X 4

8/1/66

RCA

MSP

ANAGEMENT
ERVICES
ROJECT

MASTER PLAN
FOR
DOCUMENTATION MANAGEMENT AND USE

MASTER PLAN

FOR

DOCUMENTATION MANAGEMENT AND USE

Prepared For

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama
August 1, 1966

by

The Radio Corporation of America
Master Plan Study Team
Contract NAS8-4110

W. W. Thomas, Chairman

Accepted by:

V. C. Sorensen, Chief
Management Services Office

TABLE OF CONTENTS

		Page
SUMMARY		vi
INTRODUCTION		xii
SECTION I	DATA ORIGINATION AND USE	
1.1	Background	1-1
1.2	Data Origination	1-1
1.2.1	Transition Period	1-1
1.2.2	Saturn I Status	1-2
1.2.3	Saturn V Status	1-2
1.2.4	Apollo Application Status	1-2
1.2.5	Conclusions	1-5
1.3	Data Use	1-5
1.3.1	Who is the Data User?	1-6
1.3.2	Where is the Data User?	1-11
1.3.3	What Data is Being Used?	1-16
1.3.4	Why is Data Used?	1-21
1.4	Conclusions	1-24
1.5	Recommendations	1-25
SECTION II	MANAGEMENT	
2.1	Data Management Organization	2-1
2.1.1	Definition	2-1
2.1.2	Findings	2-1
2.1.3	Analysis	2-1
2.1.4	Conclusions	2-2
2.2	The Role of Data Management in Program Management	2-7
2.2.1	Definition	2-7
2.2.2	Findings	2-8
2.2.3	Analysis	2-9
2.2.4	Conclusions	2-9

2.3	The Role of the Marshall Repository in Data Management	2-11
2.3.1	Definition	2-11
2.3.2	Findings	2-11
2.3.3	Analysis	2-12
2.3.4	Conclusions	2-12
2.4	The Role of Research and Development Operations in Data Management	2-13
2.4.1	Definition	2-13
2.4.2	Findings	2-13
2.4.3	Analysis	2-14
2.4.4	Conclusions	2-14
2.5	Recommendations	2-15
SECTION III	DATA ACQUISITION	
3.1	General	3-1
3.2	Findings and Analysis	3-2
3.2.1	Requirements Identification	3-2
3.2.2	Data Procurement	3-4
3.2.3	Product Assurance	3-6
3.3	Conclusions	3-9
3.4	Recommendations	3-10
SECTION IV	DATA RELEASE	
4.1	Release of Class II Data	4-1
4.2	Release of Class I Data	4-4
4.3	Conclusions	4-6
4.4	Recommendations	4-7
SECTION V	DATA STORAGE, RETRIEVAL, AND INDEXING	
5.1	Introduction	5-1
5.2	Discussion	5-4
5.3	Analysis of Specific Possible Systems	5-6
5.3.1	General Summary	5-6
5.3.2	Miscellaneous Systems	5-6
5.3.3	Data Storage and Retrieval Equipment	5-14
5.4	Conclusions	5-97
5.5	Recommendations	5-97

SECTION VI DATA DISTRIBUTION

6.1 Definition 6-1
6.2 Discussion. 6-1
6.3 Automatic Distribution. 6-2
6.3.1 Monitoring Automatic Distribution. 6-3
6.4 Random Distribution. .6-5
6.5 Satellite File Operations. 6-8
6.6 Alternative Approaches 6-10
6.7 Recommendations. 6-11

SECTION VII MASTER PLAN IMPLEMENTATION

7.1 Executive 7-1
7.2 Program Management. 7-1
7.3 Data Management 7-2
7.4 Repository Management 7-2
7.5 Implementation Schedule. 7-3

LIST OF TABLES

Table	Title	Page
1-1.	Breakdown of MSFC Data Users by Organization.	1-8
1-2.	Direct Data Shipment Breakdown.	1-13
1-3.	Results of Survey of Data Users Indicating Purpose of Use Ranked by Frequency of Occurance.	1-22
2-1.	Responsibilities of IO, R& DO, and AO Data Managers. . .	2-4
3-1.	Types of Major Defects in Engineering Data (January - March 1965)	3-8
4-1.	Comparative Analysis of Direct versus Indirect Class II Data Distribution.	4-2
5-1.	Storage and Retrieval Systems.	5-15
5-2.	Transmission Systems.	5-19
6-1.	Manning of Satellite Files	6-8
7-1.	Master Plan Implementation Schedule.	7-4

LIST OF ILLUSTRATIONS

Figure	Title	Page
A	Interrelationship of Data Administrative Functions	viii
1-1.	Saturn I Documentation Flow	1-3
1-2.	Saturn V Documentation Flow	1-4
1-3.	MSFC Vendor Locations	1-17
1-4.	Repository versus No Repository Concepts	1-19
2-1.	MSFC 500-6 Apollo Data Management Organization	2-3
2-2.	Actual MSFC Data Management Organization	2-5
4-1.	The Dual Release System	4-3
4-2.	Basic Flow of Class I Data	4-5
5-1.	Data Reproduction	5-2
5-2.	The Command Retrieval Information System (CRIS)	5-26
5-3.	The File Search Storage and Retrieval System	5-34
5-4.	The Holoram Storage and Retrieval System	5-40
5-5.	The Magnavue Storage and Retrieval System	5-44
5-6.	The Minicard Storage and Retrieval System	5-60
5-7.	The Photo Image Retrieval System (Cypress)	5-74
5-8.	The Selectriever Storage and Retrieval System	5-82
5-9.	The Ampex Videofile Storage and Retrieval System	5-86
6-1.	Sample Distribution List from Positive Feedback System	6-4
6-2.	Proposed Document Requisitioning Sampling Procedure	6-7
6-3.	Representative Satellite File	6-9

SUMMARY

The objective of this study is to describe a comprehensive plan for the development and full utilization of methods and means to be employed in the years prior to 1976 for the effective acquisition, collection, storage, retrieval, distribution, and use of engineering documentation. Because of the violently changing state of the art of data acquisition, storage, and retrieval the description of the plan does not embrace the details of a total decade of phased change. Rather it describes actions that can and should be taken in the relatively near future, and proposes a continuing series of later studies to keep this plan current for the full decade.

The plan sets forth a base of principles and concepts which will remain valid and constant. From this base adjustments to future, unforseeable changes can be made.

In some instances recommendations have been made which are retreats from the contemporary emphasis on the addition of more and more sophistication to the documentation system. For instance, recommendations were not made for the procurement at this time of automated storage and retrieval devices; a complex Data Management Organization that would require broad changes to the basic financial authorities of the Marshall management structure; further experimentation with complex data flow interfaces between data originators and users; and the development of sophisticated data transmission devices to replace currently effective manual techniques.

The Study Team has recommended a straightforward and basically simple approach to the organization of data management activities; has recommended a continuing use of flexible and proven storage and retrieval methods; has recommended a full commitment to a classically sound, centralized control of data; and has recommended a close look at an even more rudimentary approach to local data delivery than the satellite file method now being employed.

The theme that runs through each of these negative and positive recommendations is consolidation, a pulling together of all existing resources and principals into a unity of purpose and direction. From this unity a full understanding and measurement of system effectiveness will become possible. When present shortcomings are discussed, it is to show that no such understanding can come from a multi-purposed, disjointed system. Difficulties are analyzed to pinpoint their causes so that recommendations can be directed at the true sources of problems rather than at effects.

Abstractions such as organizational origins and MSFC mission/data interdependencies are considered in detail; but the recommendations are directed toward elemental operating disciplines such as quality control of data, release of data, storage and retrieval, and distribution of data.

The Team has considered these elements as parts of a unified total data system, and recommends a relationship that is both practical and logical. There is a distinct relationship between the release of data and the quality control of data. The methods of storage, retrieval, and indexing are inseparably bound to the distribution discipline and their effectiveness is determined by the resultant quality of the data specified in the data identification and acquisition element, which is, in the final analysis, the product of the relationship between Program Management and Data Management Administration (See Fig. A). The MSFC documentation management will be no stronger than the effective relationship between Program Management and Data Management. A harmonious relationship is essential.

The following Study Team recommendations should be implemented as Phase One of the Master Plan

1. That Marshall Administrative and Procedural Document MSFC 500-6 be revised to:

   a. identify and assign responsibilities to a Center Data Manager as required by NPC 500-6 (Para. 2.1),

   b. describe role of Program Management as the agent responsible for the implementation of Data Management, for all relations with contractors on Data Management problems, for the leadership of the Center Ad Hoc Data Review Teams, for final approval of all discrete Data Management actions, and for control and approval of data requirements (Para. 2.2.2),

   c. the role of the Center Data Manager should include responsibilities for coordination of the development and description of a total MSFC data system inclusive of requirements identification, data standardization, interfaces with data originators, storage, retrieval, indexing, and distribution of data, and purging of data files (Para. 2.2.4),

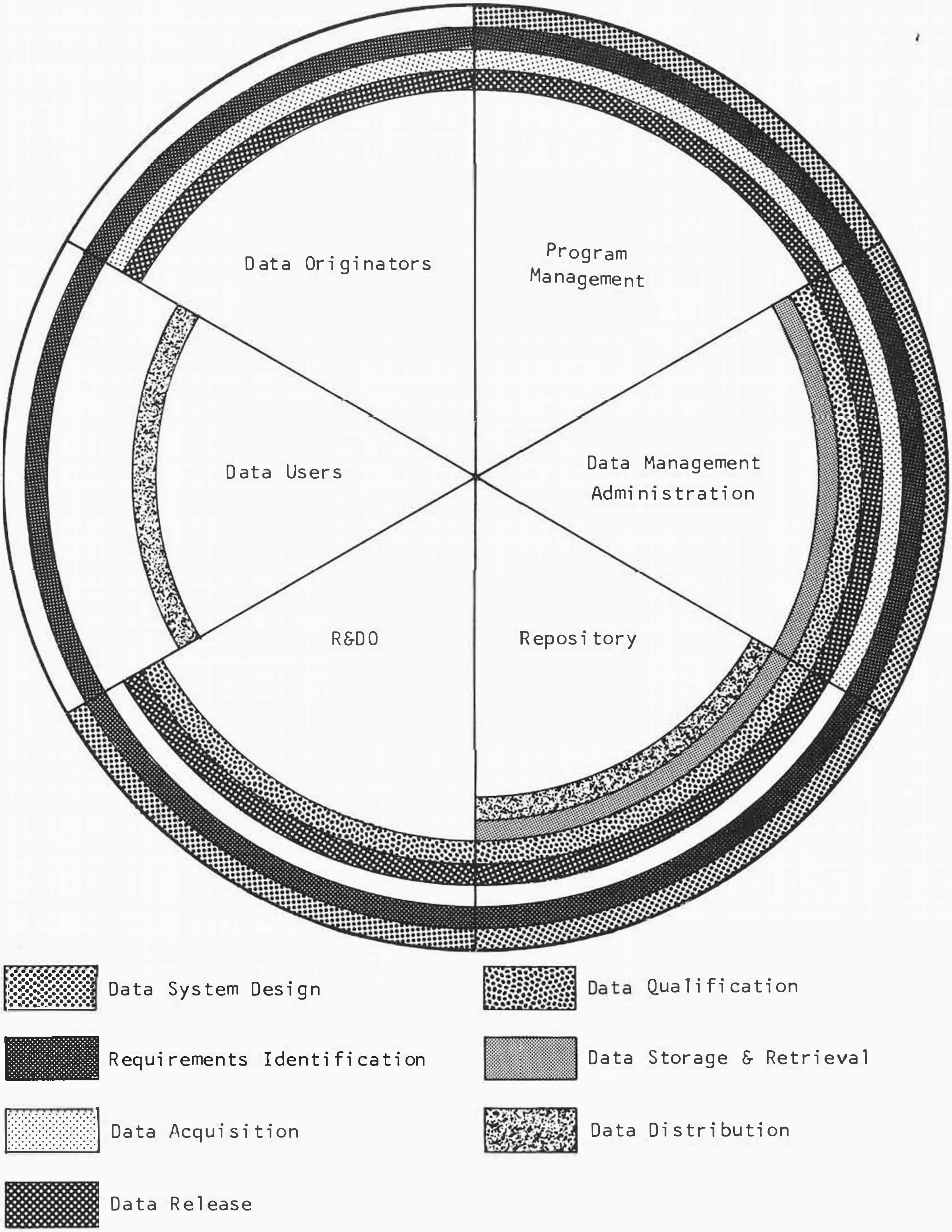


FIGURE A. INTERRELATIONSHIP OF DATA ADMINISTRATIVE FUNCTIONS

d. the role of the Center Data Manager should also include a continuing responsibility to assist Program Management in the implementation and operation of the Data Management concept, and to coordinate the efforts of all Program Offices (Para. 2.2.4),

e. designate official MSFC Repository (Para. 2.3),

f. Describe Research and Development Operations Data Management mission, to emphasize prime supporting role in data requirements identification and MSFC distribution matrix maintenance (Para. 2.4), and

g. insert the Repository directly into the mainstream of Data Management activity for the purposes of coordinating data media requirements, data distribution concepts and procedures, and control disciplines for interfaces with data originators and data users.

2. Initiate an immediate Ad Hoc effort to compile a comprehensive procurement specification and to set forth methods and procedures for upgrading the Document Requirement Description (DRD) and Document Requirements List (DRL) so that full and precise data specifications would be included. (Para. 3.2.1.1 and 3.2.2.2)

3. Establish a policy commitment to the central repository concept and alter existing methods to agree with this commitment. (Section I)

4. Establish a policy commitment that all engineering data generated at MSFC and by all MSFC contractors will be stored, indexed, retrieved, and distributed by the officially designated Repository. (Para. 4.2)

5. Evaluate all existing data, by contract, for consideration of retrofit to standard data specifications, retrofit to be undertaken only when a clear value can be gained. (Para. 3.2)

6. Instigate a program of quality control of Class II data. (Para. 3.2.3)

7. Phase out the NASA APIC project and incorporate the test data and other APIC documentation into the IDEP. (Para. 5.3.2.1)

8. Redesign and implement automated control of all distribution matrices, to be similar to the system developed in I-RM but without "positive feedback" feature. (Para. 6.3.1)

9. Revise procedures R&DO 25-1 and MSFC 25-2 to incorporate disciplines of redesigned distribution control system to eliminate references to "Technical Data Representatives," to eradicate stringent "need-to-know" requirements for MSFC users, but to emphasize continuation and improvement of these requirements on competitive organizations.

10. Initiate an Operations Research study of present satellite file operations to determine feasibility of total file centralization.

11. Initiate experimental Microfiche storage system in Reports and Specifications Section of Repository, gather information and precise measurements of effectiveness for re-evaluation during Phase Two of this plan.

12. Implement a highly automated data storage and retrieval, and indexing support structure for utilization by Mission Support Operations in its Huntsville Operations Support Center (HOSC), to be regarded as both a service to satisfy an existing need and as an experimental base for the gathering of precise measurements of effectiveness of tested equipment, means, and methods.

13. Implement an indexing system for the total contents of the Repository.

14. Initiate statistical records for cataloging MSFC data users by organization and purpose of use.

The implementation of these recommendations will establish a concrete unity upon which further adjustment and growth can be based.

These recommendations are designed to make fullest use of existing resources, to provide a baseline against which state-of-the-art advances can be finitely evaluated, and to give MSFC the most readily obtainable improvements to its present data system.

Phase Two of the Study Teams recommendations have provided discreet evidence of either untreated shortcomings or areas of promising payoff. These recommendations, then, comprise a second look which is designed to see, first, if further immediate steps are needed to achieve required effectiveness, and second, to pursue goals investigated in Phase One and found valid. The following recommendations from Phase Two.

1. Take action, if advised by findings, to implement revised local data delivery plans, involving elimination of satellite files and total centralization of data storage and processing capability.

2. Take action, if advised by findings, to implement total Microfiche storage system in the Reports and Specifications section of the Repository.

3. Based on findings of the HOSC experiment and further problem analyses, develop criteria for more effective data communication systems.

4. Develop a continuing Repository surveilance of the automated document storage, retrieval, indexing, and transmission technology, to the end that specific promising industry developments may be provided with NASA sponsored Research and Development funds.

The final phase of the Master Plan is, then, not a series of specific recommendations but rather a timed framework of a continuing management adjustment to anticipated technological growth. The Study Team has sought to develop a concept of management that would negate the necessity of revisions to principles. MSFC has within reach an efficient documentation program in which actions are based on application of evolving techniques.

The Master Plan may be implemented with no substantial outlay of capital. When fully implemented a net reduction in documentation costs should be realized by MSFC.

There are substantial costs connected with the assembling of the configuration data that will form the basis for the improved Repository index. This data is required by Configuration Management and must be compiled by Configuration Management.

Personnel and most of the essential equipment are presently available to implement the other recommendations made in this Report.

INTRODUCTION

The study that produced this report was conducted by a team of documentation and management specialists of the Radio Corporation of America. The study was initiated by Technical Directive E-23, issued January 13, 1966 by the Management Services Office, Documentation Repository Branch.

The purpose of the study was to develop and describe a ten year master plan of methods and means to be employed at MSFC for the total management and control of engineering documentation. The study was to embrace a full analysis of the sources and uses of data, and to build from this analysis a comprehensive plan for the utilization of hardware, people, and systems to solve most efficiently the problems facing MSFC in the management of documentation. No side of the documentation problem was excluded from the scope of the study. The present and anticipated problems have, therefore, been approached with the broadest possible latitude, and each subject is discussed in the true sense that it is but an elemental dependent of a wholly interdependent unity. The documentation system was viewed as a closed ring; the various phases of the system as beads strung closely on the ring.

The study examined the disciplines provided to control requirements identification, acquisition, storage, retrieval, distribution, and a data system that can be made to respond to a unified, decision-making process of management control was sought. This Master Plan seeks to describe and optimize elements of that control.

The members of the Study Team were largely drawn from the operating, home office force of RCA. This allowed the accumulation of a broad base of experience and knowhow. A brief description of the membership follows.

W. W. Thomas (Team Chairman) - Mr. Thomas is the staff documentation administrator for the RCA Defense Electronic Products Company. He is responsible for the coordination of all documentation efforts in his company and is the final RCA Staff authority for the interpretation of government, industry, and company policy in the documentation field. He serves as Chairman of the Technical Documentation Division of the American Ordnance Association and in 1965 was presented the W. H. Stearns award for his outstanding and continuing contributions to the ordnance industry. He has served on loan to the Logistics Management Institute, and as a policy advisor to the office of the Secretary of Defense. He brings over 20 years documentation experience to this Study Team.

H. H. Stewart (Team Deputy Chairman) - Mr. Stewart is a permanently assigned staff advisor to the RCA Management Services Project at MSFC. He has led management study efforts in several fields, but his roots are firmly placed in documentation. He has held technical documentation management positions with several space industry corporations, and is well known at MSFC for his contributions to several outstanding publications. His knowledge of MSFC documentation organization and policies were used to coordinate the efforts of members of the Study Team.

F. L. Dixon - Mr. Dixon is the Leader of the Data Control Systems Group of the RCA Service Company. He is responsible for the technical development of automated and manual systems in the documentation and configuration management area. He has led the development of systems both for this company, for the Department of Defense, and for NASA, particularly in the areas of supply inventory analysis, documentation records control, and configuration management. His systems analysis and design capability has been well utilized by the Study Team.

C. J. Robb - Mr. Robb is a Microreproduction Systems Specialist for RCA Service Company. His knowledge of microfilming technology has been gained through his involvement in the developmental process of the science. He recently completed a report similar to this one for the U S Marine Corps and his knowledge of equipment systems was almost totally responsible for the research and documentation of storage and retrieval equipment for this report. He is a member of the National Microfilm Association and his active participation in the programs of that association has contributed much to his knowledge of microreproduction.

S. J. Brown - Mr. Brown is a Management Systems Engineer for the RCA Service Company. For the past six years he has been performing systems studies at the various government facilities supported by RCA Service Company including the BMEWS Project, Titan, and DAF. His recent assignment supporting the U S Marine Corps included documentation processing systems. Mr. Brown's experience includes approximately twenty years of industrial engineering.

The Study Team obtained the assistance of RCA Corporate Staff Work Measurement Standards personnel to investigate the feasibility of developing Repository workload prediction techniques. The feasibility has been established but the technique has not been developed sufficiently to be incorporated into this report. The prediction technique is closely related to work measurement standards and these standards are being developed as a parallel effort by the Work Measurement Standards group; therefore, the efforts will be reflected in subsequent reports.

The Study Team availed itself of assistance from specialists in a number of RCA Divisions. Data Systems engineers and marketing personnel from the West Coast Division were consulted in regard to computers, indexing, etc., as well as storage and retrieval equipment. The research supervisor and the manager of Market Development for the RCA Laboratories, Princeton, New Jersey were consulted on market trends and status of transmission devices and storage and retrieval equipment. Engineering management consultations were held with personnel from the RCA Divisions in Moorstown, Camden, and Cherry Hill, New Jersey.

SECTION I
DATA ORIGINATION AND USE

1.1 Background

Primary programs at MSFC during 1966-1976 period are the Saturn I, the Saturn V, and the Apollo Applications Program (AAP). Beyond 1972 and the completion of the AAP no specific programs have been defined; therefore, any attempts to analyze and project documentation requirements beyond this point become pure speculation.

The Saturn I program was originally conceived as a research and development effort to design and test vehicle components and concepts for future applications in space exploration. The unprecedented success of the effort has led to serious consideration of continued use of the uprated version of the Saturn I vehicle as a workhorse launch vehicle in the AAP and other contemplated programs. The program first set out to develop a cluster concept booster using existing components and technology. Applying the building block technique, components and stages were developed, tested, and adopted as integral parts of the program.

1.2 Data Origination

During this period of extensive research and development MSFC controlled almost all hardware and documentation internally. Chrysler Corporation, Brown Engineering, Douglas Aircraft Company and others assisted in various tasks, but the vehicles were essentially Marshall designed, Marshall built hardware. Documentation originated primarily within the various laboratories of MSFC, was distributed by the cognizant office or the Repository as directed by the project offices, and consisted almost exclusively of MSFC controlled Class I documentation.

1.2.1 Transition Period

With the completion of the basic research and development and the subsequent qualification testing of all the components and stages of the Saturn vehicle, the function of MSFC began to change rapidly. The stages were fabricated in contractor facilities and documentation was generated in contractor facilities. Contractor originated Class II documentation became the majority portion of MSFC data.

1.2.2 Uprated Saturn I Status

Uprated Saturn I documentation is presently generated principally by four contractors: Chrysler, Douglas, Rocketdyne, and International Business Machines. Attempts to assure the timely delivery of documents to all known users of the data has led to some irregularity in the manner and form in which the documents are delivered. Some recent changes have been made since the preparation of the documentation flow chart (Fig. 1-1); however, the chart will demonstrate the complexity of the problem of supplying documents to users in time to satisfy his needs and in the form that is most practical for his use. One recent change to the data flow is the way that Douglas Aircraft Company supplies engineering drawings to users. This change entails direct distribution to Boeing and Chrysler at Michoud as well as to Kennedy Space Center (KSC) and MSFC. A reproducible copy or microfilm of all drawings is sent to the MSFC Repository so that subsequent requests for drawings may be filled by the Repository and so that the MSFC historical file can be maintained.

1.2.3 Saturn V Status

Saturn V documentation is generated primarily by Boeing, Douglas, North American, Rocketdyne, and International Business Machines. Like the Uprated Saturn I, the Saturn V program office has had difficulty in expediting the delivery of documentation and has resorted to interim measures to assure that certain vital functions were supplied data. The flow of documentation (Fig. 1-2) is even more complex than that for Saturn I because of the greater number of originators and users of documentation.

1.2.4 Apollo Applications Status

AAP documentation comprises principally data on the Apollo spacecraft. None of this data had been introduced into the MSFC documentation flow when the Study Team looked into the matter in May, 1966. Some hard copies of reports had been obtained from Manned Spacecraft Center by the Program Office, and some preliminary analysis of the functioning elements of the Program were discussed with the Team.

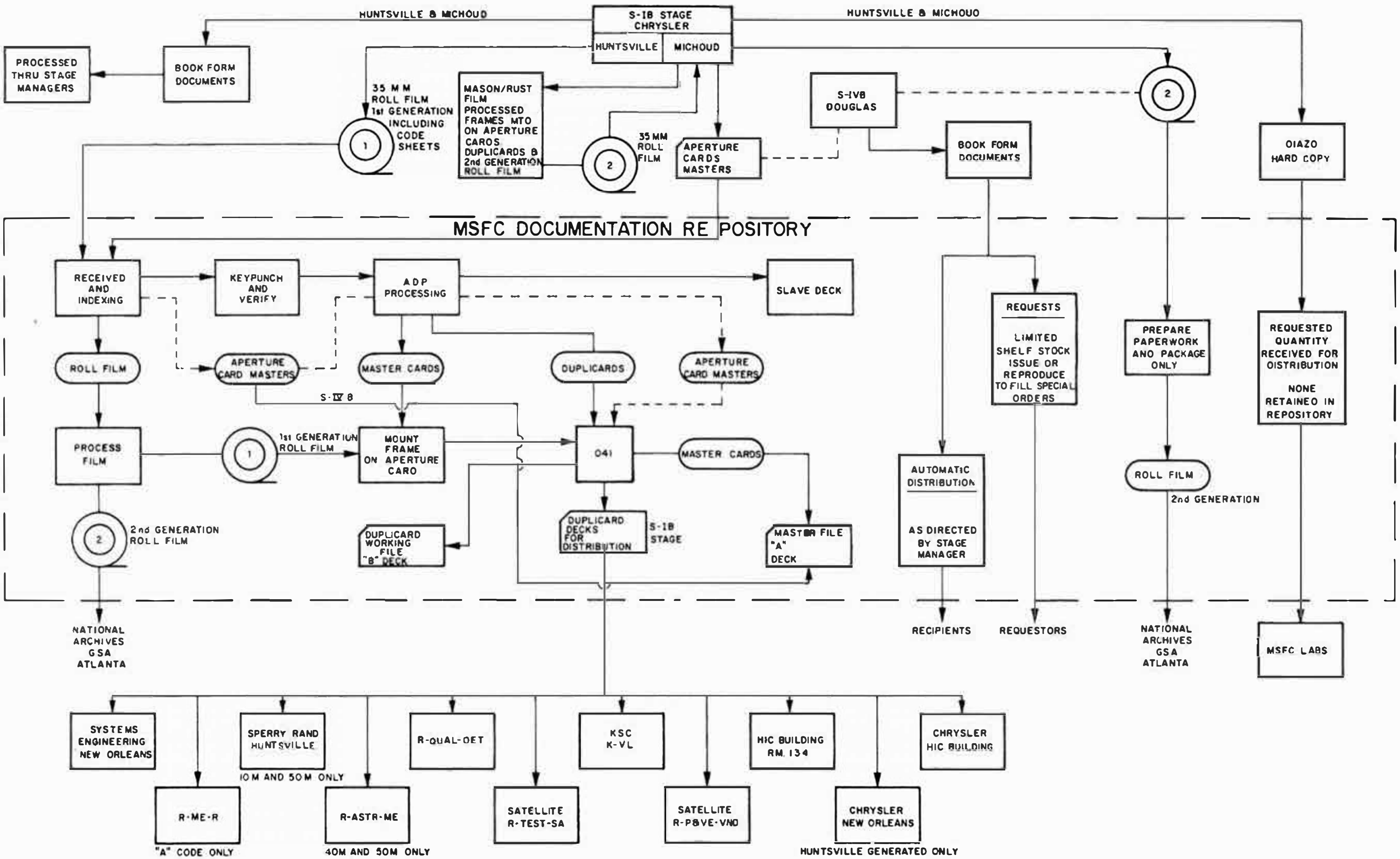


FIGURE 1-1. SATURN I DOCUMENTATION FLOW

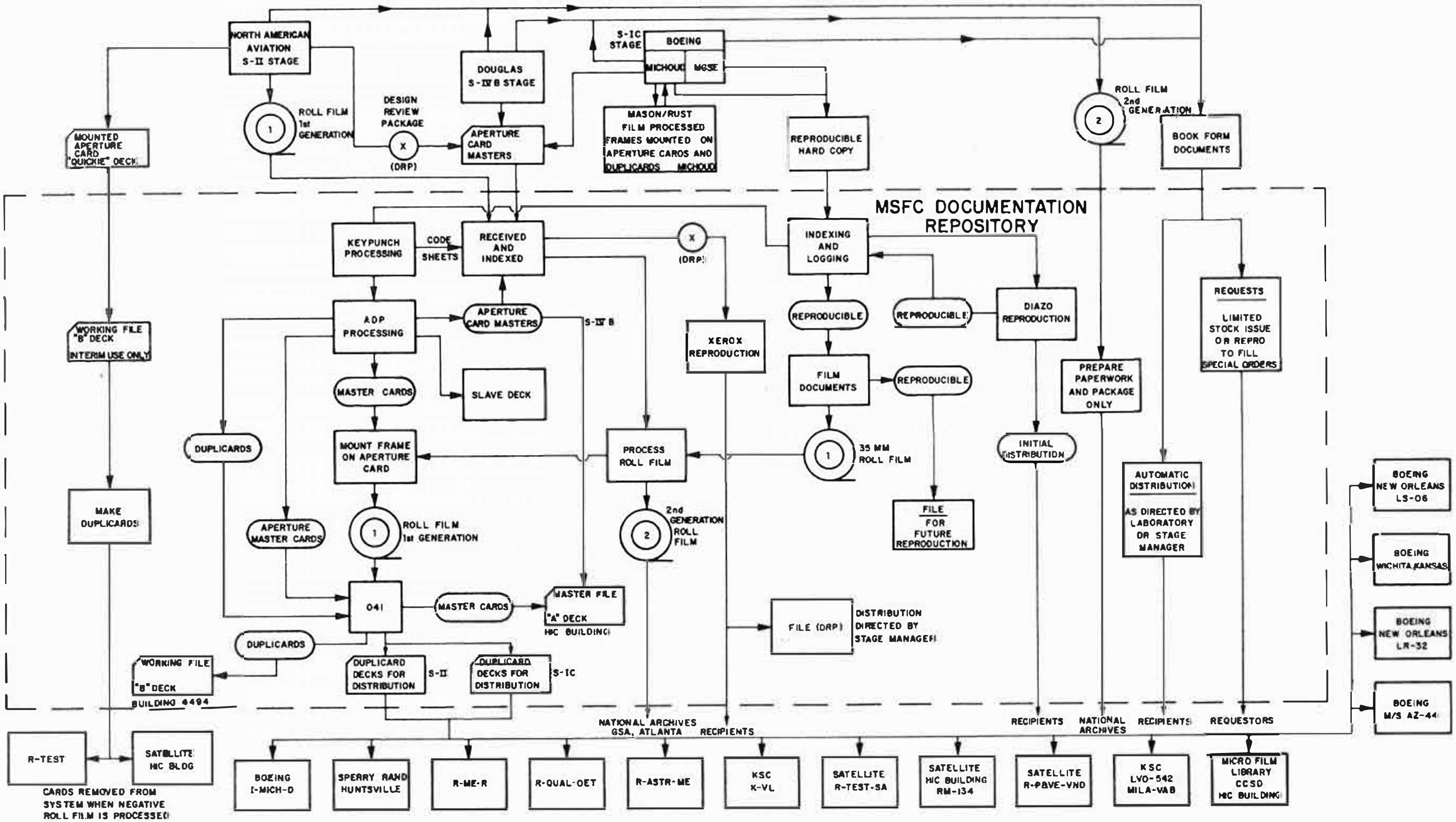


FIGURE 1-2. SATURN V DOCUMENTATION FLOW

1.2.5 Conclusions

The experience curve has been extended to the point now that the growing pains are about gone. Program Management is managing the data origination so as to minimize waste and assure timely delivery of documents. Improvements that appear needed include:

1. Adoption of a system that will link the reports to the applicable hardware and cause the reports to be stored together in the Repository and Libraries.

2. Quality Assurance provisions should be invoked on all documentation to see that all released data can be understood, is free of any weaknesses that dilute its subsequent use, and can be reproduced. This is discussed in detail in Section III of this report.

3. Maintenance of close coordination with Data Management and the Repository management by the AAP to assure that this Program benefits from previous mistakes and initiates an effective data flow system at the outset.

1.3 Data Use

All elements of the data system from acquisition to distribution, have one objective, use. Data has no value other than that derived from its use. The most effective data acquisition system, for instance, would set out to buy data that is needed for use, to eliminate data that is not needed, and to require data in the media and form that will best facilitate its use. The subsequent elements of the data system, release, storage, retrieval, indexing, and distribution, are well planned only if they move data efficiently from acquisition to use.

It follows, then, that these elements must be designed from a full knowledge of the data user. Who is the user? Where is the user? What data does he use? Why does he use it? These questions have to be answered and the answers fully understood before a total data system design can approach optimum effectiveness. This section of the report will deal with these questions.

1.3.1 Who is the Data User?

MSFC R&DO, IO, Michoud Operations, prime contractors, other centers, integration contractors, and vendors are users of data produced or procured by MSFC. MSFC is obligated to furnish data to these users; but their specific identities coupled with their geographic locations and varying missions and capabilities intervene to complicate the simplicity of merely handing them the documents they require. The amount and the complexity of the array of data being handled also complicate the data handling picture, but these are factors that remain constant irrespective of the data use spectrum. Great amounts of complex data present minor problems if the use rate is low or relatively constricted. For instance, the library of Madison County real property registration records includes a file of highly detailed information almost as large in numbers of documents as the MSFC Repository. Though the files of other counties are even larger, the use rate of such a file is small because its potential users are restricted to one or two highly specialized fields. Still, the problems in maintaining the file and satisfying its users are small in comparison to those at MSFC.

The question of who is the data user, then, must be explored with the particular goal of determing those peculiarities in the identity of the users that contribute to the data problem at MSFC.

1.3.1.1 MSFC is a Data User

A survey conducted by the team preparing this report has shown that over 60 per cent of the data issued by the MSFC Central Repository is issued to local MSFC Organizations. Another large amount of data is issued through the various subsidiary files at MSFC, but this activity is largely segmented.

The subsidiary (satellite) files at MSFC issue almost all their data to MSFC users while the file in the Huntsville Industrial Center is 100 per cent in support of contractor users. The subsidiary files are placed at locations adjacent to high volume MSFC users. There is a satellite file in each of the following locations:

Building 4481	P& VE
Building 4666	TEST
Building 4487	ASTR
Building #3 HIC	Boeing & Chrysler (principally)

A fifth satellite file located in Building 4610 (P& VE) is scheduled to open late in July. Two other files, supported by the Repository but organizationally independent of it, are operated by R& D, one in Building 4708 (QUAL) and one in Building 4705 (ME).

At MSFC the greatest users of data are the R&D Laboratories as shown in Table 1-1. The table, however, does not include records of data issued from the satellite files. All but one of these files is located in Laboratories, a fact which confirms R&D as the principal user of data at MSFC. These satellites have been deployed near these users at their request, because their needs require fast, almost immediate service. Long lag times between request and receipt have not been judged acceptable.

The Study Team findings and conclusions in this area are based on a reasonably small statistical sample, because of time limitations. Since there was no tabulation of this sort of data available, larger samples and a continuing analysis should refine the repository management decision-making capability; thus, a continuing collection of this data is recommended.

