "jukebox."

LMS: Lasor Magnetic Storage International Company.

lpi: Lines per inch.

LSTAR (1X series): Limited distribution STAR documents. See "STAR."

LU: logical unit.

M-O: See "magneto-optical."

M: Abbreviation for "mega."

m: Abbreviation for "milli."

Magneto-optic: Information stored by local magnetization of a magnetic medium. Reading is done optically, through rotation of the plane of polarization of probing light via the Faraday effect or Kerr effect.

Mainframe: A large, expensive, powerful computer intended for centralized application.

Mapping: In a jukebox environment, the process of translating a volume name to a disk's slot number.

MB: megabyte, or one million (2^{20}) bytes.

MCAV: Modified constant angular velocity. A media format with greater data density then CAV, but without the performance compromise of CLV. See "CAV."

MCLV: Modified constant linear velocity. See "CLV."

Media: Properly, plural of "medium," but widely used as both singular and plural.

Medium: A substance or object on which information is stored; usually refers either to the sensitive coating on a writable device or to the device itself (e.g., disk, tape, card, etc.).

Mega: Prefix meaning one million.

Migration: The movement of data up and down within a hierarchy of storage devices.

MIL: Military

Milli: Prefix meaning one thousandth (10^{-3}).

MIPS: Million instructions per second; a measure of the speed of a computer.

Mount: (1) An operation that makes the contents of a volume available to a file system; (2) The act of determining the location of a volume in a jukebox and insuring it is spun up in a drive.

MS-DOS: Microsoft Disk Operating System.

ms: millisecond; 2^{-3} seconds; one thousandth of a second.

MSP: An image file format for Microsoft Windows Paint program.

MSS: Mass storage system.

MTBF: Mean time before failure.

Multiplex: The simultaneous transmission of many signals on one channel. These signals can be separated in frequency, time, phase, or any other dependable means.

N/A: Not available.

Nano: Prefix meaning one billionth.

Nanosecond: One billionth of a second. Abbreviated ns or nsec.

NASA: National Aeronautics and Space Administration.

NCP: Network control program.

NMA: National Micrographics Association.

Noise: Unwanted signals present on a medium, either before or after recording.

NPV: Net present value.

ns: Abbreviation for nanosecond.

nsec: Abbreviation for nanosecond.

OA: See "office automation."

OCR: See "optical character recognition."

ODD: optical data disk

OEM: original equipment manufacturer

Office automation: An unhallowed buzz phrase describing the use of electronic and computer devices in office applications.

OMDR: optical memory disk recorder. A DRAW device used to write analog or digital information to an optical disk.

Operating system: A specialized program that provides a computer with its basic "personality," including its interfaces displays, and memories (see "access method"). Two such microcomputer operation systems are CP/M and MS-DOS. One for larger microcomputers and mini-computers is UNIX. Two mainframe operating systems are VM and MVS.

Optical character recognition: A process of recognizing characters or numbers in printed or bit-mapped form through the use of optical scanning technology.

Optical disk: A disk read and/or written by light, generally laser light; such a disk may store video, audio, or digital data.

Optical file server: A PC with a high-capacity optical disk acting as a file server. See "file server."

OROM: Optical Read Only Memory.

OS: See "operating system."

OSI: Open Systems Interconnect. A mass-storage interface standard promulgated, in a striking case of acronymic symmetry, by the ISO.

Overhead: In computer jargon, the amount of storage or other resources used to accomplish some task. For example, error correction code added to data might increase total storage requirements by 20 percent, which would be referred to as the overhead of that error correction code.

Packet Switching: A technique of data multiplexing in which individual data streams are divided into "packets" (which are identified by the sending and receiving address) and sent out into the common channel; basic to the Ethernet LAN.

Parity bits: Extra bits added to blocks of data to provide a very simple form of error detection and, sometimes, correction. See "framing."

PC: Personal Computer.