1.3.1.2 Stage Contractors are Data Users

Stage Contractors are major data users, but the greatest amount of this use/need is satisfied from the contractor's internal files. Stage Contractors do not, therefore, rank high on the list of MSFC Repository customers.

In the early stages of a contract, though, Stage Contractors do receive a large amount of Class I MSFC produced data. This amount, however, never approaches the volume of Class II data produced on the normal (SIVB, SII, etc.) stage development contract.

MSFC's obligation to supply data to Stage Contractors is a minimal one and the design of the system for providing data support should deemphasize the needs of such users. Program Management must clarify this relationship in RFP's or contract specifications with all Stage Contractors so that they fully recognize the requirement that they support themselves with their own data.

TABLE 1-1. BREAKDOWN OF MSFC DATA USERS BY ORGANIZATION

Organization	No. Documents	% of Total
R-AERO	17	5.0
R-AS	1	.3
R-ASTR	62	18.3
R-ME	9	2.7
R-OM	1	.3
R-P&VE	115	33.9
R-S	1	.3
R-QUAL	54	15.8
R-TEST	29	8.6
TOTAL R&DO	289	85.2
I-DIR	2	.6
I-E	7	2.1
I-FP	1	.3
I-I/IB	10	3.0
I-MICH	12	3.5
I-MT	2	.6
I-RM	2	.6
I-V	12	3.5
TOTAL IO	48	14.2
Other	2	.6
TOTAL SAMPLE	339	100.0

Class I data must be furnished to Stage Contractors. This fact should guide contracting people and data support planners to seek a means for identifying the Class I data package at the earliest possible time during contract life. This thought will be amplified later in the discussion "Where is the Data User?".

1.3.1.3 Integration Support Contractors are Data Users

Unlike the Stage Contractor, the Integration Support Contractor derives the major amount of his data support from MSFC. By definition this is necessarily true, for the integrator's role is one of putting together an assortment of subsystems not necessarily built or documented by himself. He must be given a clear description of each subsystem, and this description is conveyed to him by MSFC as data. This requirement alone is important enough to justify a centralized Marshall Repository for data.

Boeing (Saturn V) and Chrysler (Saturn I) are important customers of MSFC's data support system. Attempts during this study to measure the extent of this support (as a percentage of total activity) have been frustrated by the widely fluctuating workloads, but measuring other major users and intuitively extrapolating from these criteria have indicated that Integration Contractors receive about 20 per cent of all Repository outputs. This percentage coupled with the fact that there are only two such contractors places these contractors high on the list of Repository customers. Their needs, like those of R& DO, require minimal turnaround time support.

The importance of their mission and the contractural requirement for MSFC to supply data to Integration Support Contractors have recently brought about several sweeping maneuvers to make data available to them. The satellite file in the Huntsville Industrial Center, Saturn V Directive No. 6, and a counterpart directive from the Saturn IB Program office have accented these efforts. It can be anticipated that AAP will increase the importance of Integration Support Contractors and of the data support they must receive from MSFC.

1.3.1.4 Other NASA Centers are Data Users

KSC and the Manned Spacecraft Center (MSC) use much MSFC data. By the fact that it launches all vehicles developed by MSFC, KSC is, of the two, the larger user; but the emerging AAP will tighten the relationship between MSFC and MSC.

MSFC is obligated to furnish to KSC a complete set of documentation for all hardware delivered. The means by which this obligation has been carried out have not followed a planned pattern. In the past MSFC has delivered either full-sized prints or microfilm of the required documents, but more recently KSC has acquired much documentation directly from stage contractors.

Douglas Aircraft in particular has set a pattern of delivering multiple sets of data to KSC, and KSC has employed Douglas personnel to maintain files of this data. While the latter fact is unimportant, it further illustrates the approach being taken by MSFC in its relations with KSC; for the Douglas personnel as well as the data being furnished KSC are being financed by MSFC.

MSFC's support of the Manned Spacecraft Center (MSC) has centered mainly on upper-stage interface documentation, but already the AAP has brought about new lines of data exchange. The future will certainly see a greatly increased demand by MSC for MSFC documentation.

There is an MSFC interchange of data with Chrysler and Boeing at Michoud. MSFC furnishes Chrysler and Boeing design criteria, specifications, and standards and the contractors furnish MSFC with engineering drawings and reports. All of the contractor furnished documentation is supplied by MSFC in turn to Chrysler and Boeing integration support efforts as required.

1.3.1.5 Vendors are Data Users

The many hundreds of specialty vendors who support MSFC and its contractors depend to some extent on MSFC for documentation. These data users are dispersed throughout the United States. Correspondence with them is normally of a response nature, but approximately 200 vendors have been placed on automatic distribution for the MSFC Standards Manual.

The volume of data shipped to vendors is surprisingly low, resulting from the fact that many MSFC commodity type items are manufactured to specifications and standards developed by other governmental and industrial organizations. These activities are the prime sources for such documentation.

1.3.1.6 Other Data Users

The users described in the preceding paragraphs account for more than 95 per cent of all documentation issued by MSFC. There are, however, a number of activities occasionally requiring data from MSFC, including Department of Defense Agencies and other less directly related NASA agencies. Their total requirements are less than those of any one of the users described above. The correspondence between these users is exclusively of a responsive nature. The volume of requests is extremely low and the number of documents per request averages less than two. These other users, then, are at present insignificant, and any emphasis on their support would be misplaced; but there can be no guarantee that some future program, military or NASA, will not bring about a stepped-up information exchange between them and MSFC. Bilateral activity in space between MSFC and some other NASA center, e.g., Lewis Research Center, could easily materialize. This possibility would add another major data user to the MSFC support spectrum.

The Study Team also feels that any increased emphasis on inter-center data exchange interfaces will be an essential element to be considered in the total system.

1.3.2 Where Is The Data User?

Knowledge of the geographical location of the potential data user is a prerequisite to the planning and/or operation of a data system. A highly publicized example of the quandary that can grow from the lack of such forethought is the Library of Congress. As the library quantitatively grew in both content and coverage its array of potential users expanded so that it now covers the entire civilized world.

The role of the MSFC Repository has been greatly broadened in the past two years. Until the last two years MSFC was almost totally an R&D organization using contractor support to supplement civil service manpower. All data was internally generated Class I documentation and all users were in Huntsville or at KSC. With the advent of the Industrial Operations concept whereby contractors supplied hardware to be integrated into vehicles under the surveillance and guidance of MSFC by contractors, the data situation became more complex.

Prior to the issuance of the Apollo Documentation Administration Instruction NPC 500-6 in August, 1964, the Repository served, by design, only the needs of local MSFC users and stored only MSFC Class I data. Actions following the issuance of NPC 500-6 established the Repository as the central file for most MSFC Apollo Class I and Class II data. The users were necessarily more widespread and the data coverage was increased. This experience is loosely analogous to the Library of Congress transition. The MSFC experience was, however, compressed into a much smaller time frame so that the attendant problems were exaggerated by the suddenness of their appearance. True, in the two years since their occurrence many of the new problems have been neutralized, but the efforts and expenditures involved in the process could have been reduced had prior cognizance been taken of the increased spheres of the Repository. By the same token, an assessment now of these increases will enable the Repository and Data Management to move more efficiently through future transitions.

1.3.2.1 Geographic Distribution of Users

A survey conducted by the Study Team of 577 direct data shipments made by the Repository in the month of April, 1966, revealed the geographical breakdown shown in Table 1-2.

These figures indicate that the majority (60.9 per cent) of the Repository's April users were located at Redstone Arsenal. This represents a change of roughly 30 per cent from the 1963 user array which found almost 90 per cent of the users there. Much of this shift might be attributed to the concurrent rise in off-site manufacturing of vehicle stages, but in view of the fact that shipments to prime contractor manufacturers in April represented zero per cent of the sample, any impact that the manufacturing shift might have had would seem to be reflected only in increased shipments to supporting activities, i.e., integration contractors, vendors, Michoud, etc. This assumption is strengthened by the analysis of stage contractor data support. It follows, then, that barring a basic data support policy change, any further decentralization of stage manufacturing activity would have little effect on geographical distribution of data users served by the Repository.

TABLE 1-2. DIRECT DATA SHIPMENT BREAKDOWN		
Destination	No. of Shipments	% of Total
MSFC	339	60.9
Huntsville Industrial Center	42	7.7
Other Huntsville	22	3.9
Michoud	26	4.7
MSC	16	2.9
KSC	36	6.5
Other NASA Centers	20	3.6
Other Gov't Agencies	3	.5
Various Vendors	73	9.3
TOTAL	577	100.0

NOTE: The above figures do not reflect bulk shipments of microfilm to KSC and Michoud, nor do they include day-to-day issuances made from various satellite files.

1.3.2.2 Integration Support Contractors

The same may not be said, however, of integration support contractors. Data shipped to the Huntsville Industrial Center (7.7 per cent of total) is almost exclusively destined to an integration support contractor. The satellite file in the Huntsville Industrial Center is almost in total support of the Boeing Company's integration effort. This file is as active as the satellite file that is directly supporting MSFC's largest data user, the Propulsion and Vehicle Engineering Laboratory (P&VE) The Saturn V integration support contractor, then, must be regarded as one of the two most active data users. It is certain that the Chrysler Corporation as the Saturn I integration support contractor would also be a heavy data user, but early data policy actions established a comprehensive file of data within Chrysler so that this company is now relatively self-supported, except that the Repository still channels all SIVB data to Chrysler. For evaluation purposes Chrysler may be regarded as a major data user.

This discussion leads to one conclusion: integration support contractors inherently require heavy data support. So far, this fact has had little impact on MSFC's data support geography because both major integration contractors maintain their facilities in the Huntsville area; but the fact must be remembered in future planning. The AAP or some other major program may delegate integration roles to a remote contractor. To bridge the miles between MSFC and this contractor with data will require imaginative techniques, for it is a certainty that his documentation support requirements will be increased, not lessened, as the distance between himself and the prime source of information, Huntsville, widens.

This is partially true of all data users; but the impact of such an increase takes on importance only when it is initiated from a large base. For example, if XYZ Company were receiving two documents per month from MSFC and a change in location from Huntsville to Boston tripled this requirement, no impact would be felt. But if the Boeing Company relocated its integration support effort to Renton, Washington, a small increase in requirements would create a problem.

Distance is not an appreciable determinant of the effort required to support fixed requirement users, such as commodity vendors. These users identify their requirements, submit a request, and the data is forwarded. A small (4- or 5-day) but acceptable delay is encountered. If, on the other hand, the user has undetermined data requirements, each data order and receipt is likely to spawn several new data requirements and subsequent re-orders. Each cycle of receipt and order will include the fixed delay, which could result in unacceptable accrued delays if the number of cycles prior to final answer were large. Of course, no data user invariably falls into either of these categories; but it can reasonably be asserted that integration support contractors are most likely to be in the latter group, and in view of their requirement for small lag-time support, the problem created by repetitive order/re-order cycles is a major one.

There are two ways this problem can be resolved: (1) increase the contractor's ability to identify his requirements, and (2) reduce the distance, and thereby the delay, between him and the data source. The latter has proved effective at MSFC, but it is obvious that the former would do the job even more efficiently. This can be clearly seen when the MSFC/KSC relationship is analyzed.

1.3.2.3 Kennedy Space Center

KSC is one of the most active users of data in NASA, but most of the data used there is originally procured by MSFC. These facts necessarily demand a close data support relationship between the two centers. KSC and MSFC have shrunk the distance between them by precisely (or nearly so) defining KSC's requirements, so that the needed data would be shipped in bulk at one time.

The identification of KSC's data needs was expressed by KSC's requesting all data. In this way new requirements revealed in any document would have been already delivered to KSC and repetitive turnaround delays would be avoided. KSC is intended to be on automatic distribution for all Apollo data.

So, a corollary is apparent. The adverse effects of distance on data support are diminished by an accurate definition of data requirements. We can infer from this fact that the geographical location of users who have made such a definition is unimportant. KSC, though geographically remote, can be supported without great regard (other than for transportation) to its location. If through some short-sightedness KSC's requirement for complete data were to be administratively modified to a less clear definition, geography would again be a factor.

The geographical factors in the support relationship between MSFC Huntsville and Michoud Operations are similar to those of the MSFC/KSC relationship, except that Michoud's need identification is not an edict for all data.

1.3.2.4 Vendors

As indicated, commodity vendors dispersed over the entire country received 9.3 per cent of the sampled data. This dispersing might have presented problems to the Repository, but this is not the case. A request from Maine is no less processable than one from Huntsville. The only adversity associated with distance accrues from the building of delay upon delay when receipts spawn further requirements. The sample has shown, however, that vendors know their requirements from the beginning. Only three vendors submitted more than one request in April, and none more than three. An analysis of these requests indicated that they were generally for Engineering Standards, documents that normally do not reference many other documents.

Nevertheless, there is an advantage in documenting the locations of these vendors, and it may become advisable to seek some means of reducing the turnaround time from its present four or five days.

The map in Figure 1-3 shows the distribution of MSFC vendors in the United States. The map includes only those vendors that showed up in the April sample.

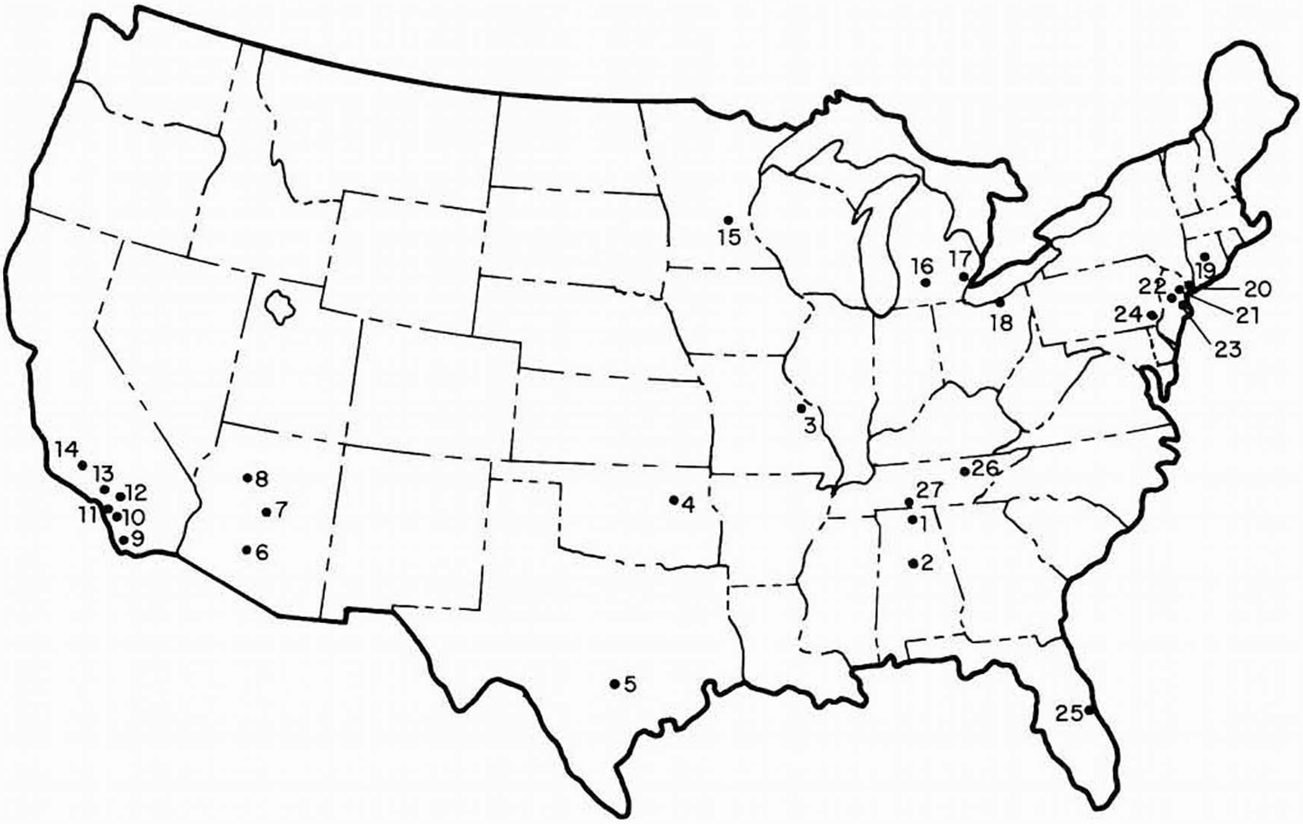
1.3.3 What Data is being Used?

By direction, this study is concerned with "engineering and related hardware oriented documentation." More specifically this includes

Engineering Drawings,
Technical Reports,
Progress Reports (Hardware projects),
Specifications,
Standards,
Manuals and Handbooks,
Vendor Catalogs and Brochures,
Test Records, and
Parts Lists, Configuration Lists, Data Lists, etc.

At first look it would appear that any concern with what data is being used could be relieved by a simple categorized accounting of the Repository's output. But such a tabulation would not include data not issued by the Repository. To be meaningful, the figures would also have to take into account the total population by category of data in the Repository. For instance, if records showed that the Repository contained only 100 Progress Reports and that from this population 200 requests were filled in a given period of time, the 200 per cent use ratio of Progress Reports must be regarded as a significant figure. Population records by category were not available to the Study Team.

Lacking valid experimental data, then, the Study Team viewed this problem from an analytical or logical point.



1. Huntsville
2. Birmingham
3. St. Louis
4. Tulsa
5. Austin
6. Phoenix
7. Scottsdale
8. Jackass Flats
9. San Diego
10. Santa Anna
11. Downey
12. Santa Monica
13. Los Angeles
14. Bakerfield
15. Minneapolis
16. Jackson
17. Detroit
18. Cleveland
19. Broadbrook
20. New York
21. Union
22. Princeton
23. Newark
24. Philadelphia
25. Cape Kennedy
26. Oakridge
27. Fayetteville

FIGURE 1-3. MSFC VENDOR LOCATIONS

1.3.3.1 Analysis

If population and usage records by document category had been available to the Study Team they would have been used to determine the best method by which data would be delivered from source to user. If, for instance, a particular category of data were used by only one or two individuals, system planners could prescribe that the data be issued by the initiator directly to the users. This data would need to go to the Repository for record only.

So, that with which we are primarily concerned is "What data should go to the Repository?"

Toward an analytical approach to this question we may hypothesize that all engineering documentation should be handled by a central repository. We have seen from a small sample that the users of MSFC data are widespread and numerous. The originators of documentation, though not so numerous, are equally widespread.

Figure 1-4 compares the repository hypothesis and its alternative.

The network on the right is not so complex as it graphically appears. The faults of this approach are:

1. Most data producers are contractors and therefore will have to be paid for every document delivered, a situation making it almost impossible to audit and control the cost performance of the data producer.

2. The users' problem of document identification will be compounded. He will not only have a problem of identifying documents but also of identifying the source.

3. Data will flow from source to use without a formal government acceptance. Product quality will suffer.

4. No alternative will eliminate the absolute need for a government managed final repository.

These reasons do not make an incontrovertible case, but for the purpose of analysis they demonstrate evidence that a central repository containing <u>all</u> data could not be replaced by a "no repository" system. Could the total repository system be replaced by a repository that handled less than all engineering data? The answer is "yes,"

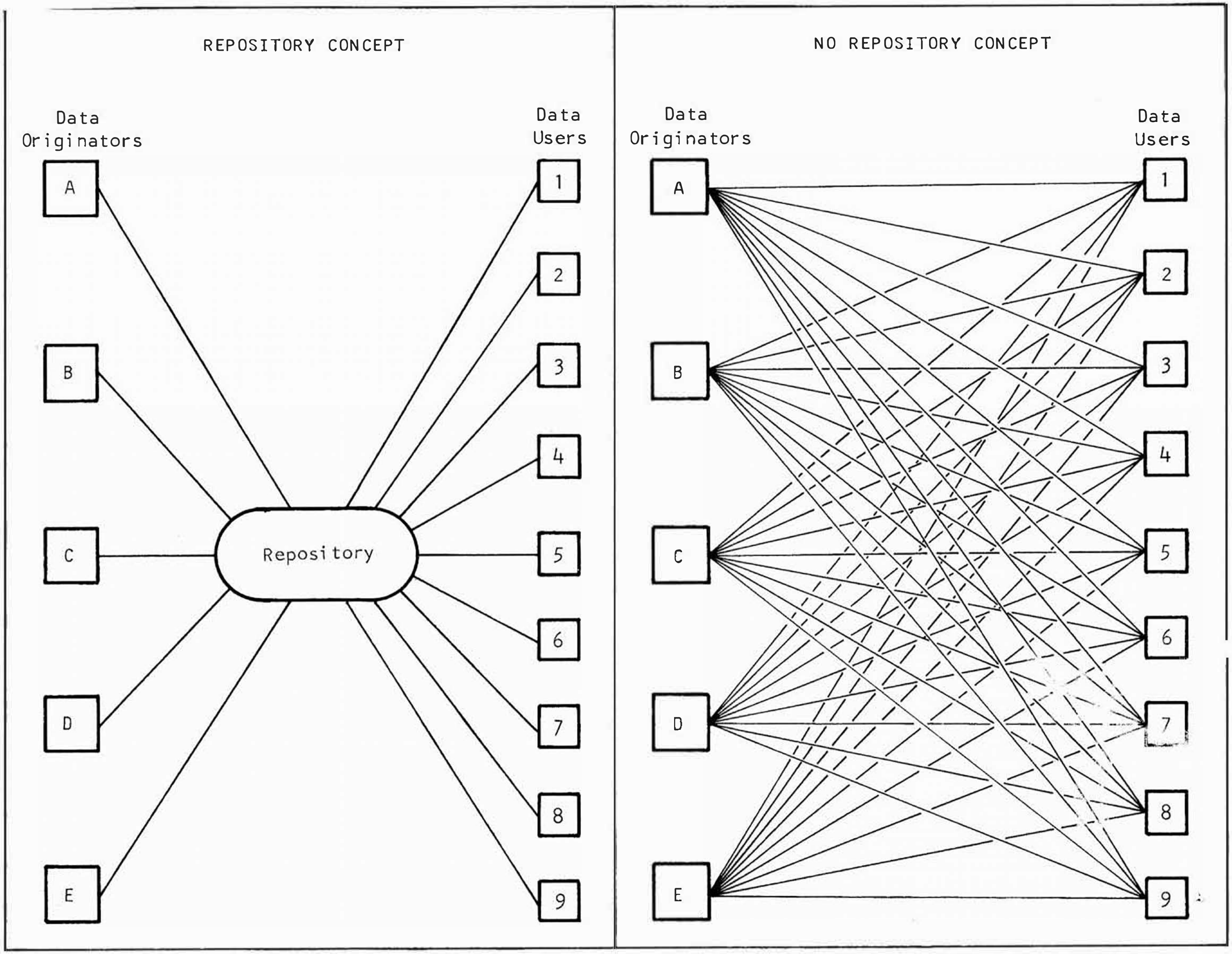


FIGURE 1-4. REPOSITORY VS NO REPOSITORY CONCEPTS

but a more important question is: Why should it handle less than all? The idea of a central repository of all data presents many obvious benefits.

1. All data could be brought under one administrative control. This in itself is an advantage of far-reaching effect; e.g., the cost of data can be more easily measured if the handling costs appear in one set of books.

2. Quality of all data could be controlled.

3. Programs for data storage, retrieval, indexing, and distribution could be more easily coordinated. An example of what can happen without a central repository is the APIC Program. This program is concerned only with a small segment of the data spectrum, yet much more than $1,000,000 has already been spent with no appreciable results.

4. Access to data would be improved. There would be one location for data, one number to call.

With such advantages accruing to a system involving a single repository of data, MSFC should ask for very good justification for any proposed alternative.

1.3.3.1.1 Need to Know

A reason offered for withholding data from a total collection is that the critical nature of the data should limit the number of users to those who have a "need to know." The fear is that this critical data might lose identity in the repository and be distributed to parties who have no reason to receive it. In the atmosphere that surrounds the systems integration program, it is impossible to identify in advance all the users who will have to use the data.

A repository can guard need to know as well as, or better than any other activity; thus, the need to know argument is not sufficient to justify by-passing the Repository as the storer of all engineering data.

1.3.3.1.2 Problems of Control

Another reason given for withholding data is that "such a large collection of data will be unmanageable and support would collapse." It is unrealistic to assume that the Marshall Repository has approached such a point. Any such fears for the Marshall Repository are not supported by experience or logic. MSFC has not seriously tried the concept; thus, they have no experience in such an endeavor. The conclusion of this team is that the idea is more plausible than any considered alternative.

1.3.3.2 Conclusion of Analysis

This study has concluded that MSFC should direct its documentation efforts toward a centralized repository concept. The idea is marked by its simplicity as a workable system. In pursuing it MSFC will avoid the trials and errors that must inevitably attach to experimental efforts. The very nature of MSFC's mission during the next few years demands that tried and tested administrative disciplines be employed, and that needless experiments be avoided. In MSFC's case, the central repository concept fully implemented will solve all forseeable documentation handling problems.

1.3.4 Why is Data Used?

The answer to the question "why" is important to the understanding of documentation problems that face MSFC. The survey conducted by the Study Team was designed to gather a cross-section of data use. The results were limited by the frequent failure of the data user to describe his use concisely. Subsequent observations made by the Study Team, however, enabled the development of a reliable description. The results of the survey, supplemented by observations, are presented in Table 1-3.

The statistical sample here, has the same weakness mentioned in conjunction with Table 1-1; thus, continuing examination of this type of data, is also recommended.

The fact that engineering design uses represent the majority of the total coincides with other survey results that indicate P&VE and Astrionics as the major MSFC users of data. This fact also indicates that the prime MSFC mission is design engineering. When compared to the low percentage of data use for manufacturing purposes, the figures accurately depict the changed emphasis at MSFC from builder to design overseer. The relatively high percentage of configuration management uses adds validity to the overseer role; in fact, with the exception of the parts analysis, manufacturing, and work planning catagories, all documentation uses revealed in the survey are indicative of a Program Management, prime integrator type of operation.

TABLE 1-3. RESULTS OF SURVEY OF DATA USERS INDICATING PURPOSE OF USE RANKED BY FREQUENCY OF OCCURRENCE

Use	% of Total	No. Items
Engineering Design	51.4	136
Configuration Management	14.3	38
Contract Analysis	8.0	20
Specification Review	4.6	12
Documentation	4.0	11
Parts Analysis	4.0	11
Procedure Analysis	4.0	11
Manufacturing	3.4	9
Inspection	2.9	8
Project Management	2.3	6
Work Planning	1.1	3
TOTAL	100.0	265

Engineering functions normally provide baseline design criteria to this type of operation or develop complete design packages for smaller components. The Saturn I and Saturn V Instrument Unit is an example of the latter. The prime contractor, International Business Machines, was given a complete design and his mission was basically to manufacture. The SII Stage and the SIVB Stage are examples of the former type of systems engineering effort. Baseline design criteria were developed by Marshall, but the prime contractors extended these designs to the detail level.

In April of 1966, neither of these two normal engineering support activities was very prevalent at MSFC. Baseline criteria for all hardware under development at this time was complete, and any component design work that was being done would certainly not have been so widespread as to account for 51.4 per cent of total MSFC data use or even a significant portion of that percentage.

The explanation lies in MSFC having a continuing responsibility to guarantee the soundness and feasibility of all vehicle designs. In exercising this responsibility MSFC reviews and approves or recommends changes to the design outputs of its contractors. MSFC's retention of this responsibility is necessitated by the nature of rocket technology. It is a young science, and its development has culminated in a circumstance that finds the greatest concentration of rocket engineering capability available to this country accumulated at MSFC. This capability approaches uniquity. It is certain that no contractor possesses a comparable capability.

Sound management, therefore, demands that this capability be employed to the fullest possible extent. If, for reasons of personal choice, this capability has not gravitated to contractors (which would have diluted its effectiveness), if, in fact, it has remained and is at MSFC, then MSFC must lead, as its capability demands, the vehicle development programs of the NASA Mission in space. That, precisely, is what it is doing, and the engineering design use to which data is presently being put at Marshall is one manifestation of that leadership.

Recognition and full understanding of this fact provide a clear insight to the nature of data as it relates to MSFC. The primary purpose of MSFC data, as produced by contractors, then, is to communicate program and design progress to MSFC during and concurrent with vehicle development. Intelligence derived from the data guides MSFC either to approve or to redirect the contractor's concepts. Marshall is the prime integrator of space vehicle designs, a role similar to that of the prime contractor in an airframe program. This characteristic markedly differentiates MSFC's need for data from that of other government agencies.

The Air Force, for instance, reviews the designs of its contractors from design reports that reflect the results of the contractors integration efforts. MSFC reviews designs also but because it must perform the integration effort it works from detailed final drawings. Final drawings to the Air Force are not primarily functional as conveyors of design criteria during the development and production life of the airframe. Following airframe delivery Air Force data becomes a tool for the operation of the logistics program. The real need for technical data does not exist in equal degree in the Air Force prior to hardware acceptance, hence the decision to defer data delivery. At MSFC, the reverse is true, for after delivery, the vehicle hardware has no long life expectancy to be supported by data. The exception is, of course, that NASA may wish to rebuild a particular vehicle or component configuration. This use of data would not negate the prior need for it.

MSFC's technological capability has brought about a unique interface with data. This interface amplifies the importance of documentation to Marshall, for we have seen that the Marshall capability is exercised (during contractor performance) as a response to information conveyed by documentation. If documentation does not include sufficient or proper information or if it is handled by means which hinder its use, the total Marshall engineering capability will be adversely affected. It is from this knowledge that Program Management, through its Data Management arm, must move to provide the required means and support for a documentation system to bring about a timely and accurate interchange of information between contractors and the MSFC technology leadership. Beginning with the identification of data requirements this primary MSFC mission must be recognized, and the minimum essential documentation must make available the maximum needed information for the accomplishment of this mission

1.4 Conclusions

The users of data consist principally of MSFC R&DO Laboratories, Integration Support Contractors, and KSC. There is a tendency toward more widespread dissemination of data. The majority of the use of MSFC data still occurs in the Huntsville area. The effects of distance could be substantially reduced by an effective identification of needs.

The central repository concept best suits Marshall's needs. It is a practical approach, and it is one capable of handling the data storage, retrieval, and distribution problem at MSFC. This approach outweighs any advantages offered by any alternative.

1.5 Recommendations

The Repository should initiate statistical records for more accurately determining breakdown of MSFC data users by organization and purpose of use. These records may be by continuous sample or random sample, but sample size should be large enough to assure statistical acceptability.

MSFC should retain its central repository concept. The necessary facilities should be supplied to accomodate a well arranged central Repository large enough to store a minimum of 10 million aperture cards in diebold files plus the reports, specifications, administrative, and reproduction requirements.

SECTION II
MANAGEMENT

2.1 Data Management Organization

2.1.1 Definition

On August 1, 1964, NPC 500-6 was released. This document, titled "Apollo Documentation Administration Instruction," established a NASA-Apollo baseline upon which the Centers could work toward a solution to the documentation problem. NPC 500-6 closely parallels the Air Force's AFSCM 310-1. Both recommend strong programs of requirements identification and justification, and both seek to isolate data requirements from the technical specifications of contracts. The NASA document, however, also includes, in addition to systemization details, statements of policy that define the interface between the Apollo Program Office Headquarters and the various Apollo Centers.

2.1.2 Findings

Except for requiring that the Centers coordinate their document indexes with Apollo Headquarters through a center-appointed Center Apollo Data Manager (CADM), NPC 500-6 does not establish mandatory intra-center procedures, but rather leaves the Centers with a free hand to "establish or extend" the "instruction to fit local situations."

Acting upon this mandate, Marshall, in November, 1964, issued Administrative Policy and Procedure Document, MSFC 500-6. This document contains a clear digression from the NPC instruction. The similarities to AFSCM 310-1 were retained, but the local document did not assign responsibilities to or provide for the designation of a Center Apollo Data Manager, the only explicit organizational requirement of the NPC document.

2.1.3 Analysis

The Data Management Organization described in MSFC 500-6 is divided into four parts corresponding with the major divisions of the MSFC organization, Industrial Operations (IO), Research and

Development Operations (R&DO), Administrative Operations (AO), and the Executive Staff (ES) (Fig. 2-1). The first three data management branches generally were given the same responsibilities within their respective MSFC organizations (Table 2-1). The IO Data Manager alone was given responsibility for the establishment and maintenance of the Saturn document index and document description standards. This responsibility is similar to that given the CADM in NPC 500-6, but does not denote the IO Data Manager as the CADM. The NPC document, for instance, designated the CADM as the authoritative overseer of the Center's Apollo Documentation Administration Program. (See NPC 500-6, Exhibit A, paragraph 1.c.) In MSFC 500-6, though, the lead responsibilities are given to the Executive Staff. As shown in the organization chart (Fig. 2-1), the Executive Staff communicates directly with the CADM's of the other Apollo Centers. NPC 500-6 indicates that this communication line is to be through the MSFC CADM, a nonexistent position in MSFC 500-6. MSFC 500-6 further states the following data management responsibilities for the Executive Staff:

1. Providing overall data management policy and procedures for Marshall,

2. Coordinating and approving the design of data management systems for the control and minimization of essential MSFC documents,

3. Providing guidelines and criteria for selection of essential data, and

4. Monitoring operation of Center Data Management.

The Executive Staff, then, was to act in the lead role in the Data Management Organization, the role reserved by Apollo Headquarters for the CADM.

2.1.4 Conclusions

The chart in Figure 2-1 does not depict the MSFC data management organization, for there is, in fact, a Center Apollo Data Manager at MSFC. (See Fig. 2-2.) Likewise, the breakdown of responsibilities given for the Executive Staff does not coincide with that of actual practices within MSFC. The responsibilities

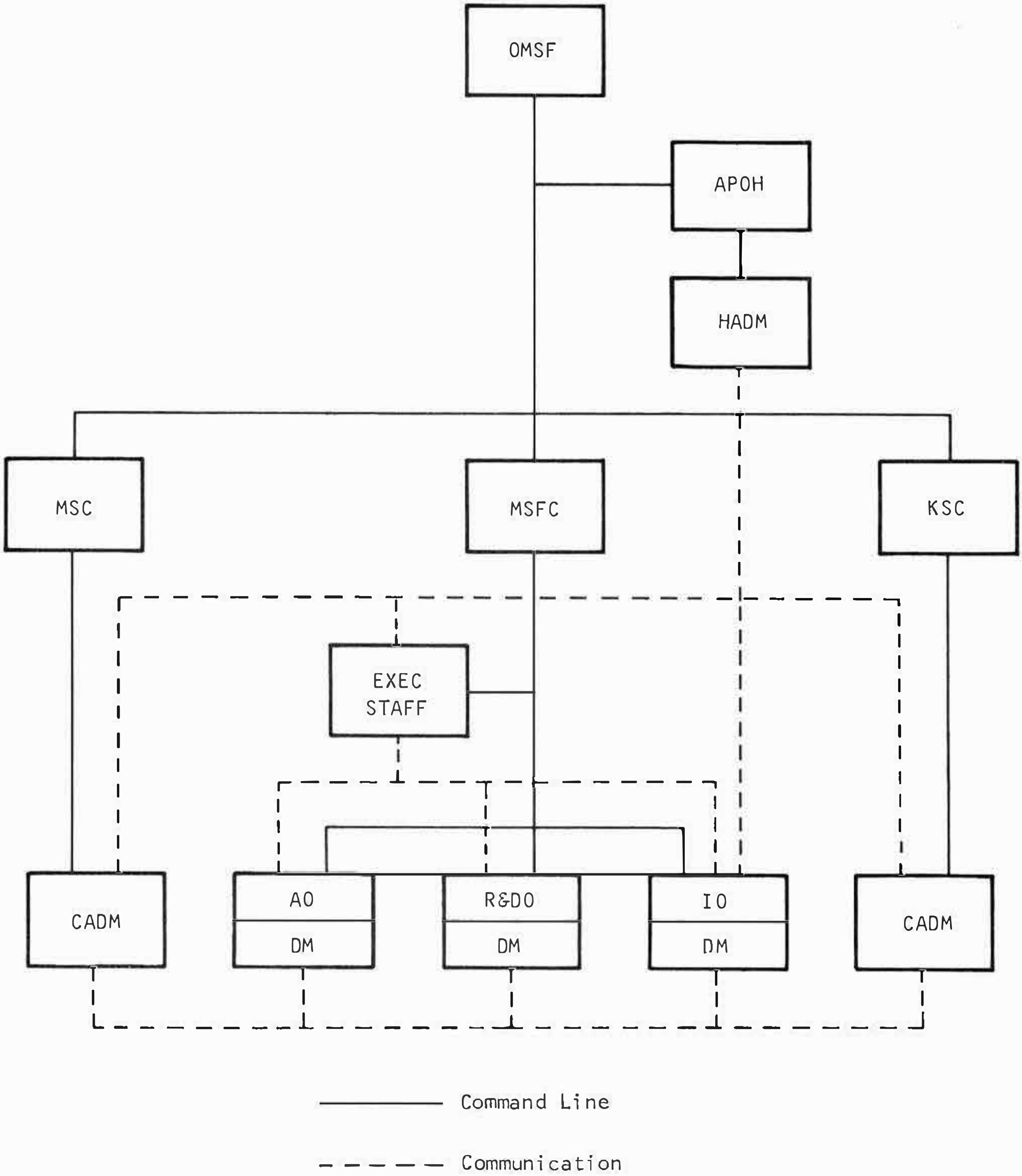


FIGURE 2-1. MSFC 500-6 APOLLO DATA MANAGEMENT ORGANIZATION

TABLE 2-1. RESPONSIBILITIES OF IO, R&DO, AND AO DATA MANAGERS			
Responsibility	IO	R&DO	AO
1. Fulfill the responsibilities of a Data Manager coordinating with the Executive Staff and other Data Managers.	X	X	X
2. Maintain data management interface with NASA Headquarters counter part and other centers.	X	X	X
3. Designate and monitor official entry and exit control point for processing, distribution, and repository of data.	X	X	X
4. Determine the most efficient manner and type of documentation to be used and establish a continual review duplication of data and to purge data no longer pertinent.	X	X	X
5. Issue call for data requirements and schedule meetings of data review teams.	X	X	X
6. Provide for annual review of data and incorporate recommendations of review teams.	X	X	X
7. Participate in establishing and apply approved Marshall data management policies and procedures.	X	X	X
8. Establish and maintain Saturn Document Index and Document Description Standards.	X		
9. Operate Marshall repository.			X

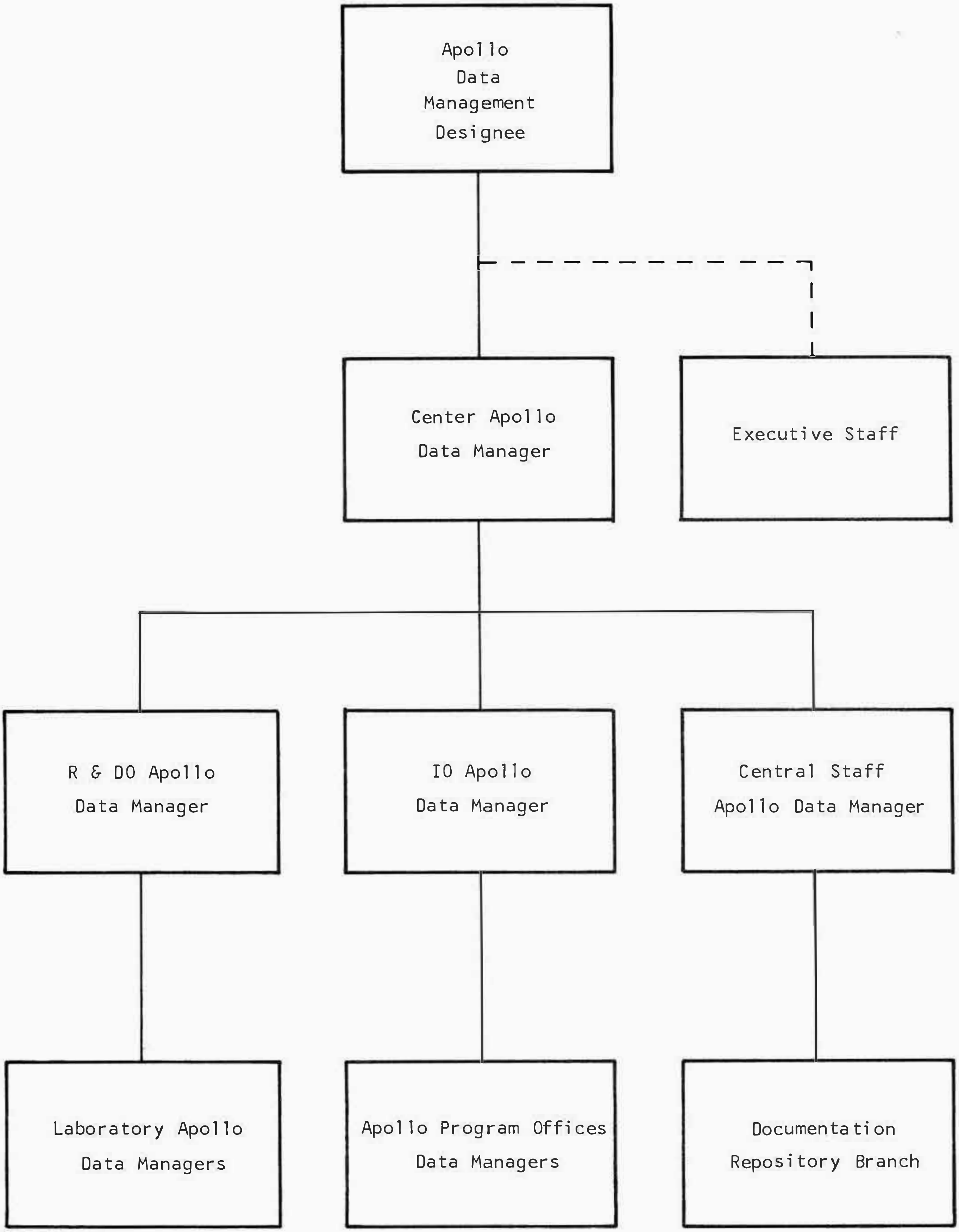


TABLE 2-2. ACTUAL MSFC DATA MANAGEMENT ORGANIZATION

given the Executive Staff did not materialize. The Center Apollo Data Manager is the Industrial Operations Data Manager, through whom the lines of communication between other centers and MSFC operate. The Data Management organization as established in MSFC 500-6 does not exist. The implied purpose of MSFC 500-6 —to establish and extend the instructions of NPC 500-6—has not, therefore, been accomplished.

MSFC is left, in effect, without a coordinated, local implementation of the Apollo Headquarters instruction. The authority for the present organization is not derived from MSFC 500-6, which is the only policy issuance made for data management at Marshall.

NPC 500-6 provides for the appointment of the CADM by the MSFC Director or a Designee. The IO Data Manager's appointment as CADM came directly from the Center Data Management Designee, the Chief of Industrial Operations. This appointment carried with it the full authority granted the CADM by NPC 500-6. The basis of the MSFC organization, then, is the NPC document and not the MSFC document. This would appear on the surface to be a more authoritative and thereby more effective base, but since NPC 500-6 recognized the need for the extension of its "instructions to fit local situations," and since MSFC 500-6 was intended as this extension, several weaknesses of implementation become apparent:

1. The CADM's authority is not conveyed by a Marshall document. The inbred autonomous nature of NASA Centers (recognized in NPC 500-6) is carried through into the working line functions at MSFC. It follows from this that any MSFC organization not based on local, fully coordinated agreement would be inherently weak.

2. The CADM appointed under NPC 500-6 is faced with the task of implementing detailed instructions given in MSFC 500-6, a document that does not recognize his existence. The mission of the CADM, being largely one of leadership and mediation, is more difficult in a framework that does not clearly identify his authority.

3. NPC 500-6 does not give the CADM direct responsibility for any policy-making activity. Still, as MSFC's data management hub he must see that such policies are issued. MSFC 500-6 delegates policy-making responsibility to the Executive Staff, but the Executive Staff has been effectively removed from the data management network by the reversion to NPC 500-6, which does not detail local dissemination of responsibilities below the CADM.

The sum of these weaknesses could be expected to reduce the effectiveness of the data management organization.

To correct this situation, the data management organization must be given MSFC authority. The incompatibilities between NPC 500-6 and MSFC 500-6 must be removed. The principal discord between the two documents lies in the failure of MSFC 500-6 to recognize the need for a CADM. The NPC document provided two mechanisms, one for local extensions of its instructions and another for the appointment of a CADM. Both mechanisms have been used at MSFC and neither in such a way that would be compatible with the other. This can be corrected by a revision to MSFC 500-6 to identify a Center Data Management Organization. The responsibilities assigned in NPC 500-6 to the CADM should be given to the Center Data Manager, and he should be identified as the Marshall counterpart of the CADM. This will effectively place Marshall in a program of total Data Management, not just Apollo Data Management.

2.2 The Role of Data Management in Program Management

2.2.1 Definition

The major defined responsibility of Data Management is to establish document description standards and maintain thereby the Saturn document index.

Program Management, not Data Management, is finally responsible for the failures and successes of the documentation program. All contractor prepared data is paid for with program dollars at the decision of the Program Manager. If more or less data is purchased than is required, the responsibility for the error then rests with the Program Manager.

2.2.2 Findings

Neither NPC 500-6 nor MSFC 500-6 gives proper recognition of Program Management's key role in the effective operation of the data management system. Each of these documents delegates responsibilities to Program Management; but in both cases Program Management is the passive recipient of Data Management's product. Program Management's principal function is described as a response to Data Management's requests for various services. While both documents, in appendixed exhibits, give Program Management the right to approve (or disapprove) Data Management recommendations, the documents do not emphasize, as they should, Program Management's authoritative responsibilities.

The Program Management responsibilities in Data Management, by NPC 500-6 are the following:

1. Provide membership for Center Ad Hoc Data Review Teams;

2. Assume other documentation responsibilities and functions as directed by Center Director or Designee;

3. In response to CADM requests, provide existing documents or prepare justification and cost estimate for new documents.

The responsibilities by MSFC 500-6 are the following:

1. Cooperate fully with the Data Managers and the Executive Staff in their administration of the Center Apollo Documentation Administration program;

2. Assure that approved DRL's and DRD's are developed which reflect that data required for inclusion in contracts and for internal MSFC Management;

3. In response to Data Manager requests provide existing documents or prepare justification and cost estimates for new documents.

Nor does the description of the Data Management System in the two 500-6 documents completely state the fact of Program Management's responsibility. This study has not found evidence that would indicate broad recognition of this fact among the Data Management and, surprisingly, the Program Management personnel at MSFC. There is, for instance, a widespread belief that "all our data problems could be solved by a fully empowered Data Management Czar" who could work his will in the data area.

2.2.3 Analysis

Such a Czar could perhaps solve the problem, but the damaging effects of this solution upon the concept of management control and responsibility would offset any benefits gained. The Program Manager can be the only "Czar" because his sphere of power embraces all products bought with program money, including data. Since MSFC does not demonstrate full understanding of the Program Manager's authority in the data area, it would seem to follow that this lack of specific definition or delegation of authority has caused independent approaches to the documentation problem by Program Management and Data Management.

Since Data Management alone has the responsibility for establishing and maintaining the Saturn document index and document description standards, and since Program Management alone has the responsibility for financial and administrative decisions concerning documentation, a close interrelationship between these two systems becomes a vital necessity. Therefore, steps must be taken to clarify Program Management's part in the Data Management System. What this part should be can best be shown by defining Data Management's role in the system. The Conclusions will first describe a concept for an effective Data Management activity and will then return to the question of Program Management.

2.2.4 Conclusions

Data Management should address itself to two major tasks, coordination of data system design and system integration. The first task would include the description of an optimum total data system design. The total system should cover all aspects of the data problem from data identification to data use, including data specification and acquisition, data flow, data storage, retrieval, and distribution, and all interfaces with data users.

The second task, system integration, would be continuing effort of assisting Program Management in its application of optimum principals developed for the data system to the particular data problems facing the Program Manager. As a part of the second task, Data Management would also coordinate data management activity in all Program Offices to guarantee a unified understanding and application of data management theory. Data Management would be the authoritative voice for the interpretation of data policy and for the mediation of inter-Program inconsistencies.

The Data Management Coordinator would have no arbitrary authority in financial policy-making decisions or expenditures. His ideas would be implemented only if they were effective in assisting a Program Manager in these decisions.

If, then, Data Management's job is to describe and coordinate an optimum total data system, it remains for Program Management to implement and use the system. The Data Management System should be operated by the Program Offices and should be coordinated and monitored by the Data Management Administrator. This arrangement resembles the present operation. The missing element is a clearly documented understanding of who has what responsibility. From the above it is evident that Program Management must be responsible for Data Management and that what is today called the "Data Management Office" is responsible only for assistance in the development and administration of the system.

NPC and MSFC 500-6 do not make this relationship clear and in some instances erroneously suggest different arrangements. (See paragraphs 5.a and Exhibit A, 1.c of NPC 500-6, and paragraphs IV.4 and V.2.e, 3.f, and 4.f of MSFC 500-6. Note also that MSFC 500-6 makes no provision for Data Management functions within the Program Offices.) These documents, then, especially MSFC 500-6, have contributed to the misunderstandings that surround the roles of Data Management and Program Management.

Part of the snarl in these documents can be traced to a major inconsistency—the lack of parallelism between the MSFC organization and the OMSF organization. NPC 500-6 indicates that the CADM is "an individual . . . . . at an Apollo Center

Program Office." There is no way that MSFC could so locate its CADM; at MSFC there is no Apollo Program Office. The organizational placement of the CADM, then, would have to be an "extension to fit (the) local situation." As has been seen, though, the question of the MSFC CADM was avoided in the local instruction. The attempt made by the MSFC 500-6 writers to work around this omission has resulted in a poor statement of policy. Data Management is not placed in the mainstream of the Program Management Operation. Unless it is, Data Management will always be just a "good idea."

2.3 The Role of the Marshall Repository in Data Management

2.3.1 Definition

The Repository at Marshall is the facility for accumulating, storing, reproducing, and distributing all documents specified by Program Management. At MSFC this service is performed by the Management Services Office Documentation Repository Branch. The facility processes engineering documentation pertaining to MSFC hardware programs. The Repository is the channel through which data is sent to its users, and must therefore be considered an essential function of the total system. Because Program Management as the center of Data Management should be concerned with the overall data procedure, from source to user, it is vitally implicated in the operation of the Repository.

It will be shown that efficient data retrieval and distribution can be handled only by a centralized and complete source of documentation; therefore, any obstruction of data flow through the Repository would disrupt the entire data system. It follows that a major responsibility of Data Management is to minimize the possibility of such obstruction.

2.3.2 Findings

NPC 500-6 provides no management discipline for a repository, but merely defines a "Data Center" where Apollo documents will be collected, stored, and distributed. MSFC 500-6 does assign each of the three line data managers (IO, R&DO, and AO) a responsibility to "designate and monitor" their respective "entry and exit (data) control points." Neither document, however, provides management disciplines to integrate a single repository with other elements of Data Management. The provision by MSFC 500-6 therefore tends to create confusion because (1) the document does not state that the managers are to monitor the same repository; (2) none of the managers has designated any entry-exit control point. To clarify this situation, then, an authoritative document must clearly provide specific definition of Program Management's and Data Management's interrelationship with the Repository.

The most recent issue of the Repository's official charter indicates that Program Management will decide what documents the Repository is to receive. This directive is in keeping with Program Management's overall control of financial and policy-making power; however, the statement does not include an indication of Data Management's role. As a result of this ommission, the relationship between the Repository and Data Management is weakened. Such a relationship was intended by MSFC 500-6. This confusion in interpretation, therefore, further obscures the Repository's place in Data Management.

2.3.3 Analysis

These contradictory directives may be traced directly to the separation of Program Management and Data Management. If these activities were seen in their proper relationship—Data Management as one of the functions of Program Management—the ambiguities would disappear and the Repository would become a recognized part of the Data Management network able to communicate with sources with authority to act on its technological needs. As we have seen, this authority can come only from Program Management. Unless these needs, principally for uniform data and disciplined data flow, are described and communicated, the functions of the Repository will become obstructed and the disruption of the Data Management System idea will result.

2.3.4 Conclusions

Any revision to NPC 500-6 or MSFC 500-6 must state a clear data management position for the Repository. It should specify what data the Repository is expected to handle and should provide the Repository with a communications line to the authoritative elements of the total data system. The Repository would then become an active participant in the development and operation of the optimum total Data Management System. Like the Data Management Administration function, though, the Repository should have no external authority except that it should not be obligated to accept documentation that did not meet the quality and format restrictions of the data system. The Repository's role should be as it is today, the tool or service. Repository Management should, however, be given explicit lines of communication with data management administrative activities, so that the Management Services Office could make the needs of the Repository known to the authoritative elements of Program Management.

2.4 The Role of Research and Development Operations in Data Management

2.4.1 Definition

Research and Development Operations (R&DO) is the most significant data requiring activity at MSFC. Use records indicate that of the data issued from the Marshall Repository to MSFC users, 85 per cent goes to R&DO. In addition to its widespread use of data, R&DO is a major producer of data. In its role as prime systems integrator, R&DO issues documentation for the use of all programs. In turn, it evaluates and approves or disapproves all major contractor designs. It is principally R&DO that requires documentation. Data Management's requirements identification function cannot, therefore, be effective without an active R&DO element in its network.

2.4.2 Findings

Review of MSFC 500-6 (See Table 2-1) does not indicate that R&DO has been assigned a unique responsibility in the areas of requirements identification, data standardization, and other use aspects pertinent to data management. Data standardization and use are not treated in the document. Even though requirements. identification is discussed in depth, R&DO is not explicitly directed to be the major technical contributor to this effort.

Another important consideration here is the Center Ad Hoc Data Review Team (CAHDRT). This is the specific committee which is directly charged with determining data requirements; yet it is described merely as being composed of "appropriate individuals."

Aside from the statement of the CAHDRT's central purpose, no definitive measures clarifying composition, organization, operation, or procedures are determined.

2.4.3 Analysis

Because of R&DO's obvious significance in the operations of Data Management, the Data Management function within R&DO should be designed to emphasize requirements identification and data use. A most effective method would be activation of the CAHDRT's members from R&DO; it seems that this committee's membership would be most appropriately comprised of R&DO representatives—those of the organization which uses 85 per cent of the data and that provides the basis for most technical documentation.

This should not be interpreted as indicating that only R&DO should be represented on this team. Program Management must be and so should the Data Management Administrator; nevertheless, R&DO should at least be represented in numbers commensurate with its potential contribution.

2.4.4 Conclusions

To assure the availability of competent R&DO CAHDRT representatives, the R&DO Data Manager should recommend to Laboratory Directors the appointment of subordinate Data Managers in each of the R&DO Laboratories whose prime responsibility would be to establish a clear visibility of the data requirements picture in his activity. This organization would resemble that currently in effect in R&DO but would be given a precise data requirements identification mission.

The R&DO Data Manager, in conjunction with Repository personnel, should also be charged with the development and maintenance of general specifications for uniform economical Class II data. Most of the MSFC experience and capability in this area is presently located in the P&VE Laboratory. This capability should be used by the Data Management Organization. Though the uniformity of Class I data has not been a problem, it is equally important that Data Management conduct a comprehensive overseeing of this data to insure uniformity of both classes of data.

A survey indicated that 17 per cent of the recipients of data on automatic distribution had no need for the data, did not desire it, and did not know how to stop the influx. Since most of the controllable users of data are in R&DO, the R&DO Data Manager should spearhead the administrative effort to clear up the automatic distribution problem. The actual development of the distribution methods and procedures should be a Repository function since these services transcend any one user organization.

2.5 Recommendations

It is recommended that MSFC 500-6 be rewritten to incorporate the following basic provisions:

1. Designate a Center Data Manager to be responsible for development of MSFC total data system, to coordinate implementation and monitor operation, and to communicate with APOH and other centers on Data Management policy.

2. Designate Program Offices as the responsible agent for implementing Data Management and to be responsible for contractor relations, contract actions, and lead CAHDRT. Develop the Program Office and other IO data requirements package.

3. Designate R&DO Data Management Administrator to be primarily responsible for coordination of MSFC data distribution matrices, coordination of R&DO data requirements identification effort, and to provide membership for CAHDRT.

4. Designate official MSFC Repository.

5. Designate Data Management Administrator for Repository Activity to coordinate Repository needs with Data Management Administration inclusive of uniform data requirements, standard data flow recommendations, input/output controls, and purging policy; and to serve on CAHDRT as advisor on data format, media, and distribution requirements.

SECTION III
DATA ACQUISITION

The key element in any efficient documentation system is data acquisition. It is during this process that the controlling factors, quality, media, and adequacy, are established. After acquisition, these criteria cannot be added except by costly and time-consuming retrofit negotiations.

If poor data is bought, the system for handling the data cannot function at top efficiency and the eventual user of the data will not receive the most effective information. Properly planned and implemented data acquisition will consider indexing, storage, retrieval, distribution, legibility, adequacy, accuracy, and data use. It will specify requirements which, when met, will result in good, system capatible data.

3.1 <u>Definition</u>

Data acquisition may be broken down into three sub-elements:

1. Data requirements identification,

2. Data procurement, and

3. Data product acceptance.

These sub-elements have the same objective, that of maximum efficiency and economy of the data system. In simplifying, it may be seen that each of the three has a specific objective. Respectively these are:

1. Minimum essential coverage,

2. Most economical price, and

3. Quality commensurate with, but not in excess of, needs.

An analysis of MSFC data acquisition, then, must consider the weight given these specific objectives in terms of the total objective and must consider their effects upon that objective and upon each other.

3.2 Findings and Analysis

3.2.1 Requirements Identification

The findings of this study indicate no major weaknesses in the theory behind the program of data requirements identification (except for the previously mentioned informality of the CAHDRT membership). The authorizing documents, NPC and MSFC 500-6, as they treat requirements identification, have been correctly interpreted and the guidelines for action have been generally followed. Document Requirements Lists (DRL's) describing contractually required documentation and setting forth data media and delivery specifications have been developed for and included in all MSFC major prime contracts and several smaller contracts.

In some contracts Data Management has shown significant reductions in the number of data items procured. This represents cost avoidance and demonstrates the potential payoff of the Data Management idea. In some instances, though, the newly contracted data package is no more than a restatement of existing requirements. Where non-uniformity had previously existed it generally still exists. To the extent that this is true, Data Management efforts have not been successful in achieving the uniformity of product that is necessary for the realization of true data effectiveness. This fact is mainly attributable to the late start of formal Data Management in defining data requirements. Much of the contracted-for data had already been delivered or was so fully developed that to retrofit was not advisable.

3.2.1.1 Specification of Requirements

An illustration of non-uniform data requirements is the equivocal approach taken in the DRL and DRD to precise media specification. The DRL contains a code to specify data media. The coding scheme is:

1. Regular

2. Reproducible

3. Microfilm

4. Other

The interpretations of the words "regular," "reproducible," "microfilm," and "other" are given in a preliminary text to the DRL. While this text suffices for identification purposes, it provides means for the growth of non-standard data media procurements. More precise, and therefore more disciplined, would be a coding scheme that translated to precise definitions of media. Example:

1. Typewritten submission per MSFC-Spec-XXXXX

2. Mylar reproducible per MSFC-Spec-XXXXX

3. Sepia reproducible per MSFC-Spec-XXXXX

4. Microfilm rolls per MSFC-Spec-108

5. Microfilm aperture cards per MSFC-Spec-228

6. Original tracings per MIL-D-70327

7. Other as specified in DRL block XX

It is obvious, though, that before this could be done, MSFC-Spec-XXXXX would have to be established using MIL specifications or industry standards wherever these produce optimum data. The text in the DRL is serving some specification purposes at present, but this text is not standard. A general procurement specification for data is required. NASA has not moved firmly in this direction. MSFC has the opportunity to develop NASA leadership in this area.

3.2.1.2 DRL Distribution List Requirements

A second specific weakness detected in the present DRL is the method used for specifying distribution requirements. These requirements are highly dynamic. Changes are accumulated and when the quantity of changes seems sufficient a revised DRL is issued. It would be more efficient if a separate listing of distribution requirements were used.

3.2.2 Data Procurement

If usable data is to appear in the MSFC documentation system, it must be paid for in the procurement phase of data acquisition. Proper expenditures here are the only means for guaranteeing the acquisition of uniform data. If less is spent than is required, then inadequate data will be received.

3.2.2.1 Uniform Data Deviations

The purchaser of MSFC data is Program Management. But Program Management's product of major concern has been hardware. Evidence seems to indicate that Program Management has not given sufficient emphasis to data. This evidence may be found in the many deviations to the quality requirements for data. A typical illustration of this is that in every prime stage contract requiring microfilm submissions the MSFC-Spec-108A requirements for background density have been broadened beyond specified limits. Also, because the delivery schedules for data have not been adhered to, interim measures have been taken to fill the gaps left by the undelivered data. This has caused the distribution to working files of much illegible data. A small sample quality audit performed by the Study Team showed that about 60 per cent of the data in one working file was at least partially illegible.

More recently, in June, 1966, Data Management averted the procurement of non-standard microfilm aperture cards. A contractor had proposed the delivery of cards keypunched directly opposite to the requirements of the Marshall standard. Project Management and their R&DO support organization had agreed to accept this non-unifrom data. The Repository insisted that it would not cost much more to procure standard data and in short time agreement was reached to prepare the data (approximately 190,000 cards) to the Marshall standard.

The workload could have been done at no additional cost except that the contractor, based on an earlier interim decision, had already programmed to produce the non-standard cards.

3.2.2.2 Data Specifications

Until this point this Study has oriented itself toward a total data system. If this total system is to effectively utilize the data involved, data must be described as a product.

Data can be described as a product by describing data in specifications which are ultimately used during the data requirements identification phase. The data system becomes less effective as deviations allow variation to the data desired. It follows then, that if Data Management has responsibility for the data system, it must employ every effort to achieve compliance with the system's specifications. Program Management must be assisted in every way possible to develop specifications for and to procure standard data.

At the same time - no standardization of data should be imposed beyond that necessary to make the data useable downstream from the originator. Thus the specification should require only essentials.

MIL-D-70327, which is now being used in many NASA contracts, has been superseded by MIL-D-1000. Whether either of these specifications is suitable for MSFC (and NASA) use should be the subject of a separate study.

MIL-D-70327 data is expensive. Under certain circumstances MIL-D-1000 data may prove to be even more expensive.

The Study Team believes that NASA has the potential for evolving a drawing specification that will obtain effective drawings at a cost less than either of the above. Such a specification should identify the absolute minimum necessary characteristics of a drawing, in terms of what NASA needs downstream, and leave all other drafting practices to the contractor. The development of such a specification is recommended.

A weakness in the MSFC system is the lack of a controlled approach to the definition of data disclosing proprietary information. A drawing specification should cover the means by which data to be protected is identified, and the basis on which these rules are applied. The indicator on the aperture card, covered by MSFC PROC-228A is considered inadequate for this purpose.

3.2.2.3 The Cost of Data

A major objective of Program Management and Data Management is the reduction of data cost. The overall cost savings can be effected by merely reducing the quantity of data procured. However, unless a parallel effort is undertaken to build an effective data handling system for storage, retrieval, and distribution, it is quite likely that the savings gained would be offset by subsequent attempts to get information needed by data users. The Repository has been faced with a heterogenous array of data. For example, the Study Team was able to identify twelve different keypunching layouts on aperture cards presently stored by the Repository. These have come about mainly by the failure to specify and enforce a standard method.

These deviations have not only increased the cost of handling the data in NASA and user facilities, but has also resulted in a continuing procurement of non-standard products. Because it is non-standard, MSFC has not been able to develop a reliable cost basis for the contractual negotiation of these data requirements. With the non-standard product, the task of estimating costs for negotiations is next to impossible. When this interface is removed, and it must be, the MSFC purchaser could then go armed into a data requirements negotiation without being at the mercy of the seller. The savings that could be gained in such negotiations cannot be fully realized unless uniform data standards are developed and employed. Adding these savings to the data handling efficiencies that uniform data will allow, it is obvious that the procurement of standard data is a goal to be urgently pursued.

3.2.3 Product Assurance

Quality inspection of purchased Class II documentation is not practiced by MSFC. In view of the fact that MIL-D-70327 is the data specification most imposed by MSFC, the absence of a formal inspection program is made more critical. MIL-D-70327 is a rigid specification. One of its features is that it imposes government practices on industrial organizations. These practices may represent deviations from contractor internal methods. It is important, therefore, that data procured under MIL-D-70327 be given a thorough review if only to assure that the data delivered to NASA does not contain such glaring weaknesses that the data is useless to those functions downstream from the originators.

As a basic requirement, each set of data should be reviewed to assure that it does not contain the following weaknesses:

1. improper part number to drawing number and revision letter relationships,
2. inadequate change and revision summary historical records,
3. inadequate or improper part number change disciplines,
4. illegibility,
5. incompleteness of the package,
6. inadequacy of the vendor data used,
7. confusing or misleading projection or dimensioning techniques,
8. lack of essential process callouts, and
9. confusing or unconventional assembly breakdowns.

3.2.3.1 Data Quality Assurance in the Air Force

In 1963 the Air Force (AFLC) instigated formal auditing of Class II engineering data. The objective was to check submissions to the Air Force Central Depository for compliance with contract. The immediate result of this audit was the rejection of 65 per cent of all lots submitted. In 1965, this percentage had been reduced to 20 per cent. MSFC, having no such inspection, might be presumed then to be receiving data which is 65 per cent noncompliant. Table 3-1 depicts the 10 most frequent defects found in data inspected by the Air Force. (Note that the first four types of defects accounted for approximately 69 per cent of all major defects.)

In an operation as large as the MSFC Repository, many problems occur. One of the major elements causing concern is the improper identification of documents. A misplaced or missing dash in a drawing number can cause a particular drawing to be lost for automatic or manual retrieval. Each of the other types of defect has an impact on the effectiveness of the MSFC documentation system. There is, therefore, no reasonable justification for not inspecting Class II data.

TABLE 3-1. TYPES OF MAJOR DEFECTS IN ENGINEERING DATA (JANUARY - MARCH 1965)			
Rank	Para. No. (70327)	Type of Major Defect	Pct.
1st	3.5.6	Materials, processes not identified	26.4
2nd	3.6.4	Data, documents ref. on drawings not submitted	17.2
3rd	3.1.6	Drawing numbers incorrect	15.2
4th	3.3.2	Dimensions/tolerances omitted	10.1
5th	3.5	Item identification defects (other than 3.5.6)	8.3
6th	3.1.7	Types of drawings do not comply with standard	8.0
7th	3.8	Improper use of proprietary legend	4.9
8th	3.5.1	Part numbers omitted or improper	4.5
9th	3.1.20	Drawing revisions not as required	3.0
10th	3.1.24	Assoc. parts list, or LM, improper or omitted	2.4
		Total	100.0

The Study Team wishes to make it clear that we do not consider inspection of Data as similar to inspection of hardware. Data inspection in Quality Assurance will require a review by people capable of judging whether the data furnished will be adequate for use. This will require an evaluation of the contractors capability in the inspection of data per se. The Team would encourage the use of contractor inspectors subject to periodic checks on the contractors actual performance.

Class I data is extensively inspected by the checking unit in P&VE prior to release. There is no difference in the relative importance of Class I and Class II data. It would follow that the quality of Class I and Class II data at MSFC should also be equal. The exceptional difference in quality would indicate that some form of corrective action is mandatory.

3.2.3.2 Decision on Specification

The question of what data specification to invoke must be resolved in parallel with the development of a quality review function. Training of quality control personnel must be geared to the data requirements that will be placed in contracts. If 70327 is interim, shortly to be superseded, it would be unwise to gear a capability to its highly detailed requirements. If, on the other hand, the interim label is removed, there should be no major obstacle to full and immediate implementation.

3.2.3.3 Location of Inspection Function

A final and important consideration that must be made regarding the inspection of data has to do with the location at which this inspection should take place. This study will recommend that the quality review of engineering data be made at Marshall and at Michoud by MSFC employees of their single support contractors. The alternative, inspection on site in the originating contractor's plant, must be considered and the ultimate objective of substituting contractor capability certifications for inspections seriously investigated.

3.3 Conclusions

It is apparent that a difference exists between what MSFC would like to buy and what is actually procured and delivered. Problems are traceable to the failure of MSFC to define requirements and to control the quality of data to the requirements. These problems are of sufficient magnitude to justify Program Management attention. An attempt to measure this magnitude gets right to the heart of the value of data itself.

It must be recognized that the cause of the present variation from best practice has been cost. Good, controlled data initially costs more than poor data. Management's concept of its money's worth has resulted in poor data - not because management intended to buy poor data, but because it has not decided to buy good data.

"Good Data" is data that adequately, accurately, and legibly conveys information regarding its subject. It is data that can be efficiently moved from source to use. It must also be indexable, storable, retrievable, reproducible, and useable. Each of these elements must be considered as a part of a decision to buy good data. This study has found that these factors have not been given proper weight in the buying decision. The struggle has generally resulted in a trade-off of handling requirements with cost, when the only genuine money's worth is good data. Good data does not have to change to fit the system. It already fits.

A good data system does not have to change to fit the data. It was created to do so.

Assessment of proposed deviations to baseline specifications should be coordinated by Program Management assisted by Data Management. Criteria for deviation assessment should be:

1. Impact on usefulness of data;

2. True overall savings to be realized;

   (a) Value of un-waivered data minus value of waivered data,

   (b) Cost of unwaivered data minus cost of waivered data,

3. Good data at minimum cost can be achieved easiest by simple management disciplines. However, like any disciplines, each approval of a breach has a corrosive effect on the whole which must be considered as theoretically weakening the entire data system.

In examining the findings, it appears that a certain amount of retrofit should be imposed on existing contracts to upgrade the requirements for data where this will prove economically best for NASA. An indication of how vital it is to get proper data requirements into the contract from the very beginning is that the decision to retrofit becomes almost impractical in any contract where the data production is well along. In data - the "Do it right first" slogan was never more appropriate.

3.4 Recommendations

1. A firm commitment to a concept of data compatability should be sought. Approved specifications for this data should be formulated or adopted. Specifications should be comprehensive of all aspects of good data as indicated in paragraph 3.3.