PCX: An image file format created by ZSoft Inc. for its PC Paintbrush program.

Peripheral: Computerese for a machine that attaches to a computer (e.g., disk drive, printer, CRT terminal).

Picture Element: The smallest resolvable dot in an image display. Sometimes abbreviated as "pel."

Pixel: Common abbreviation for "picture element."

ppm: Pages per minute.

Processed requests: This phrase indicates those requests for reproduced NASA Technical Reports that are accepted and processed by reproducing a paper copy from microfiche or from the original stock copy.

PSCN: Program Support Communications Network.

QLV: Quantized linear velocity; see "MCAV."

R-COM: Raster format computer output microfilm. Device to transfer data from optical digital storage to microfilm; see "COM."

RAM: Random access memory.

Raster: The scanning lines that form the image or graphic output on a computer display.

Read-time: In reference to the recording of an event means recording the event at the same time as it occurs; an example of non-real-time recording would be making a replica from a master recording.

RES: An image file format of Xerox Systems Inc.

RF: Radio frequency.

RFP: Request for Proposal.

RFQ: Request for Quotation.

RPCS: Registration and Product Control System.

Run length encoding: The basis for most of the data compression methods used in digital representation of images; based on transmitting numbers describing the lengths of white and black regions of an image rather than sending separately each black or white pixel.

Scanner: A device that resolves a two-dimensional object, such as a business document, into a stream of bits by raster scanning and quantization.

SCSI: Small computer systems interface; commonly pronounced "scuzzy."

Sector: A triangular section of a disk surface within a track. A block of data is addressed by its track and sector numbers.

Seek Time: The time required to make a storage unit ready to access a specific location by selection or physical positioning.

SGML: Standard Generalized Markup Language. A standard method of tagging an electronic document file for indicating typesetting and layout formats.

Slot Number: Numeric indicator of a location within a jukebox; could be a storage slot, optical drive or the mailbox (import/export slot).

SNA: System Network Architecture promoted by IBM.

STAR: Scientific and Technical Aerospace Reports. STAR is a major component of a comprehensive NASA information system covering aeronautics, space, and supporting disciplines.

STI Facility: The NASA Scientific and Technical Information Facility.

STIMS: Scientific and Technical Information Modular System.

Storage: The capability of a computer or related device to hold data and return it on demand.

System: Any combination of things coordinated to accomplish some function.

T: Abbreviation for "tera."

Tera: The prefix meaning one trillion (10^{12}). For example, 2TB is 2,000,000,000 bytes.

Throughput: Computerese for the volume of work or information flowing through a system. Particularly meaningful in information storage and retrieval systems, in which throughput is measured in units such as accesses per hour.

TIFF: Tagged Image File Format. Developed by Aldus Corporation, TIFF is the de facto standard method for storing images captured by a scanner.

Track: A circular path on which information may be stored on a disk surface. A track encompasses one rotation of the disk, and is divided into sectors.

Transfer Rate: The rate at which data is transferred to or from a device; especially the reading or writing rate of a storage peripheral. Usually expressed in kilobits or megabits per second (Kbps or Mbps).

TSO: Time share option.

Unmount: (1) An operation that makes the contents of a volume unavailable to a file system; (2) The act of spinning down a drive, removing its disk, and placing it in a storage slot within a jukebox.

Vector Format: A representation of a line drawing by listing the beginning and end points of all the lines; see "raster."

Volume: (1) One unit of removable storage; the contents of one optical disk surface; (2) A "named" optical disk surface in a jukebox; its name (label) is usually stored in a prescribed location on its surface.

VTAM: Virtual telecommunication access method.

WAN: Wide area network.

Wave: one complete cycle of a change in electromagnetic intensity or potential.

Wide band: See "broadband."

WMRA: Write many, read always.

WORM: Write once, read many times.

Write-once: Can be written to but not erased.

ZCAV: Zoned constant angular velocity. See "MCAV."