2. The newly developed data specification should be imposed on all future MSFC contracts and MSFC laboratories.

3. Existing contracts should be reviewed for possible retrofit action. Existing contracts should not be retrofitted unless a clear value improvement can be realized. Criteria for retrofit priority should be:

   a. Remaining amount of time there is a likelihood the data will be used,

   b. Amount of present deviation from baseline,

   c. Cost of retrofit,

   d. Amount of nonuniform data likely to reach the system in in the future under the contract in question,

   e. Relative value of data called for by contract.

4. Assessment of proposed deviations should be coordinated by Program Management, assisted by Data Management using a total cost effectiveness criteria to make the "best data" decision.

5. DRD/DRL package, with references, should convey completely what data is required and the specifications for the data.

6. Formal quality control of Class II data should be initiated. The activity responsible for Quality Control should inspect and approve or reject all contractor data submissions, for compliance with the contract requirements.

7. Initiate an MSFC study effort to develop an effective drawing specification that will result in useable data at a minimum cost.

SECTION IV
DATA RELEASE

Release is the functional end of the data production cycle. It can be likened to the formal introduction of the data to the system that will store and deliver it on demand to the data user. One of its purposes is to assure that data is official and valid. Data that enters the system without passing through the release function is not registered and its validity is not assured.

If MSFC is to control the quality of data, then, it must do so either before or at release.

4.1 Release of Class II Data

This practice holds up for Class I data because MSFC performs the release function. In the case of Class II data, however, the situation is different, for the contractor must also maintain a release function. If the contractor were to distribute data directly to MSFC data users, without formal acceptance by MSFC of the adequacy and accuracy of the data, then the users would receive data of questionable validity.

In comparing the relative merits of higher quality data versus faster data (Table 4-1), several questions must be answered:

1. How much quality loss are we dealing with in fast data?

2. How much delay is involved?

3. What, if any, are the indirect advantages to either approach?

4. What are the disadvantages?

The information in the table leads to the conclusion that a release of Class II data is best made through an MSFC Quality Control function. Sixty-five per cent potential quality loss is too much, and there is not enough time gain to offset the loss. The balance between indirect advantages and disadvantages is definitely in favor of the slower, more reliable approach.

TABLE 4-1. COMPARATIVE ANALYSIS OF DIRECT VERSUS INDIRECT CLASS II DATA DISTRIBUTION

Question	If Data is Submitted Direct from Contractor to MSFC Users	If Data is Submitted to Repository by Contractors
How much quality loss might be expected?	Up to 65 per cent.	Minimal
How much increased speed would be involved?	Delivery could be made in from 3 to 6 days depending on distance and type of distribution.	An additional 2 days for quality checking function. This could vary upward in high volume situations.
What indirect advantages may be expected to occur?	1) Decreased file maintenance requirements.	1) Allows centralization of personnel and equipment. 2) Broadens span of management control. 3) Permits deeper indexing of data.
What indirect disadvantages may occur?	1) Lack of control of "total" data as an entity. 2) Increased costs. 3) Puts contractor in position of undue advantages viz-a-viz competition. 4) Proprietary data problems. 5) Widespread files (in contractors' plants) "hide" data from random users. 6) Does not actually eliminate requirement for MSFC central file.	1) Requires accurate forecasts of workload. 2) Peak load situations could be more expected to occur. (Effects could be minimized by accurate forecasts.)

4.1.1 Dual Release (See Fig. 4-1)

Class II data is prepared by a contractor, controlled by a contractor, and principally used by a contractor. If MSFC performs a release subsequent to the contractor's, there would seem to be a cross-purposing of efforts. The contractor, however, is bound to prepare Class II data that meets two general requirements:

1. The data must satisfy his needs. Here, there is not explicit delineation of the contractor's responsibility.

2. The data must conform to MSFC's requirements.

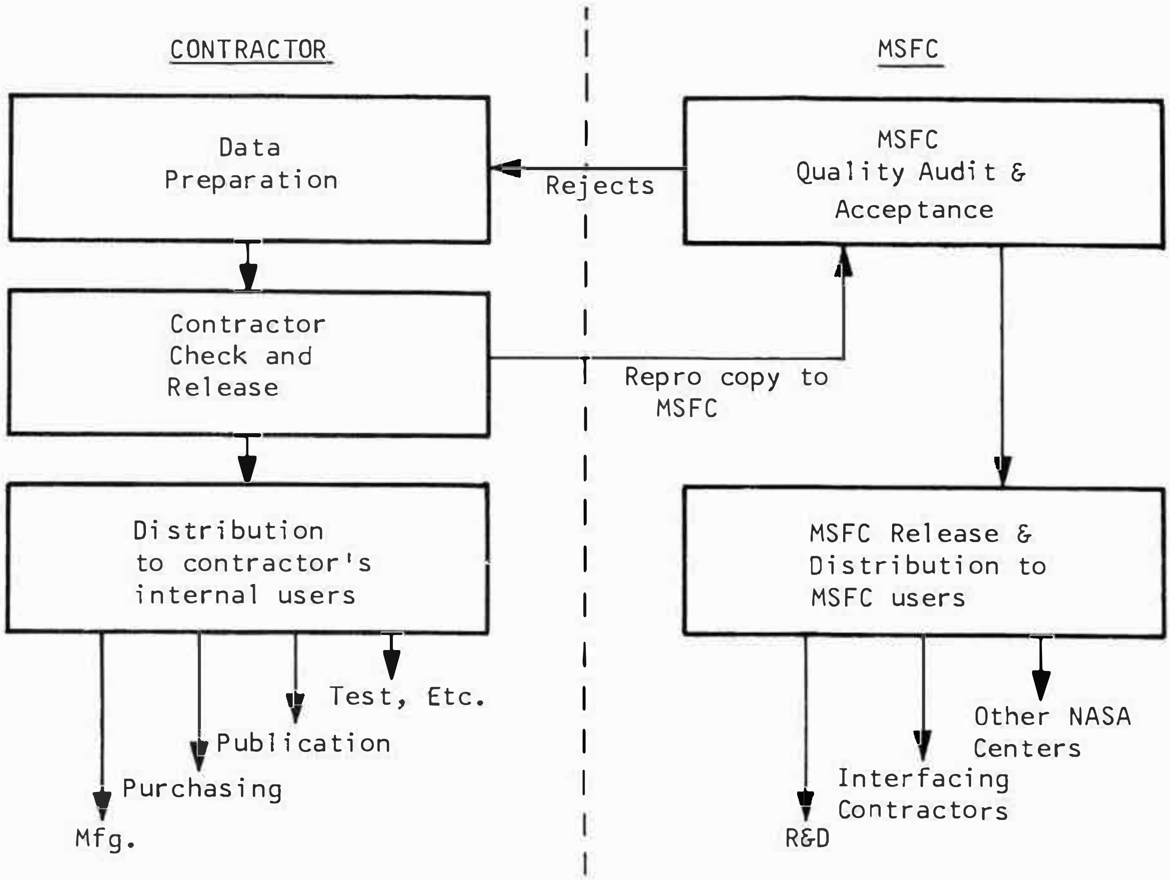


FIGURE 4-1. THE DUAL RELEASE SYSTEM

The contractor's release of data indicates that the data is sufficient for his needs. Because the data has not at this time been accepted by MSFC, there is no guarantee that the data meets requirement number two. When this data is directly distributed to MSFC users, MSFC must bear full responsibility for any decisions based upon the data.

A "point-to-point" release system would eliminate the functions to the right of the dotted line in Figure 4-1. Under such a plan MSFC users would receive data that met only requirement number one, and any quality review of data would be deferred until the program was in its waning stages and most of the decisions based on data would have been made.

The Air Force has adopted with considerable publicity a deferred data delivery plan on the C5A Program. The situation there is different from that of MSFC, because on the C5A the contractor, as the design integrator, is the sole user of the data. Air Force design review is done to layouts and design reports not detail drawings, and is often conducted at the contractor's plant. The ultimate Air Force needs for the data are for logistics not program integration and design. The probability is that this Air Force activity proves the premise of this report that the repository must be ultimately alligned with the activity having top program management responsibility.

4.2 Release of Class I Data

Class I data is controlled by MSFC. All changes to this type of data require the approval of MSFC. The Class I data concept is intended to serve either of the following purposes:

1. to convey MSFC baseline specifications to a contractor,

2. to provide control of critical interface designs, or

3. to communicate MSFC designs to internal MSFC functions and/or component manufacturers.

The release of Class I data is an MSFC responsibility. This is presently being accomplished at Huntsville by the P&VE Laboratory. Quality Control of Class I data is also a P&VE function. Figure 4-2 depicts the basic flow of Class I data at MSFC. While some Class I data is produced at Michoud, the functions normally performed by P&VE are performed in an office at the Michoud Operations.

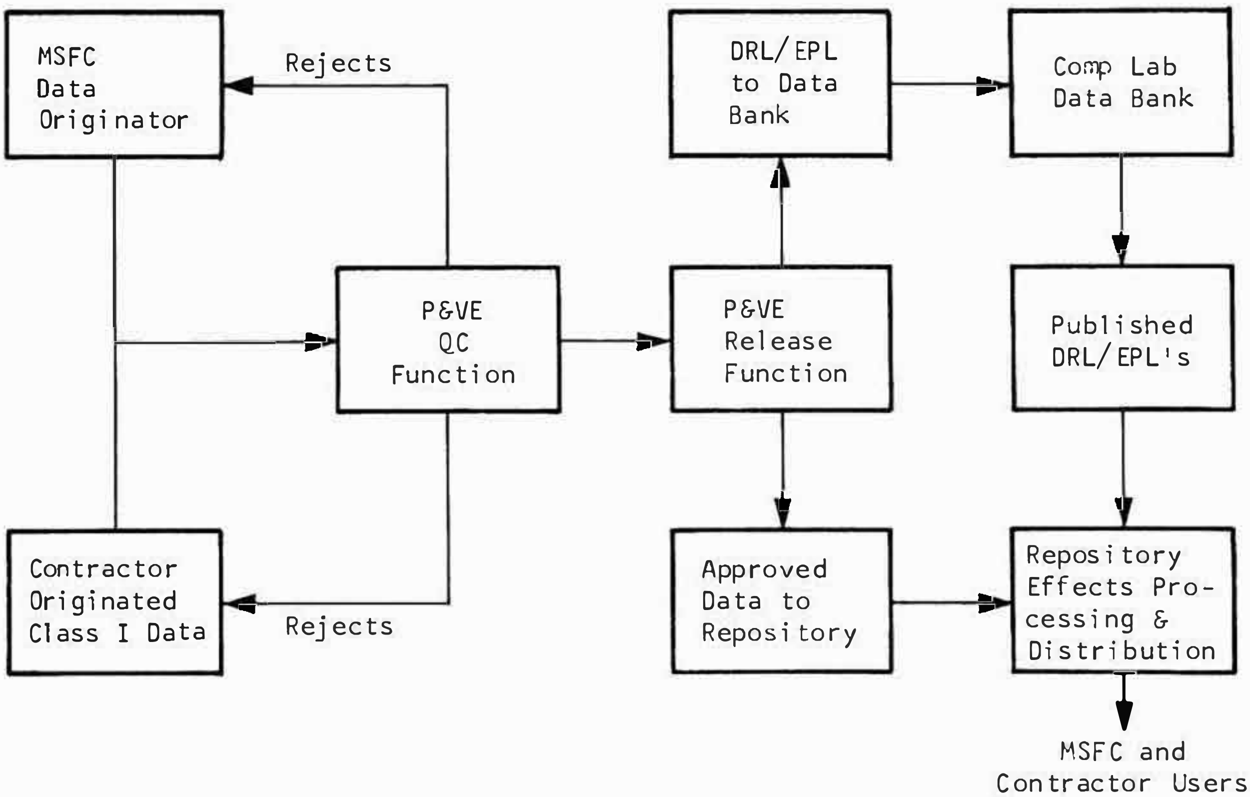


FIGURE 4-2. BASIC FLOW OF CLASS I DATA

This study has found no error in the design of the Class I release system. There is, though, a breakdown in the system at the Repository interface juncture. Much data is being produced that never finds its way to the Repository. Some laboratories do not make their data available to P& VE for checking and release. Our study has found that this failure is attributable to one of two causes:

1. Lack of definition as to what should go to the Repository (or to P&VE), or

2. A Laboratory policy of autonimity.

Recommendations made elsewhere in this study will reduce the breakdown caused by the lack of definition. Management action will be required to remove problems caused by laboratory autonimity.

This Study Team is convinced that the central Repository approach is the best method for guaranteeing full access to data. It is absolutely essential that the total data on a program be available to those with a need to know. The MSFC policy of contracted integration support management emphasizes this essential. To combat this policy, those laboratories opposed to placing data in the Repository have argued (1) all who need the data know where to get it and (2) only in the labs can critical data be protected from those who do not have a need to know.

It cannot be argued that those who need the data will know where to get it. There is too much evidence to the contrary. For example, a specific objective of the November, 1965, Saturn V Directive No. 6 was the location and acquisition of data that could not be found in the Repository. The Saturn V integration contractor needed the data. He did not know where to get it. Much of it was found in the laboratories through the efforts of the R&D Data Manager's Office, but even this effort has not found all the data. As of May 2, 1966, there were still over 2000 outstanding requisitions for Class I laboratory produced documentation. All of this data should be but is not in the Repository.

With regard to protection of data, it is believed by the Study Team that any restrictions on the free flow of data throughout the nation, except for the flow of data private to a contractor, which is protected by contract, is contrary to public law. Certainly private data should be protected wherever it is stored, but all other data should be made available to the widest use within NASA's best interests.

4.3 Conclusions

In studying data release, a detailed investigation was made of the relative merits of the point-to-point and the centralized distribution techniques. It is concluded that the centralized approach would allow MSFC to qualify all data prior to its distribution and use as well as provide the services for making data available to all users, particularly integration support contractors.

It is also concluded that the effectiveness of the MSFC Class I data system has been weakened by the failure of some R&DO Laboratories to release data through the formal release cycle. The most damaging effect of this failure is that the excluded data is not readily available to all data users. Centralized data accumulation does not adversely affect the autonimity of the Laboratories; their goal can be reached more easily by the resulting improved data handling system. MSFC should affirm a clear-cut commitment to employ the central Repository concept and all engineering data should be stored in the Repository.

4.4 Recommendations

1. Program Management must continue its current efforts to establish the central Repository concept as the MSFC data flow policy. Reliance upon contractor distribution of data to other than his own internal users should be held to a minimum and should be closely monitored by Program Management.

2. An internal statement of policy should be developed by a coalition committee of Research and Development Operations and Industrial Operations assisted by Data Management Administration to affirm an MSFC commitment to store, index, retrieve, and distribute all engineering data, Class I and Class II, from the Repository.

SECTION V
DATA STORAGE, RETRIEVAL, AND INDEXING

5.1 Introduction

In order to supply the various users of data it is necessary to reproduce the documents received by the requester. At present, data is received by the Repository in many different forms, including: vellum, bond, Chronoflex, 35mm roll film, and aperture card microfilm. Users usually request copies to be supplied in either hard copy or microfilm. In view of this requirement, not only to produce copies but also to change media, a proficient staff and much equipment are necessary.

The Data Reproduction operation is essentially as shown in Figure 5-1. Until very recently the processing of silver diazo microfilm was accomplished in Chicago. RCA Management has now established a processing capability at MSFC and has also streamlined the logging and indexing of drawings to reduce the time differential from receipt to availability.

In Figure 5-1 three separate and distinct modes of reproduction are employed, namely: offset reproduction, diazo reproduction, and microfilming. In addition to these three methods, some reports and specifications are reproduced on the Xerox 914; thus, there are really four reproduction techniques employed. Each of the four methods requires specialized equipment, supplies, and some operator training.

The present system for storage and file retrieval is the 35mm aperture card system. Aperture cards have been in use throughout government and industry for several years and have proven their usefullness.

The system employs a tabulating card with an aperture punched in the right hand side of the card. A frame of 35mm microfilm is positioned within this aperture.

This system is one of those suited for engineering drawing applications. One microfilm aperture card can contain any size document up to one "E" size drawing (34" x 48") filmed at a reduction ratio of 30:1 on a 35mm frame. Larger drawings are filmed in sections of 48-inch lengths with a four-inch overlap.

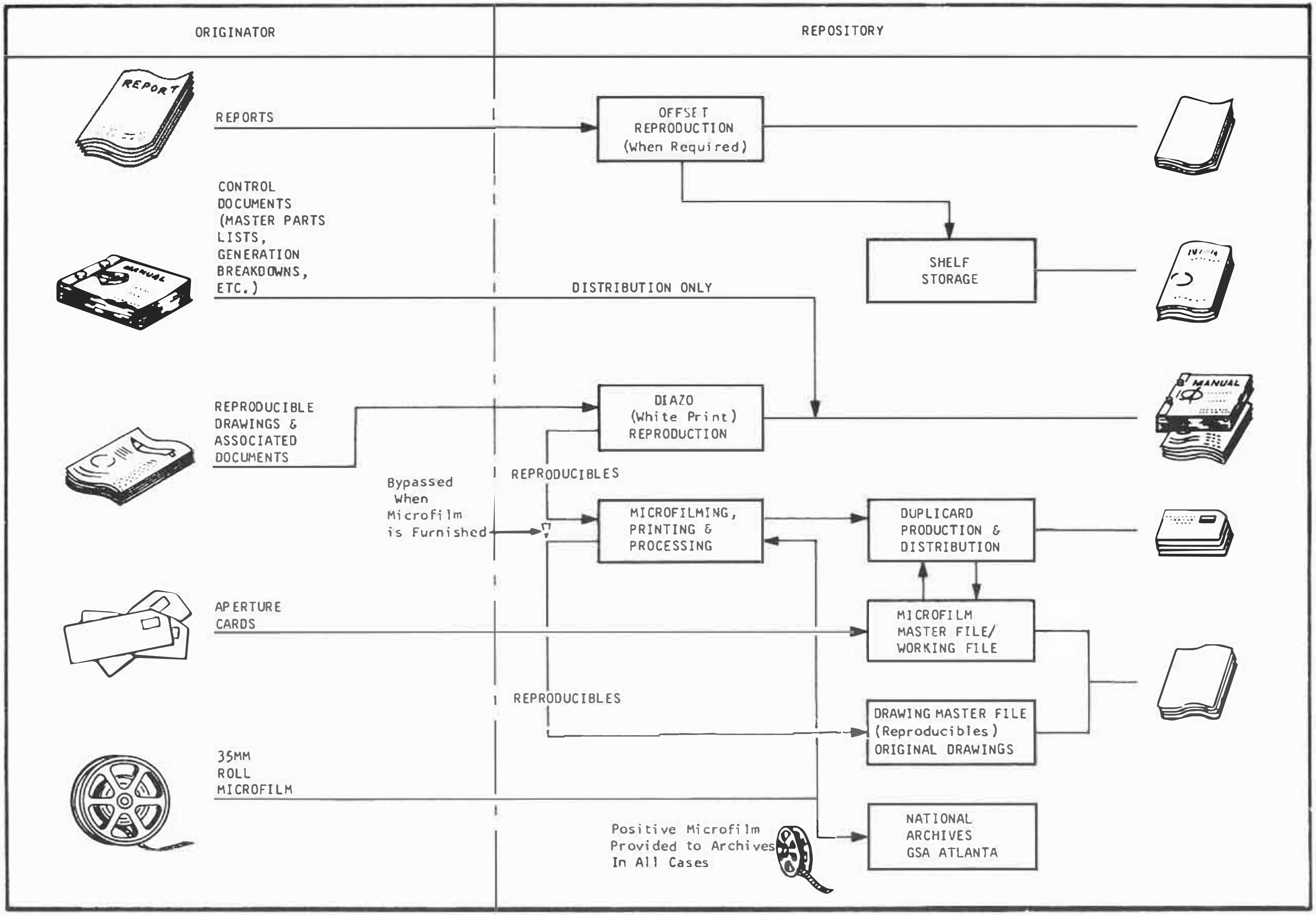


FIGURE 5-1. DATA REPRODUCTION

Card punching adds to the versatility of an aperture card system. The aperture card can contain the punching for automatic machine processing of the card. The automatic machine processing enables the system to sort the cards periodically into sequence, to merge or collate large quantities of cards into a master deck and to reproduce additional decks of cards.

In retrieving from the file, a request for a drawing or list of drawings is given to a file clerk who goes to the appropriate file and retrieves the drawing in aperture card form. Since it is the objective of the aperture card file to keep the file in an active status, the file cards are reproduced (duplicate card or hard copy) and the reproductions are given to the requestor. At present the reproductions can be a hard copy (18" x 24") or a duplicate aperture card. In more sophisticated systems the card image could be transmitted to a remote location.

In most instances when a user requests a drawing from a file, it is not for the purpose of making a physical change to the original drawing(s). Therefore, many aperture card repositories reduce the needless production of paper by producing the reproductions on diazo duplicards. The diazo duplicard is then inserted in a microfilm card reader by the requester where the image is presented on a screen and the necessary information is extracted. After the card is used, it is discarded, since the cost of producing the card is much less than the refiling cost.

Every library and repository of documents is but a memory storage unit which must have an access route in order to be useful as a source of reference. At present there is no effective access route to documents in the Repository.

The access route used in a library is the catalog card system (with its titles and abstracts). The most effective access route to a drawing file is through an assembly breakdown of the hardware delineated by the drawings in the file.

The ultimate objective would be an index that shows:

1. A pictorial overview of the system at top levels.

2. A list of applicable data at lower assembly levels.

Such an index can be prepared as a product of combined responsibility of present MSFC Configuration Management efforts and Repository Records.

An ultimate development in the document indexing field would be a digital/analog computerized display on which a total system could be viewed. The use of an electron light pencil or other real time X-Y coordinate translation device would be used to focus on a particular assembly or detail in which the user was interested. Our investigation has found that such a system is technically feasible.

The Repository has prepared a magnetic tape that lists, in drawing number sequence, all drawings in the file. The Reports and Specifications section of the Repository maintains a library card index of the file contents in order to respond to inquiries, but no published index is available to users.

Documents such as configuration manuals and illustrated parts handbooks and parts lists now provide makeshift indexes to the Repository.

5.2 Discussion

To determine the most feasible and efficient manner of storing, retrieving and reproducing data, it is necessary to consider all possible systems of storage, retrieval and reproduction known to exist. The Study Team consulted the representatives of all identified manufacturers of reproduction equipment, studied each of the approximately thirty-five systems now in use for the storage and retrieval of data, and reviewed the information available on all known systems now in the R& D phase.

The Repository now files reports, specifications, and standards in hard copy form and produces copies by Xeroxing, if the quantity is 1 to 15 copies, or producing a Multilith master by means of the Xerox 914, and running hard copies on the Multilith offset press.

Engineering drawings are received from the MSFC Laboratories in full-sized hard copy, microfilmed, and stored on aperture cards. Drawings from contractors are received in 35mm roll film or aperture cards. The roll film must be indexed and mounted in aperture cards before filing while the aperture cards are indexed and filed as received.

The advantages of storing large quantities of documents in microfilm form are that they require less storage space and that they facilitate handling. Storage facilities required for those types of data indicate that microfilming has been desirable for some time, and an experimental effort to use microfiche was considered more than a year ago. Most of the equipment required to produce microfiche has been procured. The MSFC Library Section is now equipped to produce microfiche, and there are microfiche readers in each of its satellite facilities.

The Study Team sought a single reproduction technique that would satisfy the identified requirements of MSFC. No single method was found that would satisfy all requirements, but some of the systems now in R&DO indicate that such a system may be available within the next two or three years.

In the interim, economy justifies that we encourage all drawing users to accept aperture card microfilm reproductions.

If the requirements for full-sized prints can be negated, some 2500 to 3000 square feet of floor space can be reclaimed in Building 4494. All the blueprint reproduction, folding, and handling equipment could then be disposed of.

While total use of microfilm files and readers is not a practical suggestion, it is apparent that, disregarding the cost of hard copy printing equipment, the ideal situation is to have hard copy producing equipment immediately adjacent to the user at his microfilm reader. All data would be processed in microfilm form until the user makes a discrete decision at the viewer that he needs hard copy.

The economies of printing hard copy do not now justify use of reader/printers for all hard copy requirements at this time, but the current trend in this direction justifies continued attention to reproduction techniques that will ultimately supply this service.

As in the case of data reproduction, the Study Team did not accomplish its objective of identifying an ideal system for data storage and retrieval. An ideal system would possess the following characteristics:

1. An index that is readily available to the user which identifies the identifying number of the documents desired with a minimum of scanning through superflous information.

2. A means of locating and extracting the desired document from the file.

3. A means of minimizing the time a document remains out of the file.

4. A means for purging of the file for maintenance of accuracy and currentness.

5.3 Analysis of Specific Possible Systems

5.3.1 General Summary

There are a number of existing methods for storing documents which are evaluated. A full outline is not presented on those systems not considered to have application to the MSFC Repository.

Since the Study Team was directed to consider specifically the APIC Program, DARE (Magnavue), and similar systems and make recommendations concerning their relationship to the Repository, these systems are given special attention. These systems are grouped under the heading Miscellaneous Systems and precede the alphabetically arranged discussions of storage and retrieval and document transmission equipments.

5.3.2 Miscellaneous Systems

5.3.2.1 APIC Program

APIC utilizes the Ampex Videofile equipment for retrieval of information on Qualified Apollo Parts. The APIC system was developed from the PRINCE System in July, 1965, and is basically an information service on Apollo parts and materials. Test data is abstracted from information submitted by the various Apollo Program participants, entered into the APIC index of information, and stored by the Repository. The index of APIC information is put on magnetic tape for an updated computer printout. The Ampex Videofile is to store an index of the location of the APIC data (shelf or file drawer reference indicator, tape number, and tape location indicator) and a brief summary of the test data. The internal storage capacity of the system is 750,000 images (three reels of video tape). Only one of the three proposed video files has been delivered to date; the other two were to be located in the Repository and in the Astrionics Laboratory. The Computations Laboratory is to handle the reproduction and search of the tape data.

During the period of January through March, 1966, approximately 100 inquiries per month were received by APIC. In February, 83 inquiries were not answered because of lack of data in the system. Less than 10 per cent of the total applicable data has been identified in the Apollo Program and approximately 5 per cent of the total data has been entered into the APIC system.

In view of the very limited usage and even more limited capabilities of the APIC system to supply timely data, the Study Team recommends that NASA support the Interagency Data Exchange Program (IDEP) more fully instead of sponsoring a very nearly parallel effort such as APIC. The present Ampex Videofile might be used in the Repository for central storage and video transmission of indexes. This concept appears to be entirely sound, but the hardware has not been perfected to implement an economical system to transmit images larger than $8\frac{1}{2}$" x 14" with the desired resolution. Limitations in on-line storage capacity comprise another problem area in the video tape storage systems.

5.3.2.2 DARE System

The DARE System is an automated document storage and retrieval concept using 35mm microfilm chips. This concept has been developed in the two custom-built systems. One of these systems was designed to store some 900,000 images (300 magazines with 3000 chips per magazine); the other is designed to store twice that many images.

The Magnavue systems were built for retrieval of parts data only and have not been in operation long enough to supply reliable evaluation criteria. Some observations are made, however, concerning applicability of the concept to the MSFC documentation retrieval problem:

1. Magnavue requires that the storage media be changed to film chips. Inputting aperture cards to the system would require approximately two years or an undetermined amount of money to procure the conversion of over two million aperture cards to film chips.

2. Retrieval time for the 900,000-image system is 20 to 40 seconds. A system that would store four or five million images, such as we anticipate at MSFC, would probably be 10 to 20 seconds slower. Aperture cards can be pulled manually in approximately 40 seconds; thus all that the expensive systems would achieve would be that all documents would remain in the file at all times, as opposed to having documents pulled manually and being out of the file 4 to 8 hours. Duplicate cards could be stored to avoid even this disadvantage in the aperture card system.

3. The mechanism used by the Magnavue concept to extract cards from the storage drawers scratches the film chips and limits the useful life of the film chips in an active file.

5.3.2.3 16mm and 35mm Roll Film

In the early days of microfilm, the rolls were the only available compact medium for storing documents. In the past eight years significant improvements in the microfilm industry have antiquated the use of roll film as a means of document storage and retrieval. Such media of storage as microfiche, aperture cards, cartridges, and acetate jackets have far surpassed the practicality of using roll film. At present there is not an easy method of updating revised drawings other than to remove the frame from the roll physically and splice in the new revision. Splicing has not proven to be durable enough to withstand the retrieval demands placed on the MSFC Repository regardless of the claims made by the manufacturers of film splicing equipment.

Until such time as a suitable and practical storage and retrieval system employing roll microfilm (excluding cartridge systems) is introduced, it is recommended that roll film be limited to catastrophe file applications.

5.3.2.4 16mm and 35mm Acetate Jackets

The acetate jacket, although less costly and having the same packing capacity as microfiche, does not have the reproduction capability that is inherent with microfiche. To duplicate an acetate jacket, the original camera negative must be duplicated to a positive to be used as an intermediate master and then subsequent negative copies are produced. The camera negative and the subsequent reproduced negatives are then inserted into the acetate jackets.

If sporadic distribution is required, as in the MSFC Repository, then a considerable amount of film would be wasted. An example of the waste involved is the following typical situation. If one roll of film contained twenty reports and five of the reports required one distribution copy; five other reports required three distribution copies; and the remaining ten reports required five distribution copies, the total number of film rolls to be reproduced would be five. In this example, five reports on four of the film rolls and five reports on two of the film rolls would be thrown away.

Resolution of hard copy reproductions is impaired because the image to be reproduced must be projected through the transparent acetate material which has a diffuse transmission density factor.

The use of acetate jackets as a storage medium in the MSFC Repository is not recommended because of the limited capabilities as stated above.

5.3.2.5 Microfiche

The microfiche specifications have become standards through the efforts of the Committee on Scientific and Technical Information (COSATI). These standards have afforded both the government and industry considerable efficiency and economy in processing all reports in one uniform method, standardization of interfiling, and uniform compatability of viewing and printing equipment.

There are two methods of producing Microfiche, step-and-repeat and strip-up. Both methods produce the same end product. Each method has about the same number of advantages and disadvantages, therefore the two methods are discussed in brief comparison.

The equipment required for the step-and-repeat method includes the following:

1. A step-and-repeat planetary camera capable of producing 105mm x 148mm microfiche on 100 foot rolls. The camera must be capable of making 18:1 and 20:1 reductions, maintaining a constant resolution of 127 line/mm, producing a background density of 0.9 to 1.2, and meeting all COSATI, ASA, and NBS qualifications.

2. A film processor for 105mm film capable of meeting the COSATI, ASA, and NBS specifications.

3. A film cutter.

4. A typewriter or varityper.

The equipment required for the strip-up method includes the following:

1. A 16mm rotary camera or planetary camera with a conversion unit. The camera must be capable of producing 105mm x 148mm microfiche on 100 foot rolls. The camera must also be capable of making 18:1 and 20:1 reductions, maintaining a constant resolution of 127 lines/mm, producing a background density of 0.9 to 1.2, and meeting all COSATI, ASA, and NBS specifications.

2. A film processor for 16mm film capable of meeting the COSATI, ASA, and NBS specifications.

3. An adhesive applicator for applying adhesive to the horizontal edges of the roll film.

4. A film strip positioner and adhesive remover for locating the strips of film on the acetate sheets.

5. A microfiche duplicator for producing an intermediate diazo master.

The microfiche system, regardless of which method is used to convert the document to the microfiche format, requires only a file cabinet designed for storing the cards. A cross reference index is normally required to facilitate the various formats in which requests are received. To automate the file, a special punch code is located along the bottom edge of the microfiche. This punch code is not in the form of the holarith punch used in EAM cards but rather a notch (maximum of 7 notches per card). The microfiche card is then placed into a special automated file which automatically retrieves the requested card when a requester keys into a console the index number of the microfiche card.

Microfiche programs have been established in many government agencies and industrial corporations throughout the United States. This microform has saved these organizations countless dollars in the storage, retrieval, and dissemination of technical publications, specifications, and standards. Microfiche, standardized by COSATI and the National Microfilm Association, insures continuity and compatibility throughout the world and allows interchange of all technical type information in an economical and feasible manner.

Advantages to be gained by implementing a microfiche program are reduced retrieval and filing time, possibility of automating the microfiche cards, more productivity from existing personnel, and reduced distribution copy costs.

A microfiche program could be effected on a partial basis which would allow proper and current orientation of personnel. Approaching the conversion project on a trial basis will also allow correction of deficiencies in the system before the total project is completed.

". 3. 2. 6 CARTRIDGE, 16MM MICROFILM

There are three concepts of the cartridge system presented under this section. This section restricts itself to those cartridge systems that are not oriented toward automatic retrieval, but rather the type that requires manual retrieval techniques.

The three cartridge systems discussed are the Bell & Howell Autoload cartridge, Minnesota Mining and Manufacturing (3M) 400 C cartridge, and the Recordak Lodestar cartridge.

a. The Bell & Howell Autoload features a no-rewind cartridge (single unit feed and take-up) that can be placed on the Autoload Reader/Printer and scanned until the document (image) is located.

The system capabilities are as follows:

Input: Input to the system is one cartridge with a total capacity of 200 feet of film containing approximately 6,052 images at a 24:1 reduction ratio.

Output: Output to the system is a possible image in graphic form of one $8\frac{1}{2}$" x 11" hard copy each 25 seconds. Search for a new document can be started within 10 seconds after the print button is activated.

Updating: Updating is by hole punch through the previous revision document and addition of the new revision is a new cartridge or by addition of the new revision onto the same cartridge that contains the previous revision. The latter requires that space be allocated for addition of revised documents.

Reproduction Technique is by the silver print - stabilization process. Reproduction Form is a full-sized $8\frac{1}{2}$" x 11" hard copy.

b. The Minnesota Mining and Manufacturing (3M) 400 C Cartridge system does not require any special pre-indexing of a roll of microfilm. Index numbers or bar graphs are on the film roll. This means that any 16mm roll film regardless of when or how it was produced can be adapted to the 400 C Cartridge, a fact which is probably unique in this field.

The system capabilities are as follows:

Input: Input to the system is one cartridge with a total capacity of 100 feet of film containing approximately 3,025 images at a 24:1 reduction ratio.

Output: Output is a graphic image or one $8\frac{1}{2}$" x 11" hard copy in 6 seconds. Search for additional documents starts after the print is produced.

Updating: The system is updated by a hole punch through the previous revision document and addition of the new revision to a new cartridge or by addition of the new revision onto the same cartridge that contains the previous revision. The latter requires that space be allocated for addition of revised documents.

Reproduction Technique is by the electrochemical process; the dry print is delivered to user. Reproduction form is slightly less than full-sized $8\frac{1}{2}$" x 12" reproduction.

c. The Recordak Lodestar Cartridge system requires special indexing. The indexing is accomplished during the filming of the documents and includes three formats: (1) the Kodamatic (bar graph), (2) the image designator, and (3) the sequential document film number. All three index formats appear on the roll film and facilitate location and identification of the desired document.

The system capabilities are as follows:

Input: Input to the system is one cartridge with a total capacity of 100 feet of film containing approximately 3,026 images at a 24:1 reduction ratio.

Output: Output is in the form of a graphic image or one $8\frac{1}{2}$" x 11" hard copy each 20 seconds.

Updating: The system is updated by a hole punch through the previous revision document and addition of the new revisions to a new cartridge or to the same cartridge that contains the previous revision. The latter requires that space be allocated for addition of revised documents.

Reproduction Technique is by Silver monobath for $8\frac{1}{2}$" x 11" prints.

The total capacity of the cartridge systems is virtually unlimited. As the microfilm cartridge file quantity and use increase, additional reader/printers can be added.

The cartridge system offers an inexpensive means of implementing a document storage and retrieval system. These systems are ideally limited to those documents not subject to constant revision. Most documents in the Repository are of a dynamic nature, i.e., under constant revision. It is therefore recommended that the cartridge system not be implemented in the MSFC Repository.

5.3.3 Data Storage and Retrieval Equipment

In an attempt to keep the body of this report free from burdensome detail the Study Team prepared synopsis tables of the data systems of storage and retrieval equipment (Table 5-1). Findings of the recent United Aircraft study, the Redstone Arsenal study, and of the University of Pennsylvania study for the US Navy were reviewed to assure that a comprehensive, objective survey of the document storage and retrieval field had been made. Representatives of the leading manufacturers of this type of equipment were consulted, and numerous systems and equipments were examined.

The tables include first the storage and retrieval operative systems (Table 5-1), and second the transmission system (Table 5-2). Discussions of the two classes of equipment are arranged in alphabetical order without regard to the class. These discussions follow the tables and comprise the Study Team's analysis and comments.

TABLE 5-1. STORAGE AND RETRIEVAL SYSTEMS

System Name	Description	Manufacturer	Status	Cost	Storage Capacity	Evaluation
Administrative Terminal System	1440/2460 data processing station with Selectric typewriter, or 1052 terminal printer/keyboard for inputting data; computer memory of input record. Rate: 1100 lines per minute; left and/or right justification; provision for immediate changes and revisions. Input: rough draft pages; additional punched cards at 600 per minute. Output: typewriter, 14.8 characters per second; printer, 1100 lines per minute; tape deck (80% of maximum); disc or card punch	IBM	Off-the-shelf	INA*	8 million characters on line; 16,000 positions of core storage	The system is oriented toward composition rather than storage and retrieval. It may well have a partial or related application but is not recommended for any immediate application in this report.
Auto-Video File System	Closed circuit television network. Procedure: Retrieval by notched cards, index number to bring card to camera, image recording and transmission to monitor. Input: 35mm card, microfiche, tabulating card, etc. Output: video transmission to monitor	Mosler Safe Co.	INA	$10,000 approximately	5,000 cards	Storage is limited to some 5,000 images. Indexing is limited to some 10,000 address references for each segment. Image size is too limited for use with engineering drawings. For an expanded version refer to Selectriever. System is not recommended for Repository usage.
Command Retrieval Information System (CRIS)	Planetary/rotary cameras. Process: Scroll preparation unit, index assignment. Retrieval: master index, 20 seconds. Input: 16 and/or 35mm roll microfilm. Output: CRIS copy card or remote video transmission	Litton Industries	INA	INA	500,000 8½" x 11" pages on line/28,000 large size drawings	Current information on the system was not made available. The concept appears quite good with computer readout capability for engineering drawings, reports, and specifications.
Electron Beam Computer Output System	Electronic control system, electron beam recording station, multiple film duplicating unit. Process: production of graphic images on dry process film from digital source. Input: magnetic tape. Output: 16mm and/or 35mm graphic images	3M	Available late 1966	INA	INA	Information is insufficient for evaluation. The system might have application for publishing index type data and dissimination of similar type data over widely scattered areas.
Engineering Data System (EDS-0016)	Optical scanner, high speed output of data sheet and Miracode system; facsimile transmission of microfilm and hard copy. Process: reading by optical scanner; magnetic tape recording, cathode ray tube display for microfilming. Input: original source document. Output: Miracode Reader/Printer, remote image recorder	Department of Defense	INA	INA	INA	This is an advanced version of the DOD EDS-009 System. The principal improvement involves a transmission capability. A Miracode system for storage and retrieval of documents on 16mm cartridge is utilized.

*Information not available.

TABLE 5-1. STORAGE AND RETRIEVAL SYSTEMS (Cont'd)

System Name	Description	Manufacturer	Status	Cost	Storage Capacity	Evaluation
File Search System	35mm storage system: fixed reduction rate camera, unique indexing. Retrieval: optical binary code. Input: electronic typewriter card punch, binary code; any document up to 8½" x 14". Output: screen-projected image; hard copy reproduction; 1:1 film copy.	FMA, Inc.	Upon request	INA	32,000 per 1000' roll film	Document size capability is limited to 8½" x 14" and reduction ratio is too limited for Repository usage. This system has applicability to a scientific library rather than to Repository type operations.
Graphic Data Processing (Alpine)	Digital magnetic tape storage, graphic images by cathode ray tube and electronic pencil. Microfilm recording, on-line developing.	IBM	On-the-shelf	INA ($15,000 per month lease)	INA	The unit designed to accept aperture card input was found to be deficient and discontinued. Existing system is more suited to creation of drawings and modification of drawings than document storage and retrieval.
HOLORAM System	Laser Hologram camera, RACE card recording; index in digital random access memory. Retrieval: processor system, duplication. Input: hard copy or aperture cards; microfilm images. Output: hard copy or microfilm; possible future remote transmission.	RCA	INA (System status should be reviewed about December, 1966)	INA	840 images per RACE card	Inputting from microfilm to Holograms at the rate of 840 images per hour and unlimited storage capability make this system very attractive. Random access and speed of retrieval are plus factors for the system.
Magnavue System	Order/exposure unit, cutter developer. Process: contact printing on diazo film, transfer to binary code mask, exposure onto diazo rolls, developing, cutting into chips. Retrieval: instruction from buffer processor; magazine transport. Input: roll microfilm or aperture card. Output: punched and exposed Diazo Duplicard.	Magnavox	12 to 13 months	$800,000 to 1.2 mil.	90,000 images (Redstone System) 1,800,000 images (Fort Monmouth System)	Initial high cost, maintenance problems, and the necessity of converting storage media from duplicard to film chip render this system undesirable. Maximum storage capacity of an existing system using this concept is 1.8 million whereas the MSFC Repository already substantially exceeds this quantity. The short life of the film chips and the necessity to produce an aperture card for reproduction are also limiting factors.
Microstrip System	Microfilm strip system; duplication roll form. Input: 16mm microfilm. Output: 8½" x 11" hard copy, visual presentation.	Recordak	Commercially available (15 to 180 days)	$1969 (components only)	21 8½" x 11" images per 1' film strip (1,750,000 images)	Because of problems in resolution with 16mm film, this system is impractical for engineering drawing use. This system is somewhat easier to update than microfiche but its storage capacity is more limited. Otherwise, it is quite similar to and has the same advantages and disadvantages as microfiche.

TABLE 5-1. STORAGE AND RETRIEVAL SYSTEMS (Cont'd)

System Name	Description	Manufacturer	Status	Cost	Storage Capacity	Evaluation
Minicard System	Paper tape punched; reduction ratio 60:1; binary code recording; Minicard records . Input: original document and locater index. Output: duplicate Minicard records and/or hard copy reproductions.	Recordak	INA	INA	Unlimited, 90,000 Minicard records	This is a limited capability system. It is not suitable for engineering drawings and is too expensive for single purpose usage.
Miracode System	Microfilm documentation; punched card or manual slide switch transfer of index number. Input: 16mm microfilm by cartridge. Output: silver emulsion hard copy 8½" x 11" reproduction. Possible future contact printing.	Recordak	Commercially available (15 to 180 days)	$30,000	2000 pages per 100' roll	This is a sophisticated version of the 16mm cartridge concept. It is difficult to maintain for dynamic documents.
Mosler Rotriever Units	Reader/printer, card file input or extraction. Retrieval: keyboard control on each Rotriever. Input: aperture cards, microfiche, tabulating card, etc. Output: reproduction of master file copy, hard copy or duplicate diazo duplicards.	Mosler Safe Co.	INA	Approximately $18,680	5000 or 10,000 cards	The system has merit for small file applications. The reader/printer would function well for storage of classified information. Access time to document is exceptionally good and the price of the system is reasonable. Storage and indexing limitations would prevent general usage of such a system in the Repository.
Multiplex-Recording Photography System (MRP)	Aeroflex photographic technique; special viewer; contact printing. Input: MRP negative. Output: visual presentation or contact print.	Aeroflex Laboratories Inc.	INA	INA	INA	Available information is inadequate to evaluate this system properly.
1350 Photo Image Retrieval System (Cypress)	IBM 1351 cell file and control unit; 1352 file; 1355 photo image converter; printer/keyboard. Retrieval: 1351 and 1352 files. Input: 35mm silver halide film images mounted on punched aperture cards.	IBM	Prototype in existence since 1962	Approximately $400,000	72,000 images	This is a film chip storage system which requires a change of media from the existing aperture cards. Inputting, however, is considerably faster than that of Magnavue, and IBM is marketing a conversion service. The phototape system is too limited in capability for Repository application. This system does show promise, however.

TABLE 5-1. STORAGE AND RETRIEVAL SYSTEMS (Cont'd)

System Name	Description	Manufacturer	Status	Cost	Storage Capacity	Evaluation
Republic Microvue (Mark II & III) System	Portable storage and retrieval system, 4" x 4" film chips. Images in 99 x 99 grid pattern. Input: 16mm image reduced 260:1 stored on special micro chip card. Output: visual presentation on Microvue unit screen.	Fairchild-Hiller, Republic Aviation Division	Immediately available	Unit, $7000; special camera, $60,000; Fairchild-Hiller conversion service, $.20 per frame	99,800 images per unit	Storage capacity is very limited. A different media is required and system has not been perfected.
Selectriever System	Sophistication of Mosler Rotriever System. Cartridge storage rack, automatic retrieval; Mosler notch indexing method. Input: aperture cards or microfiche. Output: optional.	Mosler Safe Co.	INA	$30,000	200,000 images	Storage capacity of present concept is too limited. The system appears to be fundamentally sound.
Videofile System	Video television recorder; tape inclusive of index and identification address code for document segment retrieval. Input: original documents (to $8\frac{1}{2}$" x 11"), roll microfilm, aperture cards, microfiche, etc. Output: graphic presentation or hard print copy.	Ampex Corporation	Commercially available	$400,000 to $800,000	250,000 documents per 7200 feet	This video type system represents a breakthrough in the document storage and retrieval field. Storage capacity with a retrieval time of 45 seconds is very good. Document image size, $8\frac{1}{2}$" x 14", is not adequate for engineering drawings. The video tape capability is also too limited to store the volume of documents contained in the Repository.
Visual Search Microfilm File System (VSMF)	Cartridge packaged 16mm microfilm rolls. Retrieval by viewer or hard copy.	Recordak 3M	Off-the-shelf	Varies widely with system scope and size	Unlimited; number of images per cartridge varies with type of cartridge and type of film	Storage and retrieval are very efficient for documents that are revised at a rate of less than 20 per cent per year. Maximum image size is 11" x 17".
Walnut System	Process: original document filming, input control card punching, recording on magnetic tape. Reduction rate, 100:1. Input: roll of 35mm perforated microfilm, location index and input control card. Output: aperture card with photosensitive film.	IBM	One operation in use	INA	100 million images, 3 billion coded characters.	This system is designed to accommodate $8\frac{1}{2}$" x 11" documents. It has good storage and rapid retrieval capabilities. The system appears too sophisticated for use with the reports and specifications only and would probably be too costly, although accurate cost information has not been made available.

TABLE 5-2. TRANSMISSION SYSTEMS

System Name	Description	Manufacturer	Status	Cost	Storage Capacity	Evaluation
Microfacsimile System	Scanning transmitter. Process: duplication to diazo duplicard, scanning, recording. Input: aperture card. Output: dry silver or silver halide film mounted on aperture card.	3M	Delivery in 1967	INA	INA	This system might be used for remote transmission of data stored on aperture cards. The system does show promise in transmitting data by means of microwave but cost estimates appear exorbitant.
Microfilm Facsimile Communication System	Transmission system. Process: recording on varying bandwidths, 5" or 10" per minute.	Alden Electronic & Impulse Recording Equipment Co.	INA	$32,070	INA	This is a facsimile transmission system. The cost is less but the capability is more limited than the 3M Microfacsimile System.
REMSTAR System	Microfilm or document files; image transmission over coaxial cable to monitor for viewing. Input: 16mm microfilm or original document. Output: remote video viewing or hard copy at remote station.	Remington Rand	INA	INA	INA	This is a video transmission system. Costs for long distance video transmission are prohibitive; however, local transmission appears quite feasible.
VIDEX System	Video transmission system, any type data. Four components: camera unit, camera control, monitor control, monitor. Monitor activated by telephone call. Input: flat subjects. Output: graphic images, hard copy images by polaroid camera.	ITT Federal Laboratories	Immediately available	INA	INA	This is a video transmission system rather than a storage and retrieval system. Limitations in screen size on the monitor and in the camera recording paper size are realistically small. It is more applicable in the banking and insurance industries than in engineering documentation.

This page intentionally left blank

5.3.3.1 ADMINISTRATIVE TERMINAL SYSTEM

Functional Description

The Administrative Terminal system employs a 1440/1460 data processing station with a Selectric typewriter or a 1052 terminal printer/keyboard for inputting data to the system. This system records text in a computer memory. When revisions to the document are required, the original document is called from the computer memory and presented in typewritten form. The changes can be as small as deleting one word or as large as revising paragraphs and pages. The system permits corrections without affecting unchanged pages of the document. To add a paragraph to a twenty-five page document, the operator recalls the page and types the new paragraph into the system. By programming, the pages are pushed back, the new paragraph is recorded in the proper position, and all subsequent pages are automatically renumbered. The entire document can then be retrieved and printed (at a rate of 1100 lines per minute) as the final product. The printed format can be right and left justified.

Subsequent revisions to this document can be made at any time by repeating the above operation and reprinting the document for distribution. The primary advantage to this system is that retyping of pages is avoided.

The system further provides for tagging pages or documents with a special character denoting classified documents. This permits access only by authorized personnel. Output can be provided at any terminal regardless of whether it was input at the same or at other terminals.

Equipment Description

Equipment for the Administrative Terminal System includes:

1. IBM Selectric typewriter for inputting the source material into the computer storage with special required units.

2. IBM 1052 Model 2 Printer/Keyboard terminal which can be used in lieu of the typewriter with special required units.

3. IBM 1441-A6 to be used as the central processing station in the 1440 system with 16,000 positions of core storage, or IBM 1441-B6 as an alternate unit for the central processing station in the 1460 system. This system also has 16,000 positions of core storage.

Each of the two processing stations above requires the following special features: Bit Test, Console Attachement, Direct Seek, Disc Storage Control, Indexing and Store Address Register, Seek Overlap Adjuster, and Transmission Control Unit attachment. In addition to the above, all special features and units for the basic system are required.

Capabilities

Input: Data may be entered into the system either by electric typewriter or by punched card.

Output: Output from the system may be made on typewriter, high-speed printer, magnetic tape, or card punch. Typewriter output can be made at 14.8 characters per second, high speed printer at 1100 lines per minute, card punch at the rated speed of the 1402 card read/punch equipment, and tape output at 80 per cent of maximum rated speed on peripheral operations.

Updating: New, revised, and deleted text can be presented to the system by recalling the stored data, making the necessary corrections and entering the new data into the system.

The total capacity of the 1311 Disc Storage is 8 million characters on line with an access time of 250 miliseconds. The 1440/1460 data processing stations will store 16,000 positions of core storage.

Comments

The Administrative Terminal System is applicable to proposal, specification, and report writing. It is not recommended that this system be implemented in the Repository.

5.3.3.2 AUTO-VIDEO FILE SYSTEM

Functional Description

The Auto-Video File System, an automated document storage and retrieval system for aperture cards, is coupled with a closed circuit television network. Special notches along the bottom edge of the aperture card (microfilm) are the key to the retrieval of the card. The index number of the document is keyed into the retrieval unit. The equipment automatically searches for that index number, and the card is brought to the viewing area. The television camera records the image and transmits it to the television monitor.

The system is equipped with an optional 250:1 magnification for close viewing of specific parts of a drawing. Remote television transmission is possible up to several miles. This remote capability allows keyboards to be located at the monitor stations, eliminating the necessity for requesters to travel to the file for data. Any existent aperture or microfiche card can be adapted to this system.

The notches are produced on the card by a special punching device, which allows up to 4 numeric digits. Although the indexing is somewhat limited physically, it can be expanded in several ways. For instance, all drawings associated with a specific project could be located in one segment of a file, thereby allowing up to 10,000 possible index numbers for each segment.

Equipment Description

Equipment for the Auto-Video System includes:

1. Card Notcher, special equipment manufactured by Mosler for notching the bottom edge of a card.

2. Rotriever unit with closed circuit television camera.

Capabilities

Input: Input to the Rotriever system may be a 35mm aperture card, microfiche, tabulating card, etc. Regardless of previous indexing the input cards can be easily adapted for use in the Rotriever unit.

Output: Output of this Rotriever system is a video transmission of the microform image to a television monitor. The television components operate on a bandwidth of 12 MCS to 20 MCS with a line scan of 525, 675, or 875.

Updating: Updating the files in the Rotriever unit requires that the operator key into the keyboard those document numbers to be removed. The Rotriever automatically retrieves the documents from the file. New cards are fed into the unit and automatically positioned in the file.

The total capacity of this specific file is 5000 cards. Part time personnel can be assigned for daily maintenance. Approximately 12 square feet of working area are required. System cost is approximately $10,000 including the Rotriever unit with the camera and a monitor with about 15 feet of cable.

Comments

This specific system does not have applicability in the engineering drawing section of the Repository. However, it certainly could have potential use in the reports and specifications section, if the file were converted to microfiche. Most of the documents in this section are segmented by subject category. For example, the engine manuals are filed by contractor, and the MSFC specifications in another section are filed numerically by specification number as are the military specifications.

5.3.3.3 COMMAND RETRIEVAL INFORMATION SYSTEM (CRIS)

Functional Description

The Command Retrieval Information System (CRIS) utilizes a 17" x 400' scroll as the storage medium (See Fig. 5-2). It is capable of storing approximately 500,000 8½" x 11" documents or 28,000 large drawings. Combinations of the two can also be adapted to the system. The scroll is segmented into frame formats of 1 1/4" x 1 3/4". Each frame format is capable of storing one large drawing or 9 subframes, each containing two 8½" x 11" documents.

Documents to be recorded in the system are microfilmed on standard planetary/rotary 16mm or 35mm cameras. The film is processed and inspected; then roll film is inserted into the scroll preparation unit where the images are transferred to the scroll format. An index or address is simultaneously assigned to each document. The scroll is then placed into the CRIS unit.

Retrieval of the document(s) from the CRIS unit is accomplished by selecting the correct address of the document from the master index. The address is keyed into the CRIS unit and the document is retrieved and projected in 20 seconds. A CRIS copy card is produced from the system. Hard copy may be produced on a conventional reader/printer.

The system can be augmented by a computer complex. The concept is to store the index in the computer rather than on paper and manually to retrieve the address. The index, once retrieved from the computer, is punched onto paper tape which automatically feeds into the CRIS unit. The retrieved image can be projected on the screen or transmitted to remote stations.

Equipment Description

The CRIS equipment includes the following:

1. 16mm and/or 35mm microfilm cameras for filming the source document.

2. Scroll Preparation Unit for transferring the 16mm and 35mm images to the scroll format.

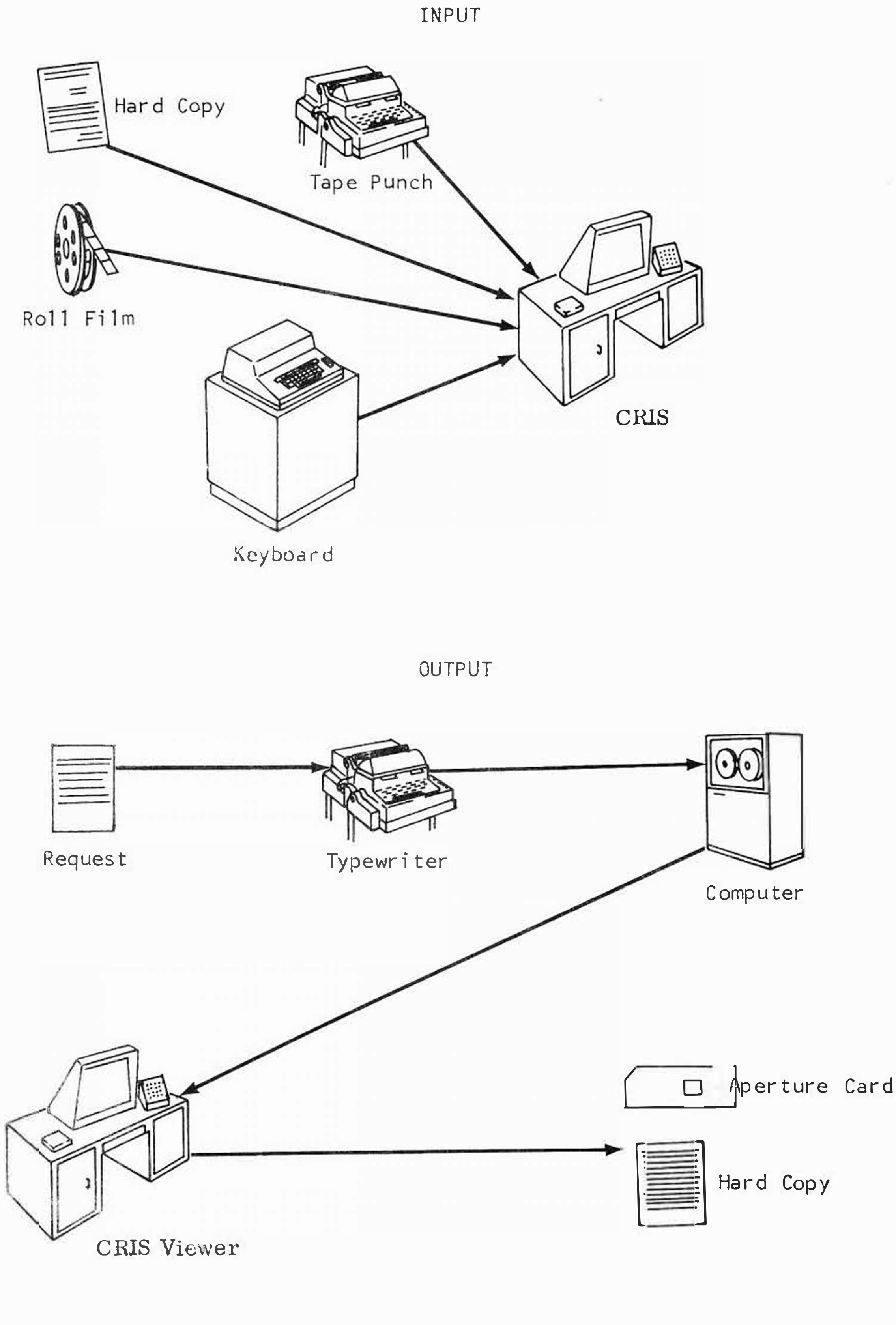


FIGURE 5-2. THE COMMAND RETRIEVAL INFORMATION SYSTEM (CRIS)

3. Film Processor for processing the exposed 16mm and 35mm roll film.

4. Inspection equipment for the 16mm and 35mm roll film.

The above services can be contracted to a local service company.

Capabilities

Input: The input to the system is 16mm and/or 35mm roll microfilm.

Output: The output is in the form of a CRIS copy card. This card is assumed to be similar to the Diazo Duplicard. Remote video transmission is also available with the system.

Reproduction technique: The Diazo Duplicard process of exposing the copy card film to ultraviolet light and developing by heat and ammonia fumes is employed. The total storing capacity of the system on line is approximately 500, 000 $8\frac{1}{2}$" x 11" pages or 28, 000 large sized drawings, or any combination of the two.

Comments

Current brochures were not available. The concept is sound; however, storage limitations are too low to accomodate the Repository needs.

This page intentionally left blank.

5.3.3.4 ELECTRON BEAM COMPUTER OUTPUT SYSTEM (EBCO)

Functional Description

The concept of the Electron Beam Computer Output System (EBCO) is to record the output from a computer onto microfilm. Basically the system produces graphic images on dry process silver film from a digital source at magnetic tape compatible data rates. The system depends on three major equipment elements which are an electronic control system, an electron beam recording station, and a multiple film duplicating unit. To record format the system recognizes special symbols which identify vertical and horizontal placement of the data. Available as modular options are unique symbol fonts, sizes, and vector generation. Background forms may be superimposed on or interspersed with the symbolic information. The system is compatible with most generally available electronic data processing systems in data format. Recording rates are equivalent to those of commercial magnetic tape systems.

Recording resolution of at least 100 lines per minute permits several thousand resolvable spots per frame. Image polarity is positive. Recording the frame rate is dependent on the information quantity per frame. A processed image is available in two to ten seconds, depending on the developing station utilized. Line and background density are compatible with good microfilm practice with conventional photographic processes.

Equipment Description

The EBCO System includes the following equipment:

1. Electronic control system, including the necessary logic for control of the independent magnetic tape drive or the main memory interface for input of the digital data to the recorder. Input digital data is converted to analog signals which are sent to the beam deflection circuitry of the recorder.

2. Electron beam recorder which records directly onto 16mm or 35mm film. A separate recorder is required for each film size.

3. Film duplicating unit for simultaneous production of multiple dry silver duplicate films in 16mm cartridges. This programmed system operates without manual film handling for either exposure or processing, and it provides cartridge loaded film copies ready for use on microfilm readers and reader/printers.

Capabilities

Input: The input for the system is taken directly from magnetic tape on the peripheral computer equipment.

Output: The output is in the form of 16mm and/or 35mm film.

Updating: When updating of roll is required the appropriate magnetic tape is run on the computer and the output of the tape is recorded on microfilm.

Reproduction technique: The dry silver film process is employed.

The total capacity of the system is limited by the speed of the associated computer equipment. This system is expected to be made available during the latter part of 1966. System cost is between $70,000 and $100,000.

Comments

Any recommendations made for this system at this time must be tentative since complete information is not available. Consider this system for an economical means of publishing the index to remote locations. It is recommended that this system be further evaluated when it is released for marketing by the manufacturer.

5.3.3.5 ENGINEERING DATA SYSTEM (EDS-0016)

Functional Description

The Engineering Data System (EDS-0016) is an improved version of the EDS-0009 document storage and retrieval system. Both of these systems are results of a project initiated by the Department of Defense for a unified and systematized method for the rapid handling of data needed by design and engineering functions.

The EDS-0016 incorporates an optical scanner input to computer, a high speed output, the Miracode system, and a facsimile transmitter for microfilm and hard copy. The Miracode and the facsimile transmitter replace the manual annotation fo data onto punched cards and the placing of data on film with a converter and microfilm camera used in the EDS-0009 system.

The source document is read by an optical scanner and subsequently recorded on magnetic tape. The data on the computer tape is displayed on a cathode ray tube for microfilming on a high speed camera. The hard copy print from the Miracode unit is reproduced using the silver monobath technique. The system is an assemblage of available equipments from various manufacturers.

Equipment Description

The EDS-0016 System requires the following equipment:

1. Optical scanner for automatically processing source data input to magnetic tape.

2. Cathode ray tube microfilm output equipment for producing roll microfilm.

3. Miracode film storage unit, reader/printer, and logic circuit keyboard.

4. Scanner and recorder for remote transmission.

Output: All output of the system is received from the Miracode Reader/Printer. The hard copy print can be placed on the scanner and a facsimile transmission produced on a remote image recorder.

Updating: Revisions and additions to document(s) within a specific cartridge are made by correcting the magnetic tape and then recording the new contents and producing a new roll of film. The old roll of film is removed from the system and discarded.

Comments

The EDS-0016 system supports design engineering efforts in minimizing the redesign of parts. The concept has merit but this system has the same constraints as to size of image and updating that the other cartridge type systems have and should not be considered for Repository usage.

5.3.3.6 FILE SEARCH SYSTEM

Functional Description

The File Search System (See Fig. 5-3) utilizes 35mm film for the storing of documents and optically scanned binary code for the retrieval of the documents. Each 35mm frame accomodates up to 56 alpha-numeric, binary code characters. The camera unit, which is peripheral to the system, photographs documents up to $8\frac{1}{2}$" x 14". The camera has a fixed reduction ratio with variable exposure, and up to 200 feet of film can be loaded in the camera head. The system uses a unique indexing scheme in that the coded message can be of varying length and format.

The index numbers and descriptors are produced on an electric typewriter/card punch. The index information is written in binary code on a special index card. After each indexing, the document is ready to be filmed. A document is placed on the copyboard of the camera and the corresponding index card is placed in a special slot in the camera. The document and index card are simultaneously recorded on the film. At the completion of a roll of film (6400 pages maximum) the film is removed from the camera head. The filming process requires approximately 5 seconds per document frame. Each roll of film is then processed and inspected.

For retrieval of documents from the system, an inquiry card containing search criteria is prepared on the typewriter/card punch. The appropriate roll of film is manually removed from the file cabinet and loaded in the retrieval unit logic. Search is at the rate of 6400 frame (200 feet) per minute. The retrieved document(s) image is presented on a screen. A hard copy print (2/3 original document size) or a film copy of the image can be made. Film copying is at the rate of 0.4 seconds per frame.

A special feature of this system is the comparison circuitry, which permits logical AND, OR, and NOT information searches.

During the search the film is carried through the scanning station on an air cushion. When the end of the film is reached, the roll is automatically rewound at a speed of 500 feet per minute. The retrieval unit will read negative or positive film.

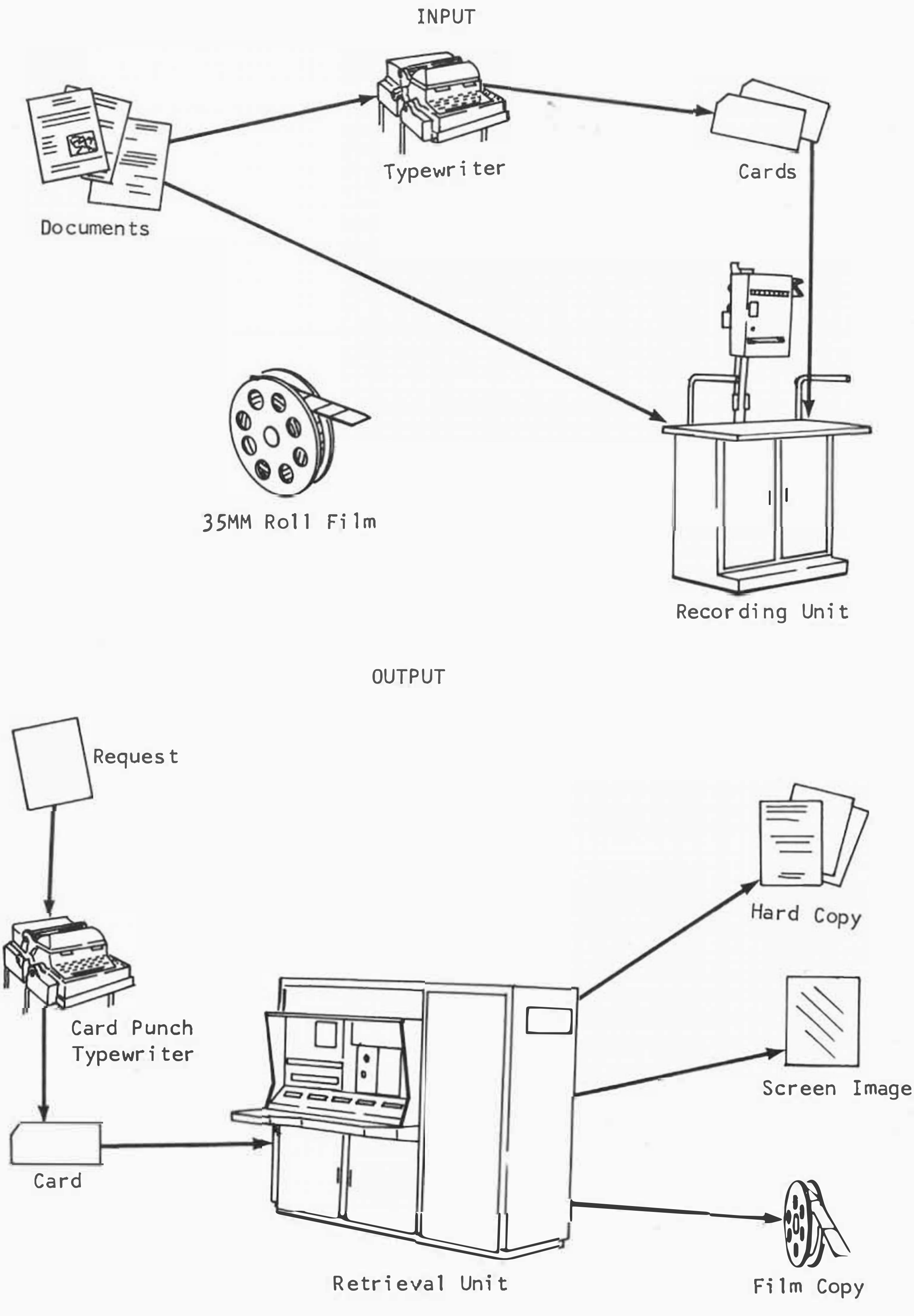


FIGURE 5-3. THE FILE SEARCH STORAGE AND RETRIEVAL SYSTEM

Equipment Description

The File Search System requires the following equipment:

1. Electric typewriter/card punch for producing index cards.

2. File Search automatic 35mm planetary camera for recording the document and converting the digital index card to binary code on the film.

3. File Search Processor for the exposed rolls of film.

4. File Search Retrieval Unit for reading and retrieving the documents from the 35mm roll of film.

Capabilities

Input: The input to the File Search System is any document size up to $8\frac{1}{2}$" x 14" and an index card containing up to 56 characters of alpha-numeric information.

Output: The system allows screen viewing of documents at approximately 2/3 of the original document size, a hard copy reproduction at the same size, and/or a 1:1 (35mm) film copy.

Updating: Additions and revisions to the file can be recorded on separate rolls of film and inserted into the main file. If desired, the retrieval unit can be used to merge revisions onto a new role of film with the documents they superseded.

The total document capacity of the system is unlimited, since all the rolls of film are stored outside the Retrieval Unit.

Although manpower requirement information was not given, three to four clerks could maintain the system. This would be in addition to the personnel required for indexing of documents prior to filming. Approximately 33 square feet of space are required for the camera and the retrieval unit. Cost is $175,000 for the total system.

Comments

This system closely resembles the concept of the Miracode System. However, the File Search system does possess some additional capabilities. The film copying device which permits reorganization of the existing files is a definite advantage. With this device it is possible to incorporate revisions without splicing film.

The limitations of this system do not make it desirable for implementation in the MSFC Repository. The largest size document is $8\frac{1}{2}$" x 14" with the reproduction limited to 2/3 of the original document size. The speed of film reproduction is faster than the Miracode system; however, the retrieval time is approximately the same.

5.3.3.7 GRAPHIC DATA PROCESSING SYSTEM (ALPINE)

Functional Description

The Alpine System concept comprises storing documents in digital form and retrieving a graphic image. The mechanics of the system permit the creation of a drawing by the use of an electronic pen and a cathode ray tube (CRT). The CRT is divided into a grid pattern addressable points and provides more than one million addressable intersection points.

Once the drawing has been produced on the CRT the image is recorded on microfilm and is developed on line. When the microfilming of the image has been completed the image is erased from the tube and another drawing can be initiated by the engineer or draftsman.

The original concept of this system was designed to accept aperture cards as input. The image on the aperture card is stored in the computer, and any changes to the aperture card are made by retrieving the drawing from the computer and displaying the image on the CRT. After changes are made, a new piece of film is produced and the image is restored in the computer.

Comments

This system design is primarily applicable to preparation and revision of drawings. It is not economical or feasible as a document storage and retrieval system. The capability for accepting aperture cards as input to the system has been discontinued; therefore, the system is now expressly limited to preparation and revision of drawings. Without the capability to accept aperture card images as input, the system would have very little potential use in the Repository.

This page intentionally left blank.

5.3.3.8 HOLORAM SYSTEM

Functional Description

The Holoram System (See Fig. 5-4) is a unique concept employing holography with random access computer equipment. The system uses a specially designed Laser Hologram Camera which reduces either a hard copy drawing (up to "D" size in one frame) or a 35mm frame of film by a factor of 200 times. The resultant image is approximately $\frac{1}{2}$" square. The storage medium in the system is referred to as a random access computer equipment (RACE) mylar card capable of storing 840 images.

Documents or microfilm images to be recorded are presented to the Laser Hologram Camera. The document or microfilm images are recorded directly onto the RACE card. Simultaneous with the laser recording, the index information for magazine number, card number, and column row/number is recorded into the digital random access memory of the computer system. The RACE card is then stored in the system with each image on the card completely indexed.

To retrieve an image from the system, the requester submits his retrieval criteria to the processor system. The processor first reviews its index bank information, selects those records which meet the input criteria, extracts the addresses, and retrieves the required drawings and their duplicates.

The conversion of the documents or microfilm images is accomplished at a rate of two seconds for each hologram at a resolution of 2700 lines per millimeter. The commercially available high resolution film and the hologram technique permit loss of 85 percent of the image before replacement of the card is necessary.

The RACE mylar card measures $4\frac{1}{2}$" x 16" and stores up to 840 holograms. The Holoram system stores up to 2048 RACE cards or a total of 1.7 million images. Average access time for index search, locating, retrieving, and positioning the RACE card in the output station is approximately three seconds.

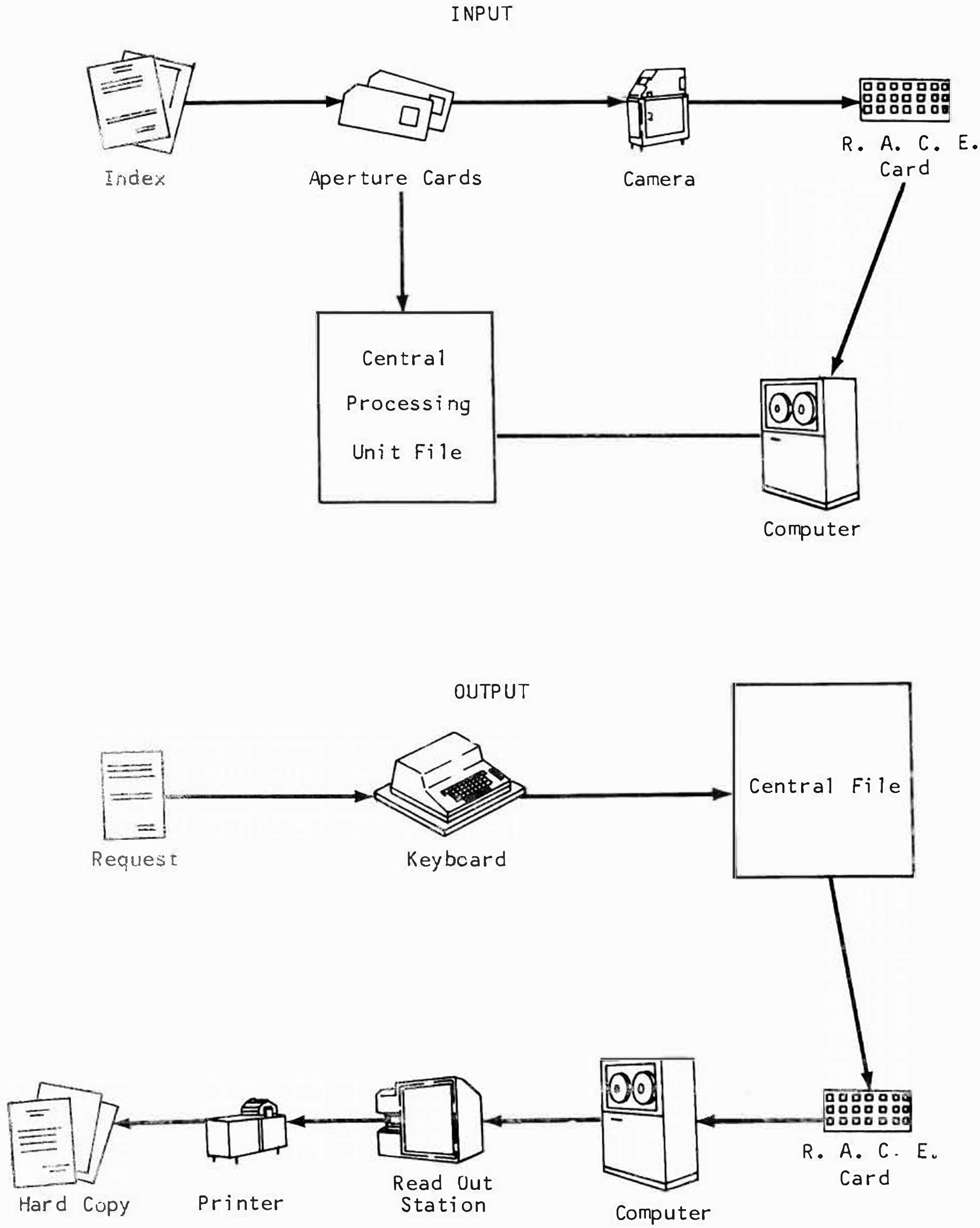


FIGURE 5-4. THE HOLORAM STORAGE AND RETRIEVAL SYSTEM

As stated previously, remote transmission will be available over several media. On a 9-MC coaxial cable remote printout can be completed in about 3 seconds. Slower facsimile transmissions can also be used which would require several minutes for each transmission.

Equipment Description

Equipment required for the System includes:

1. Laser Hologram Camera for recording the document/microfilm images onto the RACE card.

2. Card Reader Punch for recording punched information in digital form on RACE mylar card.

3. Computer controlled transport for storing the RACE cards.

4. Laser readout stations for transmitting the hologram image to the hard copy reproducer.

5. Hard copy reproducer for printing the hologram image onto hard copy and microfilm.

Capabilities

Input: Hard copy and/or aperture cards can be input to the Holoram System.

Output: The system has the present ability to reproduce either hard copy or microfilm. It is anticipated that remote transmission will also be available on the system, on closed circuit television.

Reproduction technique: Reproduction is through the use of laser beams.

The total capacity of the system for each RACE card transport unit is 1.7 million images. Since the system has not been completely developed, cost information is not available.

Comments

The Holoram system, though not completely developed and in production, appears to have tremendous potential. It is the most promising system found, being designed to accept large sized drawings in aperture cards and/or hard copy drawings. The Ampex Video-file will accept hard copy and microfilm as an input but maximum document size is only $8\frac{1}{2}$" x 14". Since the aperture card is the primary storage medium today in the MSFC Repository, the automatic system must be able to accept this as input.

The retrieval time for any one of 1.7 million images stored in the system is approximately 3 seconds, surpassing all available systems. The conversion of aperture cards or hard copy is completed at a rapid rate.

It is recommended that the Holoram system be placed on the list of systems to be reviewed periodically. If cost permits, modular retrieval units might well accomodate any forseeable volume of documents required by the Repository.

5.3.3.9 MAGNAVUE SYSTEM (DARE) (ADSARS)

Functional Description

The Magnavue System (See Fig. 5-5) is an automated document storage and retrieval system for 35mm microfilm images. The separate Magnavue systems were custom built for the Redstone Arsenal Procurement Branch and the US Army Electronic Command.

The system utilizes a 35mm x 3" long diazo film chip as the storage medium. The film chip, in addition to the image, can contain up to 80 alpha-numeric characters in photo optical binary code. The code is 80 columns per linear inch recorded in eight parallel channels with six bits per character, a parity, and a clock track. Documents are recorded on standard 35mm microfilm, processed, and inspected. A card is punched for each frame of film.

The system will accept either 35mm roll film or 35mm aperture cards. The input roll film or aperture card is contact printed onto a diazo film and at the same time the punched information is transferred to a binary code mask and contact printed onto the same 3" strip of diazo roll film in the coder/exposer unit. The diazo rolls are then developed and cut into chips in the cutter developer.

The film chips are inserted into the Magnavue retrieval system. The original film or aperture cards are returned to their master file and retained. Magnetic chips may be used in the system to augment the film chips. The magnetic chips can be used to describe a specific image further, or for cross indexing when required. The magnetic chips can store up to 1000 alpha-numeric characters in erasable form. With the addition of the magnetic chip capability the system becomes both a digital and document processor.

New film chips are inserted into an input magazine and loaded into the system. The entire file is normally processed once each day. During this processing all input, output, and purge requests for that given day are handled. The system will also facilitate priority requests during this daily processing.

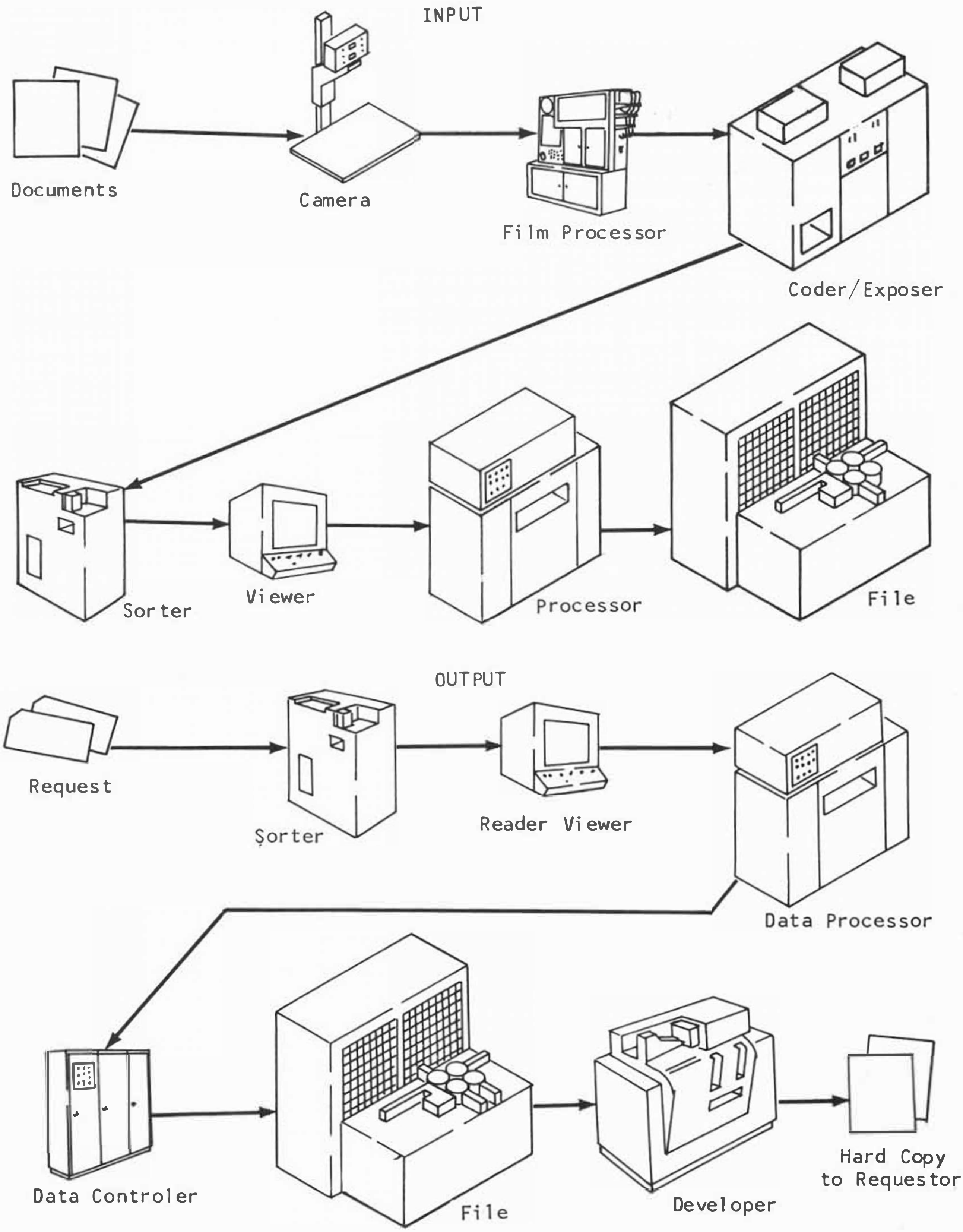


FIGURE 5-5. THE MAGNAVUE STORAGE AND RETRIEVAL SYSTEM

The requests for data from the system are first input on magnetic tape, punched card reader, paper tape reader, or typewriter. The part number or index number of the data is recorded on one of the above media and fed into a buffer processor which automatically reads into the retrieval unit. Output of the system for all requests is punched and interpreted by diazo duplicard. After card removal from the processor, each card must be developed.

The retrieval mechanisms operate on instructions from the buffer processor. The document number and location address are input to the system. This process activates the magazine transport which retrieves the correct magazine and inserts it into the chip transport unit. The chip transport unit is a series of four drums controlled by an electronic control unit that is on line with the buffer processor. Instructions in the form of a program in the buffer processor direct the selection of specific chips for copying, merging new input, purging obsolete data, or output to another on-line reproducing device.

Equipment Description

The Magnavue System includes the following equipment:

1. Coder/exposer, an off-line device for converting the input source to the 35mm film chips and converting punched data to binary code.

2. Cutter/developer, an off-line device for developing and cutting the roll diazo film from the coder/ exposer.

3. Chip transport, an on-line equipment item for transporting the film chips and a diazo copy station with a card punch.

4. Magazine access files, rack for storing 300 magazines.

5. Electronics unit, a device for chip, data, and diazo copy control.

Capabilities

Input: Input to the system is roll microfilm or aperture cards. The roll film requires recording on magnetic tape, paper tape, or similar means, the address, document number, and other identifying information in lieu of the punched data on aperture cards.

Output: Output of the system is a punched Diazo duplicard. The Diazo duplicard is interpreted and developed on off-line equipment.

Updating: The system has the capability to perform 9000 functions per 8-hour day. These functions are described as 5000 duplicard copies, 2000 new inputs and 2000 purges. If the quantity of copies and new inputs on any given day do not reach those stated, the purging capability increases. The purge information is stored in the buffer processor which automatically channels the purged film chips to an "out" magazine. The diazo film in the card is sensitive to ultraviolet light. The film is developed by a combination of ammonia fumes and heat (160°).

Since the Magnavue systems were manufactured to customers' specifications, a standard delivery cycle is not available. A Magnavue representative estimates that 12 to 18 months would be required to fabricate a system similar to either of the two now in use.

A minimum of four persons are required for the operation of this system. Approximately 1200 square feet are required, depending on the compliments of equipment involved.

The first Magnavue system installed at Redstone Arsenal was delivered at a cost of 1.2 million dollars. The second system was delivered to US Army Electronics Command for an approximate cost of $800,000. The latter system has twice the storing capacity of the first.

Comments

The Magnavue system application was evaluated for implementation in two areas, the central Repository file and the satellite files. Because of the dynamic quantity and requirements of the Repository file, this system is not adaptable in its present configuration. The high cost and the subsequent maintenance and conversion of present file to the Magnavue format discounted the system for implementation in the present files. The conversion of the present aperture cards to the film chips is accomplished at a published rate of 720 chips per hour. A file of 1 million aperture cards would take approximately 1400 hours or 200 days to convert to the film chips. The MSFC Repository file (Master File Deck A) now contains approximately 2.1 million aperture cards for a total conversion time of 2800 hours or 400 days. In addition to this the daily input must also be converted to the film chips.

Although the outputs of the present DARE system installed at Redstone Arsenal do not satisfy the needs of MSFC, the manufacturer states that output production can be increased with the addition of higher speed processing equipment. This increased speed would be helpful, but would not justify implementing such a system. The master aperture card file would have to be maintained to replace film chips in the Magnavue system that were destroyed or lost. The system would add additional initial cost for procurement and would require skilled personnel for operation. Replacement of the aperture card satellite file with this system is not recommended because of the significant increases in cost.

This page intentionally left blank.

5.3.3.10 MICROFACSIMILE SYSTEM

Functional Description

The Microfacsimile System is not a storage and retrieval unit, but a device for transmitting microfilm images to remote areas. The system utilizes an aperture card scanning device to transmit an image to remote areas. When an engineering drawing is needed in a remote location, the original silver aperture card is duplicated on a diazo duplicard. The diazo duplicard is then placed into the scanner equipment. Simultaneous with this operation the requester places a stack of aperture cards containing unexposed silver halide or dry silver film in the recorder equipment. The diazo duplicard in the scanner and the aperture card in the recorder are advanced and positioned simultaneously upon signal from the scanner equipment. The diazo duplicard is then scanned, transmitting signals to the recorder at the remote location. The complete transmission results in a processed aperture card exclusive of punched information.

There are several transmission media that can be used in this system. The transmission can be accomplished on TV grade microwave, coaxial cable, or Telpak C. Time requirements vary from several seconds on TV grade microwave or coaxial cable to several minutes on Telpak C.

Several operator controls on the equipment insure continuity of operation of both sender and recorder stations. A load switch activates the card loading device into scan position at both scanner and recorder. A select scan format switch provides for the correct card scan resolution at both scanner and recorder. A focus control which employs a special focus target for adjusting the beam focus is used once a day. The focusing is performed separately at both scanner and recorder.

Equipment Description

The Microfacsimile System includes the following equipment:

1. Aperture card scanner for generating signals to the recorder.

2. Wide band transmission link similar to TV grade microwave, cozxial cable, or Telpak C for transmitting the generated signals.

3. Aperture card recorder for receiving the generated signal and recording it onto a dry silver or silver halide aperture card.

Capabilities

Input: The input to the system is a diazo duplicard. A card stacker is included on the scanner, and the recorder holds approximately 500 cards.

Output: The output of the system is a silver halide aperture card. There is no indication that hard copy reproduction is available with the system.

The manufacturer has indicated that this equipment will not be marketed for about one year. Two personnel are required for the operation of this system, one at the scanner and one at the recorder. The scanner and recorder require approximately 18 square feet each. This space is only for the equipment and does not include the working area. The system cost is approximately $70,000, excluding the transmission line.

Comments

The system, although only in the prototype stages of development, shows a definite application for remote transmission of aperture cards in emergency situations. One possible application would be Mission Support. At present television transmission is one way between Kennedy Space Center and Marshall Space Flight Center. With the facsimile transmission capability emergency transmission of drawings could be accomplished during pre-launch. This would allow KSC to be supported with up-to-date information within a few minutes when critical prelaunch problems occur.

If this system were implemented for Mission Support, a specially designed flight satellite file would be required. Since this file has use only during launch operations, it would not be necessary to staff this file with full time employees. The file could be scheduled for updating approximately one week before countdown starts and continue into post-launch. This would provide on-hand and up-to-date data that can be transmitted when and if needed.

The cost of implementing this system is comparatively small. One requirement for using the system for each launch of a Saturn justifies its existence-if, each time it is used, the system could save several minutes of "hold" time.

It is unfortunate that the Microfacsimile System will not be available for approximately one year. It is recommended that this system be reviewed in the periodic evaluation of systems.

This page intentionally left blank.

5.3.3.11 MICROFILM FACSIMILE COMMUNICATIONS SYSTEM

Functional Description

The Alden Electronic & Impulse Recording Equipment Company manufactures this equipment as an addition to the Lodestar, Miracode, and standard 35mm aperture card system. The basic equipment includes a scanner and a recorder (hard copy). These components may be positioned adjacent to the master file or remotely located.

The recording of microfilm images from this equipment is accomplished over a wide selection of bandwidths from 3Kc to 48Kc at a 1459-line-per-inch scan density. Transmission rate over a 16Kc Telpak A-3 line is 5 inches per minute. A 32Kc Telpak A-2 line will transmit the image at 10 inches per minute.

The scanner and recorders are available in two sizes, an 11-inch and an 18-inch model. The 11-inch scanner and recorder is designed to interface with the Lodestar and Miracode equipment. The Alden equipment is attached as an added capability for remote reproductions.

The 18-inch model is used with an aperture card system where 18" x 24" hard copy prints are required. This scanner and recorder are independent of any other equipment.

System Cost

SIZE	MODEL	RPM	PURCHASE	LEASE W/MAINT.
11 inch	Scanner 9242	120/240	$7,020.	$359./month
11 inch	Recorder 9244	480/960	8,550.	392./month
18 inch	Scanner 9233B	120/240	8,000.	484./month
18 inch	Recorder 9234B	480/960	9,500.	510./month

Comments

This equipment is not a storage and retrieval system. The cost of this equipment is less than the cost of the Microfacsimile System; however, the capability is not comparable to that stipulated for the Microfacsimile System. Because of the superiority of the Microfacsimile System over the Alden facsimile, the latter is not recommended for the MSFC usage.

5.3.3.12 MICROSTRIP SYSTEM

Functional Description

The Microstrip system was designed for files that require extensive updating or revision. The system is applicable to small or large files, since it is modular in design. The maximum capacity for one work station module is 1,750,000 images; however, it is possible to increase this capacity by positioning additional work station modules with access files on both sides and in back of the operator. The media of storage for the Microstrip system is 16mm microfilm cut into 1' lengths and stored in a special plastic holder. At a reduction ratio of approximately 24:1, it is possible to store 21 $8\frac{1}{2}$" x 11" images on each 1' film strip. The system requires that documents common to a specific subject be filmed as a group. Special microfilm camera equipment is not necessary for this system. Once the documents have been reproduced on microfilm and the holders indexed, they are inserted into the Microstrip file. When a document request is received, the document locater number is located in the master index and the appropriate Microstrip holder is removed from the file and located on the reader/printer. As there are 21 images stored in a holder, the operator must manually select one of the 21 images to be presented on the screen. A hard copy reproduction is then made and sent to the requester.

Equipment Description

The Microstrip System includes the following equipment:

1. 16mm rotary camera without optional features such as sequential number device.

2. Film processor capable of processing film to NBS and ASA specifications.

3. Film strip inserter for positioning film in Microstrip holder.

4. Typewriter for tabulation of contents on master index and on film strip holder.

5. Keypunch (024-026) for preparing index on punched cards.

6. Microstrip index label kit containing multicolor precut labels for holder.

7. Specially adapted Microstrip reader/printer.

8. Microstrip access file (s) for containing plastic microstrip holders.

9. Microstrip reference station.

Capabilities

Input: The system uses 16mm strips of microfilm plastic holders as input.

Output: Output from the system is $8\frac{1}{2}$" x 11" hard copy of the visual presentation of the projected image.

Updating: Images can be purged from the strip of film by removing the revised image and splicing in the new image, or by refilming revised documents plus the other documents in the holder.

Reproduction technique: The system utilizes the silver emulsion monobath technique for the reproduction of microfilm images to hard copy prints.

Delivery of the Microstrip equipment is 15 to 180 days from placement of purchase order. This system does not lend itself to self service of the file. If self service were allowed, film strip holders would be removed from the storage containers and subsequently misfiled or not returned to the file. The space requirements for this system are predicted on the quantity of images stored in the file. Assuming a file quantity of 1, 750, 000 images, the system requires approximately 30 square feet.

System Cost

Microstrip Reader/Printer	$1,667.25
Microstrip Filler	142.50
Microstrip Access File	17.10
Microstrip Reference Station	142.50

Comments

The Microstrip System closely parallels the microfiche concept. Approximately 21 $8\frac{1}{2}$" x 11" documents can be recorded on one strip of film compared to 60 $8\frac{1}{2}$" x 11" documents on a 4" x 6" microfiche card. The microstrip system is somewhat easier to update or revise, since new frames added to the document file can be located in separate strips at the end of the Microstrip file. With microfiche, updating is accomplished by filming only the revised pages of the document, splicing the revised film onto the master microfiche card, and then reproducing distribution copies. The advantage of using microfiche is that once the microfiche card is inserted in the reader, 60 frames of film can be viewed individually on one card. A maximum of 21 frames can be viewed on the Microstrip. Distribution of duplicate microfiche can be accomplished on a card-to-card diazo printer, whereas the Microstrip must be duplicated in roll form and then each generation of film must be spliced and located in the Microstrip holder. When erratic distribution is required, substantial quantity of film would be wasted in the Microstrip system.

The Microstrip system does not possess the versatility of a Microfiche concept and therefore is not recommended for the MSFC Repository.

This page intentionally left blank

5.3.3.13 MINICARD SYSTEM

Functional Description

The Minicard system (See Fig. 5-6) is an automated document storage and retrieval system comprised of a special camera. The documents are automatically coded by frame from input on a punched paper tape. Engineering drawings, technical manuals, photographs, maps, etc., are typical of the input to a Minicard system. The system was developed for large files rather than small.

Documents to be recorded are assembled into groups and indexed by subject, document number, etc. This information is punched onto paper tape, which with the documents are sent to the camera. As each document is photographed at a reduction ratio of 60:1 on 16mm film, the corresponding data on the paper tape is recorded in binary code simultaneously at a rate of 600 frames per minute. The film is processed and then cut into the individual Minicard records. The Minicard records (16mm x 32mm) are stacked into receiving megazines where they slide onto a steel handling stick. The handling stick provides for convenient and safe transporting between equipments. A duplicate positive Minicard record (referred to as 2P) is produced on the computer duplicator.

The original Minicard record (1N) and the 2P are separately sorted at a rate of 1000 frames per minute and placed in their respective files. During the duplication of the 2P for the working file, distribution copies may be produced and dissiminated to the requesters. The 2P's are not interfiled in the main section of the working file, but are maintained in segments in a current working file.

The 1N is filed by the accession number of the document, or the date. New records added to the system are placed at the end of the file. Requests for data from the Minicard system are made by a standard request form. The pertinent information on the request form is extracted and punched onto paper tape. A specific control board is wired for each request for use in the Minicard sorter.

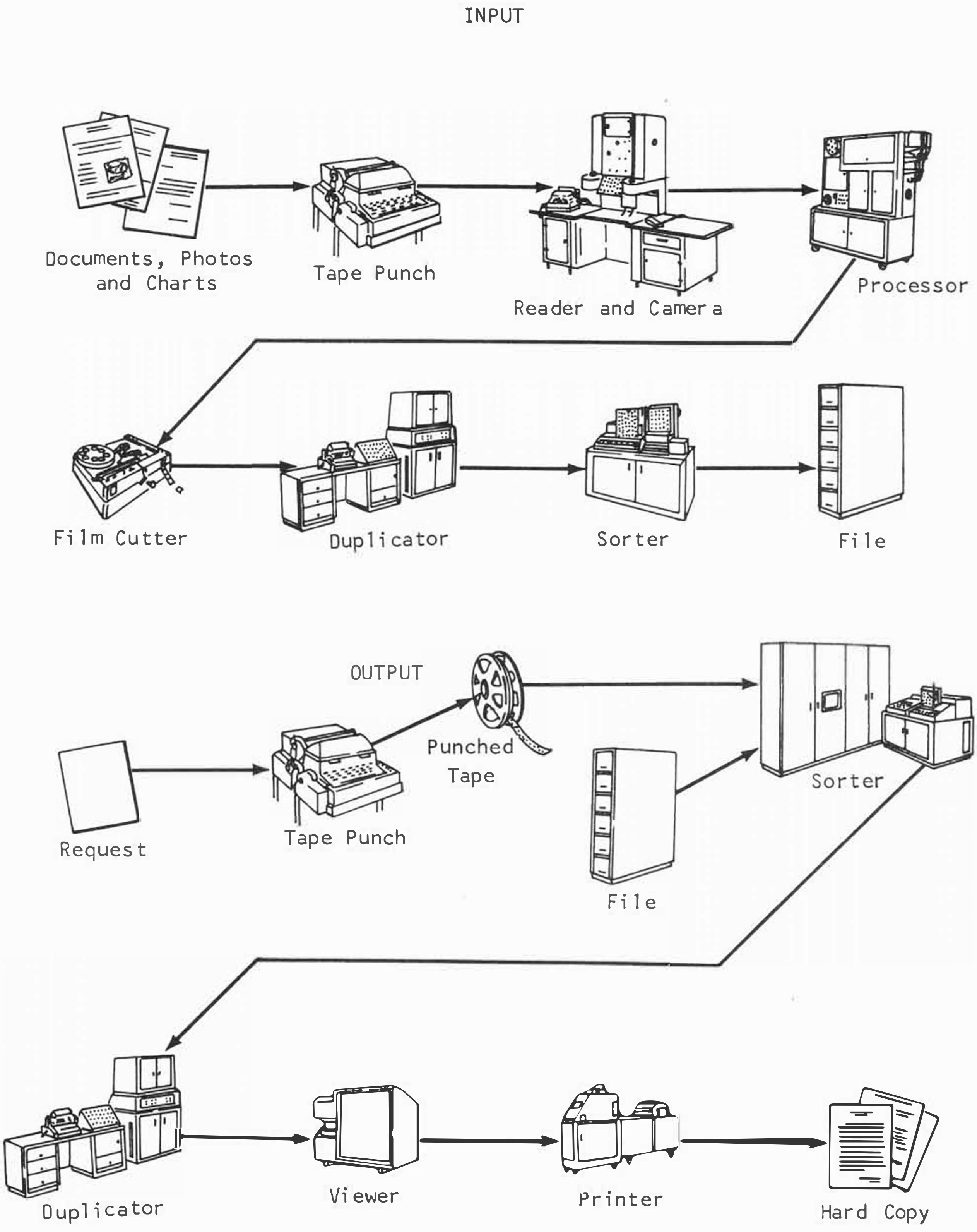


FIGURE 5-6. THE MINICARD STORAGE AND RETRIEVAL SYSTEM

The appropriate Minicard cell is manually removed from the file cabinet and inserted, with the paper tape, into the Minicard retrieval unit. The retrieval unit selects and prints the requested document onto a third generation Minicard film (3N). The film is processed and delivered to the requester. Hard copy prints may be made on a printer enlarger. The working file Minicard cell is removed from the retrieval unit and manually replaced in the file cabinet for future requests.

Equipment Description

The Minicard System includes the following equipment:

1. Minicard Camera Model CD3A for recording various document inputs, equipped with a paper tape reader.

2. Paper tape punch for recording index codes.

3. Film processor for processing the exposed Minicard film.

4. Minicard film cutter for cutting the roll Minicard film into the individual Minicard records.

5. Selector-Sorter for retrieving Minicards from the storage cells.

6. Reader for viewing the Minicard records.

7. Printer for producing hard copies of the Minicard record.

Capabilities

Input: Input to the system is the original document and a locater index on paper tape for each document.

Output: Reproduction from the system is in duplicate Minicard records and/or hard copy reproductions.

Updating: Maintenance of the Minicard system file is comparatively easy, since the new additions to the file are segmented rather than filed in sequence. When a cell of a file segment is not receiving heavy usage, that portion of the file may be placed in storage; thereby, a constant purging of the working file is performed.

The total capacity of the system is assumed to be unlimited. One specially designed file cabinet (about the size of a four-drawer legal size) will store 900,000 Minicard records. If each record contained the maximum of 12 images, 11 million pages and 44 million alpha numeric characters would be stored in one Minicard file.

Reproduction technique: Two forms of reproductions are possible:

1. Duplicate Minicard silver halide film, and

2. Hard copy reproduction - silver monobath technique.

The system is no longer manufactured, and information is not available concerning manpower and space requirements. System cost, however, is in excess of $500,000.

Comments

The film size and the physical constraints of the camera indicate that this system was not designed for filming large engineering drawings. This system might have had application if the actual Minicard records were self contained in the sorter/selector units and if large drawings could be accomodated. The cost of the system is prohibitive for use for the reports and specifications section exclusively.

This system is not recommended for implementation at the MSFC Repository. The United States Air Force Rome Air Development Center was instrumental in the development of Minicard and was the first to have this system installed in its facilities. The applications for this system at Rome are not known and therefore it can only be assumed that they were tremendously large.

5.3.3.14 MIRACODE SYSTEM

Functional Description

The word Miracode is the abbreviated trade name for Microfilm Retrieval Access Code. The system employs microfilm as the storage medium and an optical binary code preceeding the document (s) for retrieval. The document is assigned an index number prior to microfilming. The number is transferred to the film either by punched card or through the manual slide switches located on the camera copyboard. The index may be extended to subject content by category which could be divided into four subjects. For example, the subject documents could be on Systems-Document Storage & Retrieval Code 001 referring to Systems Miracode - Code 110, Lodestar - Code 111, Microstrip - Code 112, and Aperture Card Systems-Code 113. A master index list for Systems-Document Storage and Retrieval is utilized for locating cartridges.

The actual search of a full cartridge takes about 10 seconds. The modular design of the cartridge storage racks places within finger-tip reach up to 490 film cartridges, each containing approximately 2000 images (980,000 images total). The average access time to any document within a cartridge is eight seconds, provided only one pass through the system is required.

The depth of indexing required for the system will depend on the number of retrieval keyboards that will be necessary for the efficient operation of the system. It is practical to use up to 15 keyboards for descriptors in the Miracode System. The keyboards can be coupled together to equal two or more columns of binary code describing a document or series of documents.

Documents ranging in sizes up to 14" x 22", filmed at reduction ratios of 8:1 to 30:1, can be stored in this system. The film size at present is limited to 16mm.

Equipment Required

The Miracode System requires the following equipment:

1. Recordak 16mm planetary camera, model MRK-1, including Miracode film unit (Model MCK-1).

2. Miracode input control keyboard, model 1DKM-slide switches for placing binary code on film.

3. 16mm film processor capable of processing to NBS & ASA specifications.

4. Rewind kit with device for loading film into cartridge.

5. Typewriter for producing master index list for locating documents within the system.

6. Recordak Lodestar reader/printer, model PEK with parity check, keyboard control unit and logic package.

7. Miracode automated retrieval keyboard, model KIR (Inequality).

8. Recordak high speed retrieval stations, model K-1.

To enhance the flexibility of the system, an IBM keypunch (024 or -26) machine can be used for placing the index on a punched card system. The master index list can in this way be prepared on computer or electronic accounting machine equipment.

Capabilities

Input: The input to the system is in the form of 16mm microfilm inserted into a cartridge designed specifically for the Miracode system. The system cannot adapt to microfilm produced on any camera other than the Recordak MRK-1, because of the binary code required for identification of the document.

Output: The output from the system is limited at the present time to a silver emulsion hard copy $8\frac{1}{2}$" x 11" reproduction in approximately 20 seconds. An expected improvement to be added to this system is the capability for contact printing (roll to roll) onto a duplicate roll only specified images from the cartridge. This process will allow a duplicate output either hard copy and/or a duplicate image to be printed on another roll.

Updating: The updating of the file in the Miracode system is somewhat easier than in the standard cartridge systems. When a document is updated and committed to microfilm, it can carry the same image descripter as the previous revision. The film can then be placed into a separate cartridge and cataloged as a revision roll. A notation can be indicated on the master index list that a later revision of that document is available and give the cartridge number and the image descripter.

Reproduction Technique: The system utilizes the silver emulsion monobath technique for the reproduction of microfilm images to hard copy prints.

Procurement lead time for the Miracode system is 150 to 180 days from placement of purchase order. Operation of the system requires only one operator for controlling the file, and cannot be operated on a self-service basis.

The total space requirement for the Miracode complex of file cabinets, reader/printer, and work space is approximately 130 square feet. The space requirement is variable in that it directly depends on how many keyboards are to be used and the total quantity of cartridges entered into the system.

The basic system cost is stated as $30,000; however, if additional keyboards or filing cabinets are required, these costs must be added to the system.

Comments

This system has application to storage and retrieval of page size documents that are not updated or revised often. It is not recommended for Repository usage because of the dynamic nature of the vast majority of the page-size documents stored.

This page intentionally left blank.

5.3.3.15 MOSLER ROTRIEVER UNITS

Functional Description

The Mosler Safe Company manufactures three-potentially usable retrieval units. The units are the Rotriever Reader/Printer, the Open Access Rotriever, and the Manual Access Rotriever. All these units use the card notching principle.

The Rotriever Reader/Printer system is available in two models, one with a 5000-card capacity and the other a 10,000-card capacity. The system includes a reader/printer attached to the unit for either browsing or reproducing an 18" x 24" hard copy. Retrieval of any one card in the system is 5 to 8 seconds with reproduction of the image in less than 20 seconds. The cards are contained within the file which performs all the functions necessary to input or extract cards from the system.

The Open Access Rotriever operates in basically the same manner. However, it does not include a reader/printer and the maximum card capacity is 5000. The system permits random filing within segments of 100 cards. Retrieval of any one card from the file is 4 to 7 seconds.

The Manual Access Rotriever does not include a reader/printer and the maximum card capacity is 5000. Retrieval of any one card from the file is 5 to 8 seconds.

Reproduction in the latter two Rotrievers is accomplished on separate reader/printers or card-to-card copiers.

Card retrieval from this system is controlled by a keyboard control on each Rotriever. The operator or requester keys the appropriate index number into the Rotriever and the file automatically retrieves and delivers the card to the requester.

Equipment Description

The Mosler Rotriever units require the following equipment:

1. Special equipment to convert document to the system format.

2. Card notcher, special equipment for notching the bottom edge of the card. This special notching is required for the retrieval mechanism in the filing equipment. The notching is accomplished at a rate of 360 cards per hour.

3. Special file container for storing aperture cards with Mosler Notch.

4. Reader/printer for viewing or making hard copy reproductions of the microfilm image.

5. Card-to-card copier for producing diazo duplicards of the master file cards.

Capabilities

Input: Input to the Rotriever file can be aperture cards, microfiche, tabulating cards, etc., containing a special notch along the bottom edge of the document.

Output: The system retrieves the master file copy which can be reproduced in hard copy or duplicate diazo duplicards. Retrieval of a document from the file is 4 to 8 seconds, dependent on the model. Reproduction of hard copy is about 20 seconds while with diazo duplicards it is about 30 seconds.

Updating: Documents may be removed from the file in 4 to 8 seconds. New documents to be added are infiled in about 2 to 3 seconds.

Reproduction technique: The reader/printer adapted to one Rotriever unit uses the electrostatic technique of reproduction.

The total capacity of this equipment is 5000 cards per unit with the exception of the Rotriever reader/printer which has an optional unit with a capacity of 10,000 cards.

Full time personnel are not needed for this system. The basic concept of the Rotriever is for remote satellite files rather than for a central file. This allows the engineer or draftsman to make his own request and reproduction if necessary. Approximately 15 square feet are required including working area.

System Cost

Rotriever Reader/Printer

Purchase	5,000-card capacity	$7,500.
	10,000-card capacity	$10,500.

Open Access Rotriever

Purchase	5,000-card capacity	$3,820.

Manual Access Rotriever

Purchase	5,000-card capacity	$4,360.

Card Notcher

Purchase $500.

Comments

The Rotriever concept has much merit in the small file applications. The Rotriever reader/printer in particular offers good security in that the file can be located in a remote area without a full time file clerk and still function with maximum efficiency.

The time for access to a document and the refile time are exceptionally good, about 35 seconds. Few systems in this price range can offer this capability.

Cost amortization is quickly realized with the reader/printer model. This relatively inexpensive file can be located in a remote area without the need of an operator, and valuable engineering time is saved by not keeping the engineers waiting for information.

Disadvantages include the limited indexing. At present a maximum of four digits is allowed for each card in the file. Even though this can be expanded through the segmenting of the file, a very costly index would have to be established in using this method of indexing and filing.

For any sizeable file the index would have to be prepared on EAM equipment which would require buying the services or the in-house capability.

The notching operation is comparable to keypunching; however, reproduction of the notch is considerably slower than conventional EAM processing. If duplicate cards are to be notched, it is accomplished on the manual card notcher.

Because of the large number of aperture cards in the Repository, this type of indexing and storage is not recommended. The process of converting the holorith punched aperture cards to the notching punch would take about 5900 hours, assuming a file quantity of 2 million cards. The subsequent punching of the distribution cards would become another monumental task.

A possible application for the Rotriever files would be the reports and specifications section if microfiche were the storage medium. It is feasible to segment the reports and specification file so that it could be adapted to the Mosler notching (maximum four digits).

5.3.3.16 MULTIPLEX - RECORDING PHOTOGRAPHY (MRP) SYSTEM

The multiplex - Recording Photography (MRP) concept is to store approximately 400 separate images on a negative film. All of the images are the same size as the negative. Recording of images is by insertion of the MRP negative. A counter indicates the number of exposures made on the negative. The film negative is removed from the camera and processed in conventional processing equipment.

The viewing of the MRP negative necessitates placing the negative into a special viewer. Duplicate copies of the images can be made through conventional contact printing processes.

Typical applications for the MRP concept extend from ground, aerial, and space photography to microfilm and data storage.

Equipment Description

The MRP System includes the following equipment:

1. Equipment to convert document to system format.

2. MRP camera specially designed to facilitate the Aeroflex photographic techniques.

3. Film Processor for developing the MRP negatives.

4. Viewer for projecting the MRP negative images onto a screen.

5. Contact printer for reproducing duplicate copies of the MRP negative.

Capabilities

Input: Input to the system is limited to the MRP negative.

Output: The output of the system is a visual presentation of the MRP negative or a contact print of a specific image.

Reproduction technique: Conventional contact printing of the original negative to an unexposed, undeveloped duplicate film is the reproduction technique. The total capacity of the system is unlimited. Only one camera operator is required, and space requirement is approximately thirty square feet.

Comments

It is felt that the concept of this system is very good; however, its application for engineering drawings should be explored more thoroughly. It is recommended that an actual hardware demonstration be arranged with Aeroflex Laboratories, Inc., and that engineering drawings of various qualities be photographed and projected. A test of this nature should determine whether or not this system could be used in the MSFC Repository.

5.3.3.17 PHOTO IMAGE RETRIEVAL SYSTEM (CYPRESS)

Functional Description

The Cypress (See Fig. 5-7) system is a photo image retrieval system that provides automatic control for large files of microfilm images.

Filing, retrieving, and reproducing functions are performed under electronic instructions. The system may be addressed by any one of the following modes:

1. A request card inserted into the image converter,
2. A standard punched card inserted into the card reader,
3. Data entrance by printer/keyboard, or
4. Data entrance directly through a computer that may be linked to the system as optional equipment.

Documents to be filed are assigned a specific address within the system by means of the printer/keyboard or by means of the optional computer (IBM 360).

Retrieval of a document is obtained by ascertaining the address within the system from an index, and addressing the system in the desired mode of the four outlined previously. An off-line computer may be employed to store the index and read out the addresses of specified drawings or images and to produce automatically punched address cards which may then be fed into the image retrieval system.

The film chips are stored in the system in plastic containers or cells with a capacity of 32 film chips. The chips are transported within the system in these cells and are extracted only for reproduction or purging.

Equipment Description

The Cypress System includes the following equipment:

1. The IBM 1351 and IBM 1352 Cell Files to provide the IBM photo image retrieval system with the facility to store and retrieve photo image cells automatically.

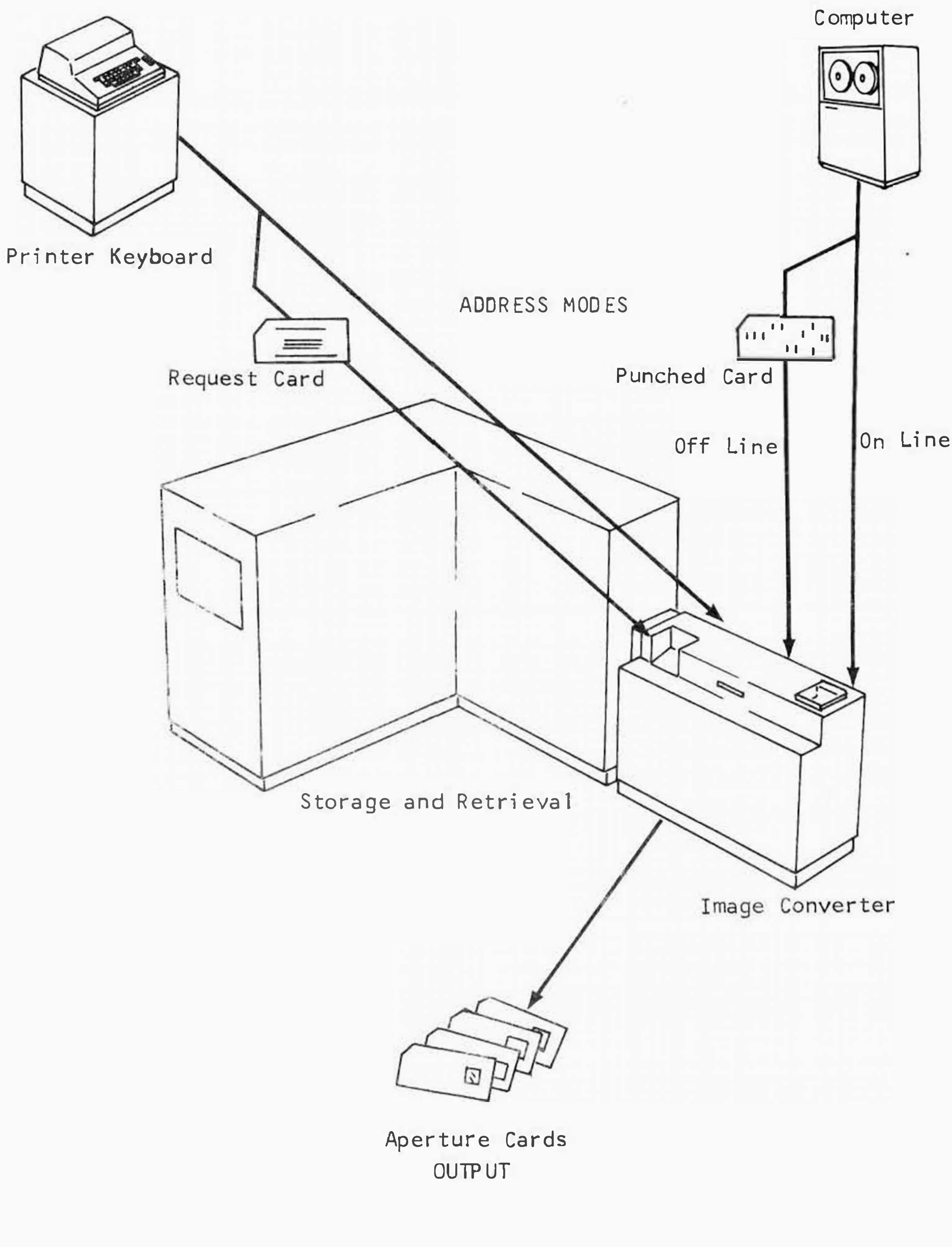


FIGURE 5-7. THE PHOTO IMAGE RETRIEVAL SYSTEM (CYPRESS)

2. The IBM 1355 photo image converter to provide the input and output functions of transferring images to and from the system, and digital data to and from punched cards.

3. Printer/keyboard for two-way communications between the photo image retrieval system and an operator, which permits the operator to initiate requests directly from the keyboard.

Capabilities

Input: The input to the system is 35mm silver halide film images mounted on punched aperture cards.

Output: The output is 35mm diazo film images mounted on punched aperture cards. The automated system is designed to answer 1000 random requests per hour.

Updating: Purging and updating should present no problems in this film chip storage system.

Marketing personnel for IBM estimate the maximum system cost to be approximately $400,000.

Comments

Limited capacity, the fact that only one system has been built, and estimates of some 18 months for delivery are the major causes for not recommending the Cypress system. The system appears very simple and very well conceived. The overall capacity must be increased by a factor of 10 from the present maximum of 504,000 images in order to be capable of storing the anticipated volume of the Repository. IBM must be in a position for marketing conversion of aperture cards to film chips at a reasonable price before the system could be considered for procurement action by MSFC.

This page intentionally left blank

5.3.3.18 REMSTAR SYSTEM

Functional Description

Remstar is a closed circuit television system for transmitting 16mm microfilm or hard copy original documents. A separate transmitter is needed for the microfilm and the original documents.

The transmitters are usually placed in proximity to the microfilm or document files. When a request is received the microfilm or document is removed from the file and inserted in the transmitter. The image is transmitted over coaxial cable to the monitor where it is viewed. A hard copy of the image can be made at the monitor by pushing a print button.

Equipment Description

The equipment for use in this system is basically the same for microfilm or original documents. The only difference is in the transmitter unit requiring a separate unit for microfilm and hard copy documents. In addition, the following equipment is required:

1. Remstar transmitter for recording the microfilm or original document to be transmitted.

2. Remstar monitor for receiving the transmitted images and displaying them on the viewing screen.

3. Remstar printer for producing hard copy of the transmitted images.

4. Coaxial cable for carrying the transmitted signals (minimum of 3000 feet without a relay booster)

Capabilities

Input: Input to the Remstar system is 16mm microfilm in unitized form or an original letter-size document.

Output: Remote video viewing of the transmitted image is allowed and/or a hard copy printed at the remote station; there may be instant transmission of image to monitor.

File clerks maintaining the microfilm or original document file can operate the transmitters. Approximately ten square feet are required for each unit.

Accurate cost information is not yet available. The manufacturer has estimated that the cost for a transmitter (microfilm or hard copy), the monitor and 3000 feet of coaxial cable to be $15,000.

Comments

This system is limited to the smaller documents. It has merit in several applications where long distance transmission is not necessary. The cost for establishing long distance video communications would far outweigh the feasibility of the system. There are more economical means available for the transmitting of data than this system. The limitations of the film size and the original document size are other drawbacks of this system. The manufacturers have indicated that they are doing R & D work in the 35mm film size and drawings up to "D" size (24" x 34"). There would be no significant advantage from the implementation of this system; therefore, it is not recommended for the MSFC Repository.

5.3.3.19 REPUBLIC MICROVUE (Mark II & III) SYSTEM

Functional Description

The Microvue (Mark II & III units) is a portable document storage and retrieval system. The system itself parallels the concept of microfiche except that retrieval in the Microvue unit is automatic. One 4" x 4" film chip stores approximately 9801 images in a 99 x 99 grid pattern. Microfilm was stated as the primary source of input. Each standard microfilm frame is reduced photographically by the use of a special camera. The reduction ratio is 260:1.

Equipment Description

The Microvue System requires the following equipment:

1. Equipment to convert documents to system format.

2. 16 mm high resolution rotary camera.

3. Film processor and standard inspection equipment.

4. Fairchild-Hiller camera specially adapted for reducing 16mm images to a 260:1 reduction.

5. Portable high density Microvue retrieval unit (Mark II or III) to enable the retrieval and display of the Micro chip images.

Capabilities

Input: The input to the system is a 16mm image that is reduced 260:1 and stored on a special micro chip card.

Output: Output from the system is presently limited to a visual presentation on the Microvue unit screen.

Reproduction technique: Although reproduction capability does not exist in the present equipment, Fairchild-Hiller has indicated that research is being conducted in this area. The total quantity of Micro chips to be stored in the system is unlimited.

This equipment is available within 180 days from receipt of order. One clerk is required to operate and maintain the Microvue unit. Approximately twenty square feet of space are needed. The Microvue unit is expected to cost between $5,000 and $7,000. The special camera for reducing the images 260:1 is indicated at about $60,000, or the conversion process is available on a service basis from Fairchild-Hiller at a cost of $.20 per frame.

Comments

Applications for this system are limited since the equipment has only recently been announced. This equipment was on display at the recent National Microfilm Association Convention. The total concept of the Microvue system is approaching the needs of industry. However, it is felt that Fairchild-Hiller has not developed the projection technique to any degree of satisfaction. Projections of the reduced images were very poor and tended to drift out of focus if left projected on one image for any length of time.

The lack of reproduction capability on the system is a definite drawback, in that the need for reproduction of the image is always present.

Although this system is not recommended for implementation in the Repository at this time, periodic investigations should be conducted on the improvements of the Microvue system.

5.3.3.20 SELECTRIEVER SYSTEM

Functional Description

The Selectriever is a sophisticated expansion of the other Mosler automated files. The system can store approximately 200,000 aperture cards in twenty square feet of floor space. The storage rack contains 2000 cartridges, each containing 100 cards each. The system will in addition to storing aperture cards accommodate 3 1/4" x 7 3/8" microfiche.

Storing of aperture cards or microfiche in this system requires a card containing 35 holes along the bottom edge of the card. These cards are then punched for indexing using the Mosler notch method. The notching is accomplished at the time the card is inserted to the system. A maximum of fourteen characters can be punched into the card for indexing. Special indexes are established for cross referencing on those documents requiring more than fourteen characters of identification.

Retrieval of an aperture card or a microfiche is accomplished by keying into the retrieval unit the index number desired. A high speed selector mechanism scans the 2000 cartridges and retrieves the appropriate cartridge. Optional output units are available on the Selectriever such as video transmission and a reader/printer. The transport time from select to delivery is about 6 1/2 seconds. Return of a single card into the system is accomplished in about 4 seconds. The system can retrieve an entire cartridge and present it to an operator as well as a single card in the same amount of time.

Equipment Description

The Selectriever System (Fig. 5-8) requires only two major equipment items:

1. Selectriever Unit for storing, retrieving and refiling cards in the system, and

2. Selectriever keyboard for producing special notch in the aperture cards.

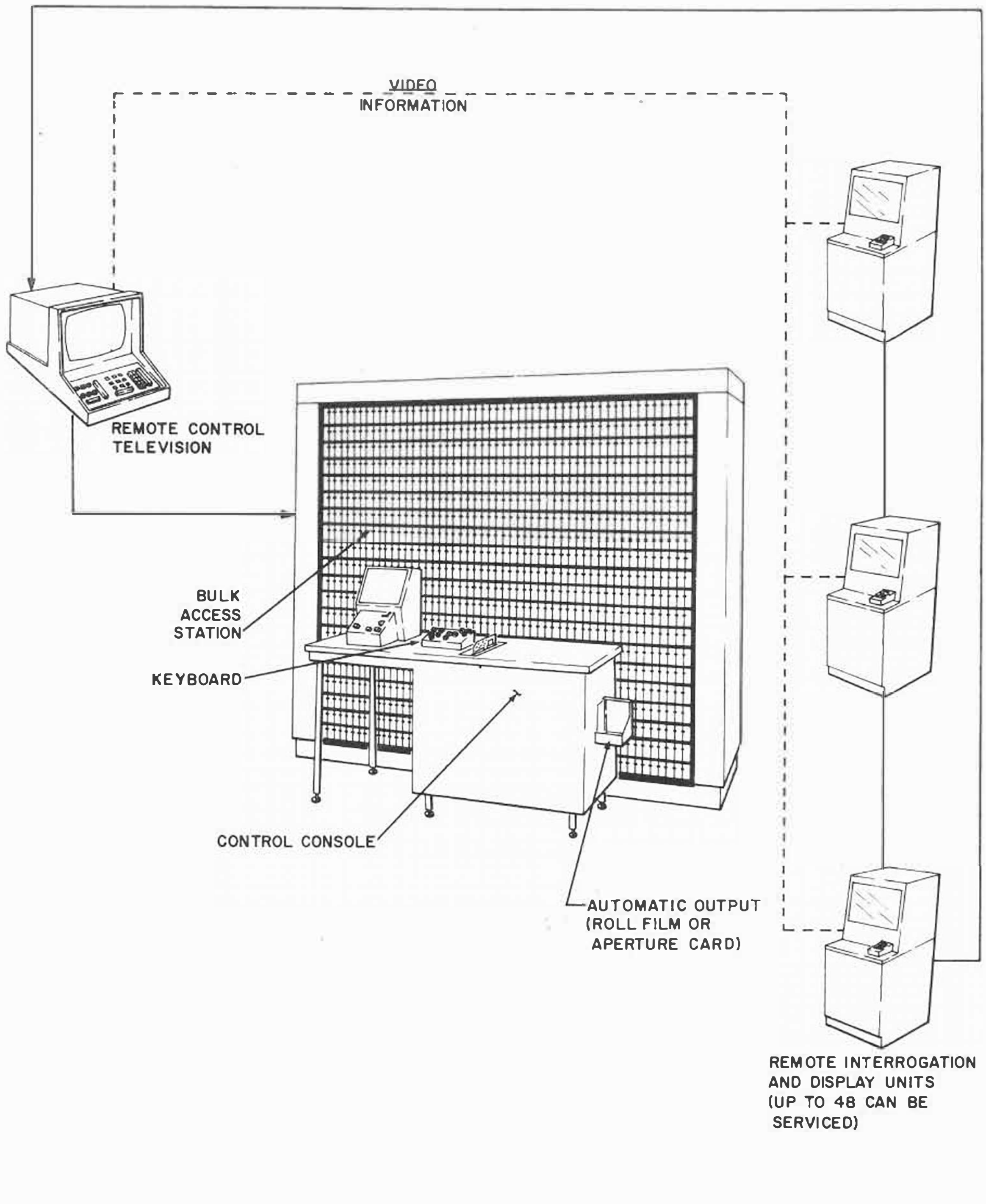


FIGURE 5-8. THE SELECTRIEVER STORAGE AND RETRIEVAL SYSTEM

Capabilities

Input: Input to this system is by aperture cards or microfiche containing 35 holes along the bottom edge of the card. These cards utilize the Mosler notch for indexing.

Output: All output of the system is optional. These optional features include up to 4 card-to-card or card-to-roll copying stations, 8 remote controlled closed circuit television monitors, reader/printers, readers, etc. Any combination of the above output devices can be accommodated on the system.

Updating: The updating of the system can be performed simultaneously when inputing the new revision.

The total capacity of the Selectriever system is 200,000 cards. Although actual cost estimates were not available, the system is advertized as costing under $30,000 complete.

Comments

The application of the Selectriever system to the MSFC Repository would be an extremely costly and time consuming task. Because of the special card notching technique employed in this system, each card in the present file would have to be adapted to this special format. At present the file quantity exceeds 2 million cards, which would require 10 Selectriever units. Additional units would have to be procured as the file expanded. Total expansion of this file by 1970 is expected to exceed 5 million cards. The cards in the Selectriever system are not adaptable to automated EAM processing. This would necessitate either the establishing of two systems or manually performing the new automated processes. Because of the tremendous conversion process, the limited storing capacity, and the non-machine processable cards, the Selectriever system is not recommended for replacement of the present aperture card system.

This page intentionally left blank.

5.3.3.21 VIDEOFILE SYSTEM

Functional Description

The Ampex Videofile (See Fig. 5-9) utilizes a video tape as the medium of storing documents. The Videofile is a true automated document storage and retrieval system, storing television images rather than microfilm images. This medium of storage allows great versatility and flexibility in the system since images can be erased or relocated in the tape. This feature is outstanding in the roll type applications, since updating of 16mm and 35mm rolls requires splicing in the revised images or totally relocating them on a separate roll of film.

The operation does not require special technical personnel, and therefore allows the training of file clerks to operate the Videofile system. Retrieval of documents from the file requires the requester to dial the address number on a telephone or key into a desk top keyboard.

A document is recorded on the tape by a Videotape television recorder. An index is assigned each document or series of documents on the tape. An identification address code is also assigned to the tape for the retrieval of the segments of tape containing the documents (s). Inputs to the Videofile systems can be original documents (up to $8\frac{1}{2}$" x 14") roll microfilm, aperture cards, microfiche, etc. New documents entering the file are recorded and indexed in random sequence during the day.

Requirements for this system are 500 remote viewing locations to facilitate some 26,000 daily requests. Of these 26,000 requests approximately 10,000 require hard copy reproduction. The 10,000 requiring hard copy reproductions are filed under 5000 individual address codes in the file. Daily additions to the Videofile are estimated at 20,000 documents filed under 10,000 separate addresses.

Average access time for each requester is 74 seconds. Each remote stations will be equipped with a dual buffer station. The special buffer permits search or inquiry on one half while viewing on the second half.

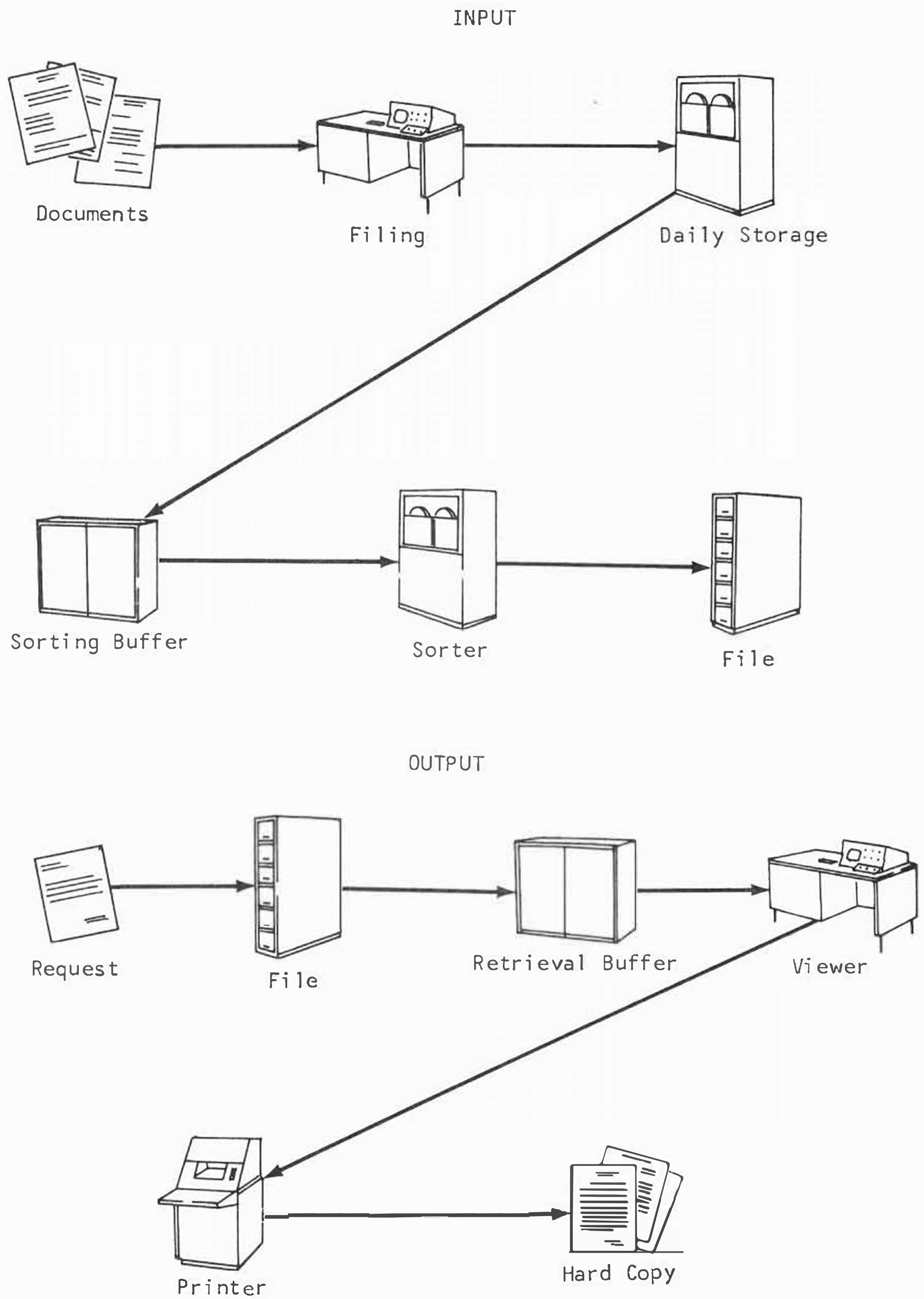


FIGURE 5-9. THE AMPEX VIDEOFILE STORAGE AND RETRIEVAL SYSTEM

Equipment Description

The Videofile System requires the following equipment:

1. Videotape recorder and tape for recording the documents into the system.

2. Memory storage (buffer) for retaining the image for a request to free the main recorder for additional requests.

3. Coder for indexing the videotape into segments for retrieval of documents.

4. Television viewer (desk top) for viewing the documents at remote stations.

5. Hard copy printer for reproduction of prints.

Capabilities

Input: Input to the system is in the form of a hard copy up to $8\frac{1}{2}$" x 14" and stored on a videotape. Each tape (7200 feet) is capable of storing up to 250,000 documents and one million addresses. The address is in binary code and can be read either in forward or reverse track.

Output: The output is a graphic presentation of the document or a maximum $8\frac{1}{2}$" x 11" hard copy print.

Updating: New and revised documents are recorded onto the Videotape in random or sequential sequence. Each day the tape containing the new and revised documents is loaded onto the recorder and automatically inserted into the proper sequence in the file.

Reproduction techniques: The reproduction technique is electrostatic, utilizing 1280 lines per frame with transmission over a narrow bandwidth, such as leased telephone lines. Since the system is modular and somewhat custom made, the total capacity of the system is virtually unlimited. As stated in the example above, a quantity of 25 million documents will be recorded in the system. Ideally each videotape would have an outline recorder station; however, economics would not permit this for extremely large files. The system could be made available in 18 to 24 months.

Manpower for the operation of the system is dependent on the size of the file, normally requiring 2 to 3 personnel. The space requirement is dependent on the complements of equipment. The first system installed was at MSFC in May, 1966. The cost of this system is reported at approximately $1.2 million. The actual price of a total Videofile system is entirely dependent on the capabilities and complements of equipment desired in the system. A price range given by the manufacturer is $400,000 to $800,000.

Comments

This particular system has definite merit within the constraint of its design. The systems design is centered around document sizes up to 8½" x 14" with standard sized printing for that size. The immense packing capacity of 250,000 images per 7200 feet of tape, the subsequent retrieval of any one of these images within 45 seconds average, and the use of videotape are major breakthroughs in the document storage and retrieval field.

Advantages of the system are the immediate and fast capability of updating the tapes on a daily basis, the erasing of outdated or revised images, and the automatic retrieval and subsequent filing without the need for human intervention. The system with the use of videotape as the storage medium offers significant advantages over the use of microfilm rolls or aperture cards. The videotape produces an instant image that does not require further processing.

Disadvantages to the system are the limited size (8½" x 14"), which does not lend itself to the engineering drawing field, and the possibility of segmenting the drawings that would not fit in one image area, which would be far from ideal. An "E" size drawing would require a minimum of 18 frames.

The manufacturer of the Videofile is currently directing efforts toward developing a document storage and retrieval system for large-sized engineering drawings. However, the inherent problems with recording large sized documents on videotape and reproducing the images from the tape are still existent.

This limited size constraint necessitates a comparatively large investment for a system that is adaptable to the lesser problem area of the Repository (reports and specifications). The need for a storage and retrieval system such as the Videofile is not warranted at this time in the reports and specifications section.

This page intentionally left blank.

5.3.3.22 VIDEX SYSTEM

Functional Description

VIDEX is a Video Transmission system capable of transmitting any type of data over leased lines. The system utilizes four components: the camera unit, camera control, monitor control and the monitor. When a document is to be transmitted a telephone call is made to the receiving station. The receiving station activates the monitor, the document is placed in the camera unit at the sending station, and the document is photographed in about 1/30th of a second. The image is then transmitted over the same telephone lines as the voice communication. The image is retained on the receiving monitor for up to six minutes, or it can be erased on command at the receiving station.

Document sizes up to 6" x 8" can be photographed and transmitted in this system. The image can be transmitted over leased telephone lines in 10 to 40 seconds from start to finish.

Equipment Description

The Videx System requires the following equipment:

1. Camera unit BV-100CU for photographing the image and transmitting the image to the monitor on the receiving end.

2. Camera control BV-100C containing transistorized amplifier and power unit to supply transmission requirements.

3. Monitor control BV-100MC containing input circuits for connecting to the telephone lines.

4. Monitor BV-107M containing a 7-inch display tube for displaying the images stored in the monitor control.

Capabilities

Input: The input to the camera unit is flat subjects ranging in size from 3" x 5" to 6" x 8". Larger documents can be fed to the camera unit by removing the side panels.

Output: A graphic image is presented on the receiver monitor 7-inch display tube.

Reproduction technique: A poloroid camera can be adapted to the monitor for producing hard copy images.

This system has been in existance for several years and it is presumed that it is immediately available. One operator at the camera unit and one operator at the receiving monitor comprise the required personnel.

Approximately twenty square feet are required for the sending and receiving stations.

Comments

The evaluation of this Video Transmission System against other systems of this type on the market today has shown the VIDEX to be inferior. The limitations of the screen size on the monitor and the paper size recorded by the camera unit fall short of the requirements at MSFC. The application of this equipment in the banking industry is perfectly suitable; however, it is not recommended for implementation at MSFC.

5.3.3.23 WALNUT SYSTEM

Functional Description

The Walnut System is for large capacity document storage and retrieval applications requiring random access capabilities. The system concept is basically a filming of the original document on 35mm perforated film. Before filming, a unique number is assigned, the page count is recorded, and an index record, including an abstract is prepared on paper tape for each document. Simultaneous with the filming of a document, an input control card is punched containing the page count and document number. The document is then returned to the originating source for disposition.

The index record and the abstract (keyword headings) contained on the paper tape are recorded on magnetic tape for inclusion in the master index. The 35mm roll perforated microfilm is reduced 1/100th of its original size onto the film strips (storage medium) in the file. The data contained on the input control card is simultaneously assigned to each document that is transferred to the film strips. The document is then permanently located in the files and does not require removal from the immediate file for reproduction. The film strip or storage medium in the system is a heat sensitive film such as Kalvar which is a completely dry process. Subsequent reproductions of the film strips are of the same type film and can be produced in about 6 seconds.

The reproductions are made on an aperture card designed to hold four images. The magnetic index and the image file are both modular in design, therefore allowing additional modules without special component modifications. With the modular additions the Walnut system can store in excess of 100 million images and 3 billion coded characters. Each image file contains approximately 990, 000 images descripted by 300 million characters of index.

The arrangement of each image file is circular in design and is operated from instructions received from the magnetic tape index file. The magnetic tape index file can be operated independent of the image file. This versatility permits independent interrogation, updating and purging the index file without disturbing the image file.

The retrieval of a document requires the user to complete a request form with as much specific information about the document as is known. The search criteria are extracted from the form and read into a processing unit. The processing unit purges the subject index for a match of the keyword (s). Those subjects matching the keyword (s) are extracted from the file and printed on tabulating EAM card. The cards extracted from the file are reviewed by the user. Only those desired are further reproduced into an aperture card.

The aperture card is inserted into the file, the retrieval equipment is activated, and the correct film strip is purged from the file. The film strip is automatically and precisely positioned within the lines and the image(s) are transferred to the photo sensitive film on the aperture card. If the document length exceeds the capacity of one card, additional aperture cards are automatically reproduced, interpreted, and positioned.

Each image file module can process a minimum of 500 images per hour, and the average processing is 600 cards per hour. Conversion of the 35mm perforated roll film is approximately 1500 images per hour or 660 hours to convert 990,000 35mm images to the system format.

Equipment Description

The Walnut System includes the following equipment:

1. Equipment to convert documents to system format.

2. Paper tape typewriter for recording the index report and the abstract.

3. 35mm Planetary camera for the first photographic reduction of the original document.

4. Film processor for processing the 35mm film to all ASA and NBS specifications.

5. Keypunch machine for producing the input control card.

6. Input converter to convert the 35mm perforated film to the document index file.

7. Document Index file for storing the subject index and the document address index.

8. Film strip image file for containing the individual film strip cells.

Capabilities

Input: The input to the Walnut System is a roll of 35mm perforated microfilm, a location index and an input control card.

Output: The output is an aperture card containing photo sensitive film and capable of storing a maximum of four images per aperture card frame. The reproduction of the aperture card takes about five seconds.

Updating: The system was not designed for ease of updating other than replacing an entire film strip (99 images). Updating could be accomplished by establishing a separate section of the file for revisions and additions. The latter method would tend to complicate the indexing and expand the image file to a vast historical file.

Reproduction technique: The film image produced on the aperture card from the film strip is the Kalvar technique. The Kalvar film is exposed to an ultraviolet light and developed by heat (240°).

Latest manufacturer information indicates that this system was developed for one special application and that no further Walnut systems have been manufactured. The available literature on this system did not indicate the personnel requirements. It is assumed, however, that it would require one to two personnel. The image file module is stated as about the size of a desk. There were no available dimensions for the index file module. Cost information was not available from the manufacturer.

Comments

The Walnut System is again slanted toward the $8\frac{1}{2}$" x 11" documents. Justification for utilizing this system is solely on large quantities of documents and the need for a rapid retrieval system. Since this system was not designed for engineering drawing applications, it would not have use in the MSFC Repository. The specifications and reports section does not have the quantity nor the rapid access retrieval requirement that is the basis of the Walnut System.

This system is not recommended for implementation in the MSFC Repository.

5.4 Conclusions

Industry has not developed an automated reproduction, storage, and retrieval system for large quantities of drawings or large sized drawings. The requirements at MSFC are far greater than the capabilities of any available automated system on the market today. While the microfilm industry has developed highly sophisticated systems, none of these appear to justify their cost or complexity in view of their limited applications. There were perplexing problems connected with each document storage and retrieval system that was evaluated that forced the team to the conclusion that the present aperture card concept remains the most practical NASA/MSFC approach.

It is anticipated that it will be a minimum of 2 to 4 years before an automated document storage and retrieval system which represents an improvement on the present system will become available. In the interim the aperture card system should remain the primary source of record retention for MSFC engineering drawings, and microfiche should be encouraged for specifications and standards.

5.5 Recommendations

1. The recommendation of the Study Team is that the present system of aperture cards remain until such time as an automated storage and retrieval system becomes available that will fully satisfy the requirements of the MSFC Repository.

2. A limited scope indexing system and transmission system study should be initiated by Repository management in cooperation with the Mission Support Office. Only that documentation identified for HOSC usage should be included in the system. The system should include documentation subject matter, applicable hardware identification, and document identification accessibility. This study should have as its objective the development of criterion for data storage, retrieval, and transmission systems in Mission Support Operations.

3. To provide convenient and rapid access to the Repository contents, the Study Team recommends that a family tree type index for each major program be made available to all the laboratory and contractor personnel that are potential users of Repository documents. The index should reflect the following:

   a. The applicable program such as the Saturn V vehicle.

   b. Identification of each contractor end item and major component of the vehicle by nomenclature, vendor, and identification number of drawings and reports.

   c. An alphabetical listing of the principal assemblies of each major component, cross referenced to assembly drawing numbers.

   d. Top down breakdowns (listings of component parts by related assembly) of each assembly listing of all detail parts of the assembly.

   The size of such an index demands that it be composed in several volumes. The larger volumes would contain the detail breakdowns and reproduction should be limited to necessary copies. One set of the large detail volumes might be located in each major using activity and the locations referenced in the smaller volume index.

4. Long-range recommendations include the preparation of pictorial indexes to take the place of the smaller indexes containing contractor end item identification by program, and a reference to detail listings of drawings and reports.

5. A Microfiche program should be initiated in the Reports and Specification Section of the Repository. MSFC specifications and standards should be converted from hard copy to microfiche. Distribution should be made in microfiche whenever feasible and the effectiveness of the program should be made as to the feasibility of storing other types of documents on microfiche.

6. It is recommended that NASA phase out the APIC Project and channel that information into IDEP.

7. A storage and retrieval systems analysis capability should be developed and maintained by the Repository. Other duties should be assigned to personnel assigned this task but adequate time and freedom to maintain close surveillance of innovations in storage and retrieval equipment should be allotted them. Toward this end a massive literature search has been initiated by RCA Staff, the results of which are only now beginnig to evolve. As a Bibliography develops, it should represent a technical baseline of knowledge on which Repository management can continue to build.

8. The storage and retrieval equipment analysis of this report should be updated annually to incorporate the findings of the systems analysis. After reevaluation of storage and retrieval equipment is completed annually, Repository management should reevaluate the mode of operation in each functional area as potentials for applications of new equipment develop.

SECTION VI

DATA DISTRIBUTION

6.1 Definition

Data distribution is the coupling between the data store and the data user. Unless distribution is as disciplined as the rest of the data system, the system's effectiveness is lost. Poor distribution practices proportionally reduce service, and distribution shortcomings deteriorate the user's confidence in the system. In many cases, the only point of contact between the data system and the user is distribution. If distribution is weak, the entire system appears weak.

The Study Team data survey in April 1966 revealed that 17 per cent of the recipients of data on automatic distribution at MSFC did not want the data. What was worse, they did not know how to avoid receiving the data. A high percentage of the recipients of ordered data felt that the service was too slow. Average reported turnaround time was greater than four days. Still others complained that back orders were not properly handled or that the mails from the Repository to the user were too slow, or that the order form (MSFC Form 433) was too complicated.

6.2 Discussion

There are two general types of distribution, automatic and random. Automatic distribution is directed toward those users who have a continuing need for documentation and who must be furnished with current information as it is released. Random distribution more resembles the normal library function. Documentation is furnished only on demand, and the user is not automatically forwarded later issues of the data unless he enters a new request. The term "random" is used because there is no feasible way to predict how many users there will be or who they will be in a given period of time. The volume of automatic distribution can be predicted. Documents may be requested by telephone, or directly at the central file or at any of the satellite files.

6.3 Automatic Distribution

The procedure for automatic distribution of data is described in R&DO Procedure 25-1. The origin of the procedure would suggest that it is applicable only to users in R&DO, but the provisions of the procedure have been extended to users in IO and in contractor organizations.

Procedure 25-1 gives three methods by which a user may obtain automatic distribution:

1. by having his data representative place him (or his organization) on the formal distribution list,

2. by having his "key" or organization symbol listed on the face of the desired document by the document preparing activity (not applicable to Class II data), or

3. by having the design activity issue special distribution instructions to the Repository.

The first method allows distribution only by large blocks of drawing numbers. This requires users who have an interest only in a specific drawing number to receive all issues made within the block.

The second and third methods require coordination with the preparing activity, the identity or existence of which may be unknown to the prospective data user. Method 2 is difficult to administer in that every change in distribution requirements calls for a change to the original document and subsequent re-microfilming, etc. The last method, though more flexible than the other two, requires the efforts of a number of activities and lacks the simplicity that marks an effective system. For instance, the diversity of the preparing activities and the general practice of third parties placing individuals on these special distribution lists often results in situations like that mentioned above, in which users receive data they do not want.

None of the described methods, then, is ideal. Each results either in the proliferation of useless paper or in the inability of a user to acquire the data he needs in the performance of his job.

6.3.1 Monitoring Automatic Distribution

The MSFC Data Management Office has recognized the ineffectiveness of present automatic distribution monitoring techniques, and has developed a computer-oriented approach to an improved system. The "Positive Feed-Back System," as it is called, employs a document distribution matrix maintained on magnetic tape and printed out as required. Document identification numbers are cross referenced to a list of users requiring automatic distribution of the respective documents (See Fig. 6-1). In addition to the list, the computer is capable of preparing address labels for use in document mailing. The system derives its name, however, from its use of a card similar to that used in national record and book clubs. Each document shipped would be accompanied by a punched card which would have to be returned by the user in order to maintain his name on the distribution list.

The positive feed-back makes it very easy for a user to get off distribution. Conversely, it requires a positive effort to stay on. This is a weakness, for while it is important to remove from the list the names of those no longer requiring distribution, it is more important to guarantee the retention of those whose requirements continue. The positive feed-back would almost certainly result in many valid users being deleted from distribution. A period of work load pressure might cause the loss of information just at the point where such information would be most critically needed. Lack of understanding, pressure, or pure oversight would cause many users to fail to return the cards. Cards might also be lost in the mailing system.

Except for this positive feed-back feature, however, the computerized control of distribution lists is a decided improvement over existing methods. It allows users to request single documents instead of all the documents in a number block. It does not require the marking of keys on documents, and because it could be centrally controlled, users could easily get on and off distribution.

There are problems with such a system. Many users would find it difficult to identify the document numbers of the specific documents they want. Centralization would make difficult the qualification of users' need-to-know.

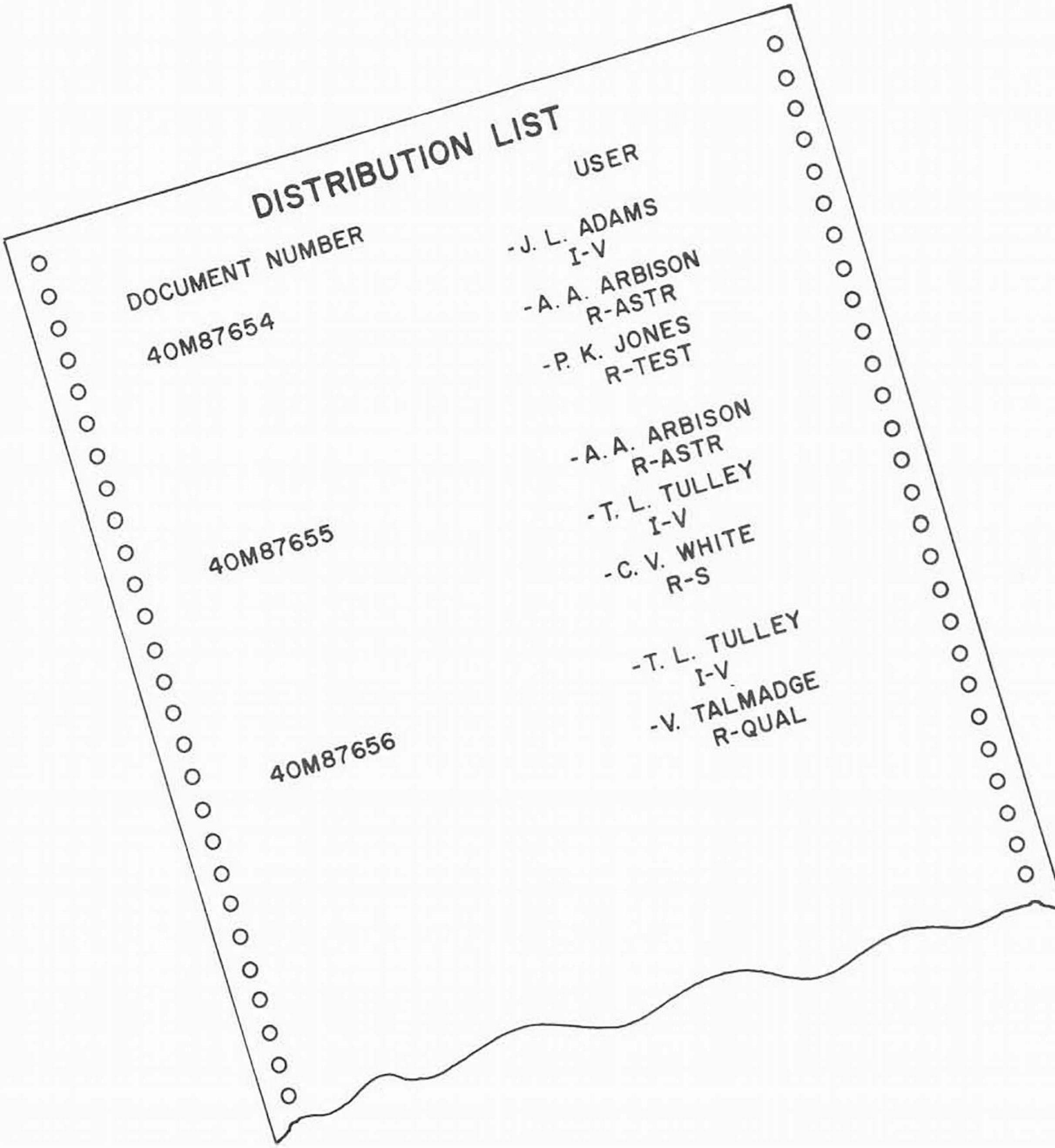


FIGURE 6-1. SAMPLE DISTRIBUTION LIST FROM POSITIVE FEED-BACK SYSTEM

The development of engineering data indexes will facilitate document identification. The problem of need-to-know must be solved by an efficiently functioning Data Management Organization. All on-list actions should be approved and coordinated by the user's Data Management Representative. This procedure is presently required by R&DO 25-1. Its enforcement would reduce the remainder of the need-to-know problem to an acceptable size.

The computer oriented distribution system is scheduled to be implemented in September of 1966 for reports. The expansion of this system to full coverage (without the positive feed-back feature) should be given a high priority.

6.4 Random Distribution

MSFC Procedure 25-2 describes the methods for ordering data from the Repository. Two such methods are given: one, submission of Form 433, two, telephone order (five or less unclassified documents only). In both cases the order is to be made by or through a Technical Documentation Representative (TDR) appointed in each work area. The TDR is to verify need to know for requests submitted by external contractors. The procedure does not indicate that a similar qualification is to be made by the TDR for internal requests, i.e., those from MSFC organizational elements and in-house contractors. Still, the procedure indicates that all internal requests are to be made by the TDR so that he can coordinate and control technical documentation requirements within his work center.

In practice, however, requests are not submitted by or even through the TDR. The requester submits Form 433 or telephones directly to the Repository. Except for classified data and a few other sensitive documents, need-to-know is not verified.

The Study Team has found that for internal requests the procedure deviation as practiced presents no major problems. The use of a functional library should be made as simple as possible. Forcing all internal requesters to go through a TDR prior to the ordering of data is a complicating factor that accomplishes nothing and which could cost MSFC thousands of lost man-hours and greatly deteriorate the human factors relationship between the Repository and its customers. Any control and coordination the representative performs is of questionable value. It was intended that the TDR reduce the amount of documentation requested from the Repository by guiding requesters to existing data within the work center. This not only is unrealistic from an administrative viewpoint but also could actually result in the growth of local files and the use of obsolete data from these files, The TDR should, therefore, be dropped from the ordering cycle for internal requests. This, of course, does not represent an actual change in practice. The circumvention is common practice now.

Unfortunately it is also common for external requests. This should not be the case. No contractor should be allowed to receive data from the Repository without a qualified need-to-know. Otherwise, competitive rights in data cannot be guarded and MSFC would fail in its obligation to is contractors as established in procurement regulations. As it applies to external requests, then MSFC 25-2 should be enforced. Presently, it is not. This failure has resulted from the issuance of two Program Office Directives that give certain contractors carte blanche access to more than 95 per cent of the data in the Repository. Unless contractor requests are monitored to verify that critical and/or proprietary data rights are not violated, there can be no assurance that abuses will not occur. To avoid redundant and overlapping responsibilities, the Data Management Organization, not a parallel group of TDR's, should monitor this activity.

A procedure similar to that described in 25-2 could be used, but a better procedure would be one based on sample reporting (Fig. 6-2). The applicable program Data Management Office would receive one copy of all Form 433's submitted by contracters and other external activities. A sample of these would be periodically selected for detailed checkout action. A report of violations and statiscal extension of the sample would be periodically forwarded to the contracting officer for corrective action. This procedure would require fewer manhours than that of 25-2 and could provide an input to Data Management for the development from the 433's of other statistical products.

The Repository should be authorized to question requests of an unusual nature. Reference is to certain requests for hundreds or thousands of documents on a single order. These should be

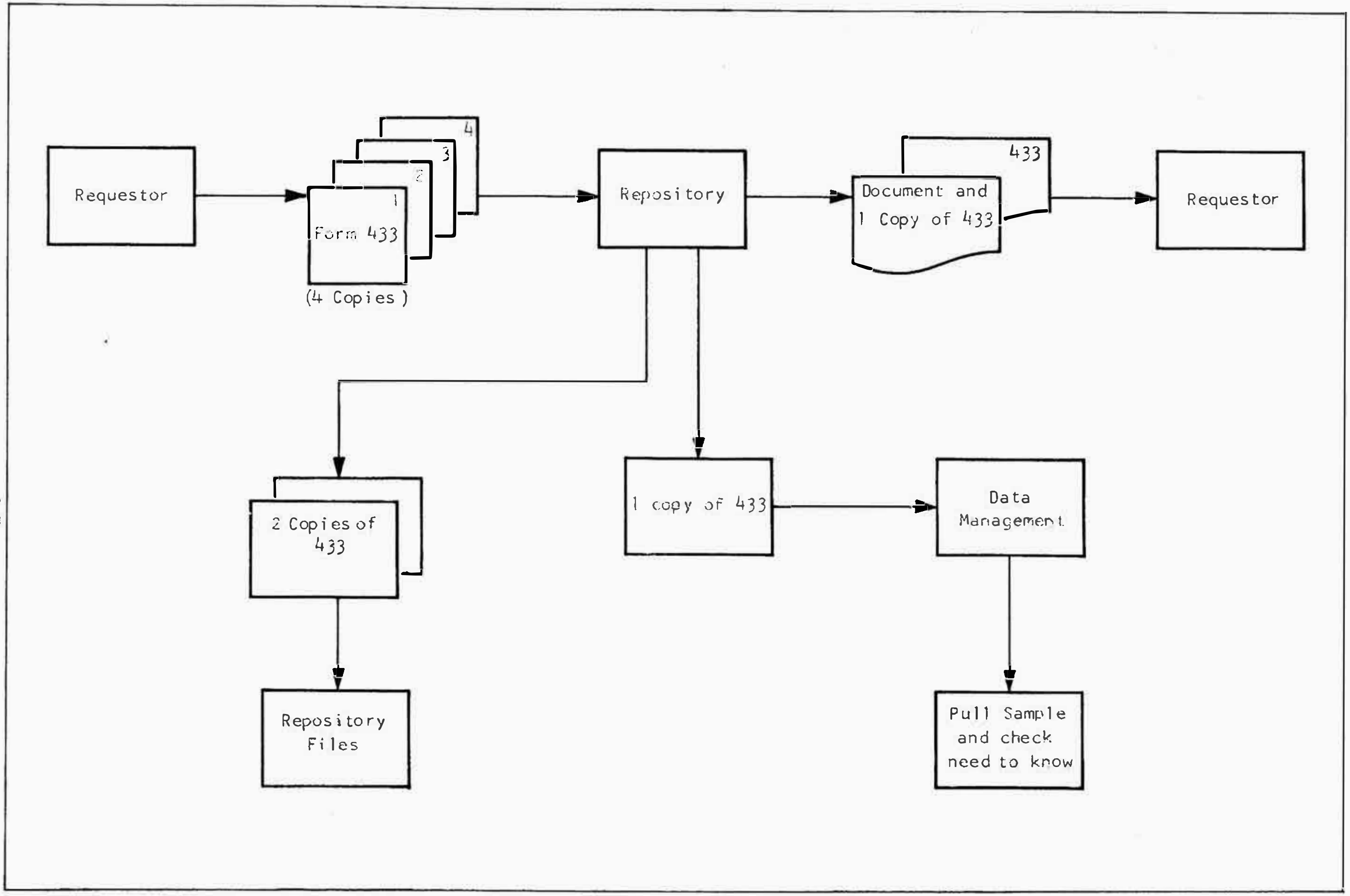


FIGURE 6-2. PROPOSED DOCUMENT REQUISITIONING SAMPLING PROCEDURE

questioned directly with the user, and if the need were not clearly justified, the user's Data Management monitor in the program office should be contacted for immediate follow-up. Data Management's judgement would be final.

Ultimately too, data preparation specifications must include methods of identifying data with limitations on its distribution, and the Repository must be able to enforce such limitations.

6.5 Satellite File Operations

Because of the widespread facilities at MSFC, the Repository has established five satellite microfilm card files near large volume users. Two other files, not managed by the Repository, are included within the satellite file support structure (Table 6-1).

TABLE 6-1. MANNING OF SATELLITE FILES

Location	No. of Personnel	Remarks
P&VE (4481)	8	
P&VE (4610)	5 (EST)	Scheduled to open July 22
TEST (4666)	4	
ASTR (4487)	1	
SAT. #3 (HIC)	19	
QUAL (4708)	6	Operated by R&DO
ME (4705)	10	Operated by R&DO

These files contain microfilm aperture cards which are retrieved by file personnel for either viewing by the user or hard copy reproduction. Figure 6-3 illustrates a representative satellite file. Satellite files are established by reproducing all or part of the contents of the central file.

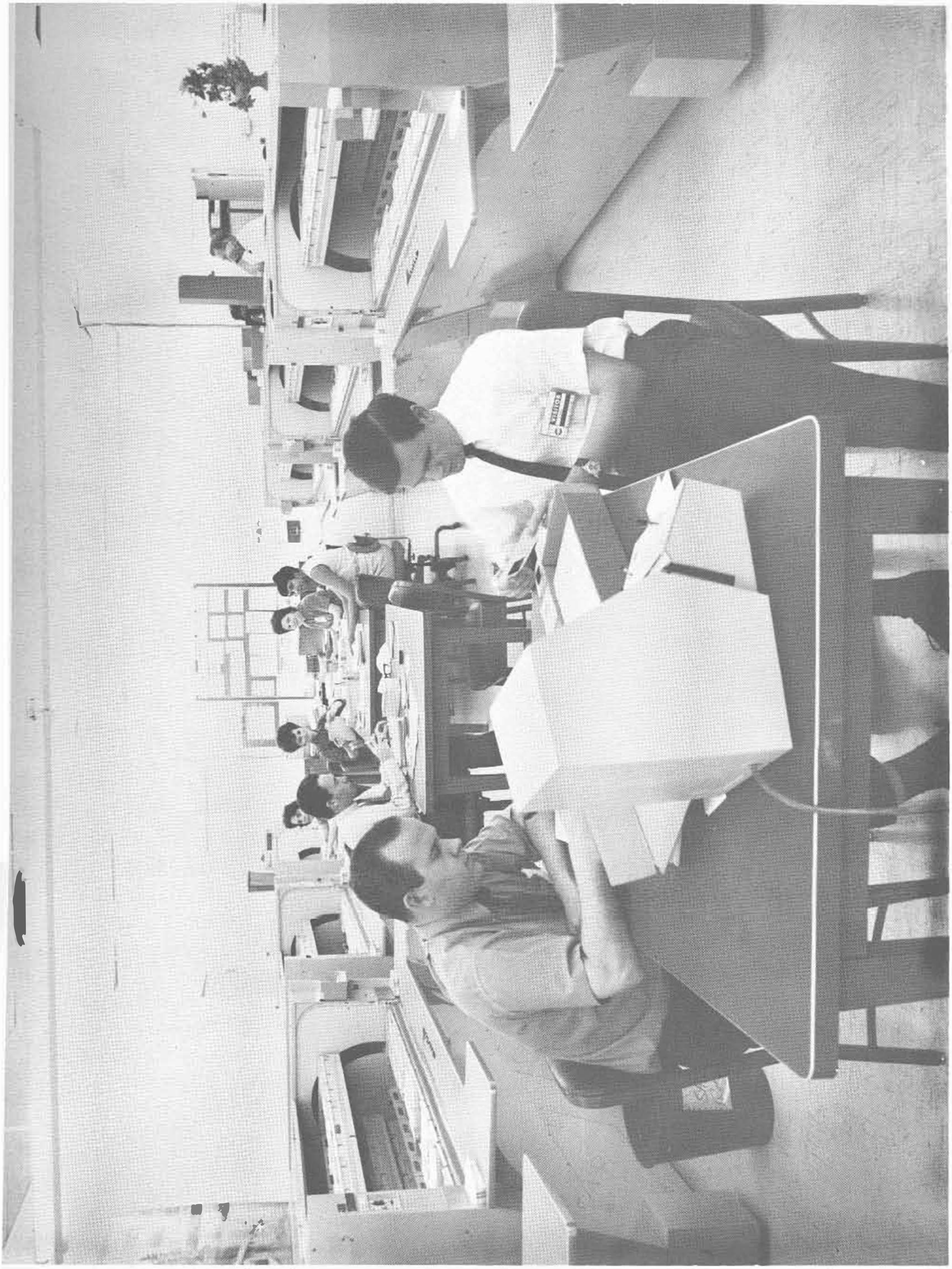


FIGURE 6-3. REPRESENTATIVE SATELLITE FILE

The satellite file concept sets out to make data more accessible to users, and to some extent this objective is accomplished. However, the cost of this approach is high. Some 53 people are employed in satellite files at MSFC. This does not include the people in the central file or the people who operate the equipment for the production of duplicate aperture cards for storage in the satellites. Without counting the cost of floor space, equipment, and supplies, the annual bill for satellite file operations is about $300,000, approximately one fourth of the total Repository operating budget. Because this cost is annually repetitive every effort should be made to reduce it while maintaining services.

6.6 Alternative Approaches

Two alternate approaches are apparent:

1. Elimination of satellite files with a commensurate (though not equal) increase in central file facilities.

2. Automation of satellite file operations by replacing files of cards with receiving devices, displays, and facsimile equipment.

The replacement of satellite files with an improved central filing and reproduction capability would almost certainly reduce operation costs by at least one-half the present cost of the satellite files. There are, however, several large "if's" associated with this approach: (1) if sufficient central floor space could be acquired, (2) if present satellite users could sacrifice 1 to 5 hours in request turnaround time, and (3) if the present users could be convinced of the feasibility of a change.

To minimize the impact of these if's, the centralized system would require an efficient and speedy courier service, a well-planned production technique in the central file/reproduction area, and a sequential ringing telephone communications system. None of the three is unattainable.

The Study Team made a thorough analysis of two approaches to this problem. The first involving manual, high-speed courier service, was found to offer savings in excess of $350,000 annually. The second, involving automated transmission of images and hard copy data, is limited at present by the sta te of the art and does not assure savings. These findings are being documented and will be issued shortly as a separate report.

6.7 Recommendations

1. Responsibility for the further development and implementation of the positive feed-back automatic distribution system should be given to the Repository. It in turn should coordinate with Data Management for the compilation of a comprehensive distribution matrix of all documentation.

2. Following final design of the improved automatic distribution system, an MSFC procedure (superceding R&D 25-1) should be prepared to describe the new discipline.

3. Procedure 25-2 should also be revised to incorporate the revisions specified in paragraph 6.4. Emphasis should be placed on simplification of data ordering.

4. An Operations Research type study should be made of the proposed centralization of satellite operations. The objectives of this study should be (1) to determine probable effectiveness of file manning cited; (2) to measure difference in delivery time between present and proposed arrangements; (3) to qualify assumptions made in discussion regarding routes and courier schedules; (4) to identify any indirect damage that may be caused by the change; and (5) to develop a comparative cost/effectiveness index. The separate report being prepared by the Study Team will provide a starter for the reccmmended effort.

SECTION VII
MASTER PLAN IMPLEMENTATION

Implementation of the Documentation Master Plan will require actions from MSFC Executives, Program Management, Data Management, and Repository Management. These actions are discussed in detail along with the rationale in the respective sections of this report and are listed in the summary.

In this section the primary actions are grouped according to the responsible activity.

7.1 Executive

The Study Team considers the following Executive actions as prerequisites to an effective coordinated MSFC documentation system:

1. Revise the basic MSFC 500-6 to include a clear concise statement of the MSFC documentation policy.

2. Provide specifically for a Center Data Manager.

3. Provide a charter for the Center Data Manager that will relate directly to NPC 500-6 provisions for intercenter data coordination.

4. Support the Center Data Manager in his efforts to implement the MSFC documentation policy.

5. Define the Program Management role in the implementation of Data Management.

7.2 Program Management

Program Management must accept its role in implementing Data Management if MSFC is to realize effective documentation control. Actions considered mandatory by the Study Team include:

1. Implementing data management and uniform data requirements on all contracts as soon as funds and program constraints permit.

2. Coordinating with Data Management and Repository Management on data release and distribution requirements.

7.3 Data Management

Data Management must provide the impetus and skill to the documentation system implementation. After the system is operating, Data Management must monitor and coordinate the system operation. Data Management must make the following contributions:

1. Design a Quality Assurance system for Class II documentation and coordinate the implementation of the system with Program Management.

2. Initiate an Ad Hoc effort to compile comprehensive document procurement specifications and document requirements descriptions.

3. Develop a MSFC total data system.

4. Coordinate the implementation of the total data system.

7.4 Repository Management

Repository Management has a vital role in effecting a sound documentation system at MSFC. The following steps should be initiated as rapidly as possible:

1. Design and implement an index to the Repository contents. Initiate a program to maintain the index.

2. Initiate an Operations Research study of the Satellite files. This study should ascertain precisely the functions served by the files, who the users are, and the purposes of the uses.

3. Catalog data users for the total Repository by purpose of use, associated organization, and types of documentation used.

4. Develop the most effective documentation distribution system possible based on the findings of the Operations Research study and an analysis of the catalog of data users.

5. Implement a Microfiche storage and retrieval system for MSFC specifications.

6. Review operation of Repository and documentation uses periodically. Adjust Repository operation to prevailing requirements.

7. Implement a documentation support program to work in conjunction with HOSC and Mission Support Operations. Experimentation with one of the sounder automated storage and retrieval systems should be initiated for this program with the goal of verifying a system concept capable of handling the total Repository contents.

8. Implement a documentation systems analysis capability to continue research on storage and retrieval systems, operations research, etc.

7.5 Implementation Schedule

This Documentation Master Plan was prepared to recommend the method and means to be employed by MSFC in documentation control for the 1966-1976 period. Uncertainty in the direction that the United States Space Effort will take beyond Lunar exploration and the status of the Apollo Applications Program insert a large number of unknown quantities into the documentation picture during the 1969-1976 period.

NASA and MSFC have been consistent in building on confirmed concepts; therefore, the Study Team has assumed that the AAP and future programs will be implemented in accordance with the Apollo Program concept. If this proves to be a sound assumption, then the only basic changes in the documentation system have been thoroughly explored in this study effort and the schedule in Table 7-1 is valid. If a substantial change of direction occurs in the respective roles of MSFC and its support contractors, a reevaluation of the effects of this change on the documentation system is mandatory.

TABLE 7-1. MASTER PLAN IMPLEMENTATION SCHEDULE

Responsible Activity	IMPLEMENT				
	1966 Cy	1967 Cy	1968 Cy	1969 Cy	1970 Cy - 1976 Cy
Executive	E1	E4			E4
	E2				
	E3				
	E5				
Program Management	PM1				PM1
	PM2				PM2
Data Management		DM1			
	DM2				
		DM3			
		DM4			DM4
Repository Management	RM1				
		RM2			
	RM3				
			RM4		
	RM5				
		RM6			RM6

BIBLIOGRAPHY

American Ordnance Association: Technical Report - Minutes of Seventh Annual Meeting, Washington, 1965.

Burns, L. L. with H. I. Jacobs and T. G. Patterson: A Proposed Corporate Program on Image Storage and Retrieval Systems, Princeton, 1966.

Dunn, Don W.: From Idea to Reality, the Apollo Program Documentation System, Chicago, 1965.

Evans, R. C. and James E. Bennett: Preliminary Engineering Report for Documentation Facility, Nashville, 1965.

General Electric Company: How to Get It - "ATIS" - Apollo Technical Information Service, Daytona Beach, 1963.

General Service Administration: Source Data Automation, Washington, 1965.

Goldston, R. L.: Documentation Requirements Plan (Draft), MSFC, 1965.

Houk, R. L.: Publication of Aircraft Maintenance and Parts Information on Microfilm, New York, 1965.

Keller, P. J.: Discussion of Information Storage and Retrieval, Ft. Wayne, 1965

Little, Arthur D., Inc.: Centralization and Documentation Final Report to the National Science Foundation, Cambridge, 1963.

Klein, E. L.: Production Control Computer Design Concept, Huntsville, 1966.

Radio Corporation of America: A Technical Information System for the Marshall Space Flight Center, Van Nuys, 1966.

Radio Corporation of America: Remote Viewing of Microfilm Cards, Huntsville, 1966.

Schnabel, Edward A.: Input Prediction Technique for MSFC Documentation Repository, Camden, 1966.

Shepherd, Lt. Col. W. C.: DOD Management of MIL-D-1000 and MIL-STD-100, Huntsville, 1965.

Sorensen, V. C.: Minutes of Briefing on MSFC Documentation Repository Operations, MSFC, 1965.

TRW: Engineering Data Management, 1965.

U S Army: Summary of "Resources for Freedom", Paley Commission Report, 1952.

van Dam, Andries: A Survey of Pictorial Data Processing Techniques and Equipments, Philadelphia, 1965.

von Braun, Wernher: The Next 20 Years of Interplanetary Exploration, NASA, 1965.

Williams, William F.: Principles of Automated Information Retrieval, Elmhurst, Ill., 1965.

MSFC DISTRIBUTION

DIR	Mr. Shepherd (Dr. von Braun)
DEP-T	Dr. Rees (Mr. Neubert)
DEP-A	Mr. Gorman
E-DIR	Mr. Maus
E-S	Mr. Smith (2)
F&D-CH	Mr. Dyhes
R-DIR	Mr. Weidner
R-OM	Mr. Fellows
R-OM-C	Mr. Klima (2)
I-DIR	Gen. O'Connor
I-CO	Mr. Hirsch
I-RM-CH	Mr. Andressen
I-RM-M	Mr. Goldston (2)
I-PL-CH	Mr. Goodrum
I-I/IB-MGR	Mr. James (3)
I-V-MGR	Dr. Rudolph (3)
I-E-MGR	Mr. Brown
I-MICH-MGR	Dr. Constan
I-MT-MGR	Mr. Balch
MS-CH	Mr. Sorensen (2)
MS-D	Mr. Garrett (10)