FINAL REPORT

TECHNICAL DATA HANDLING SURVEY

VOLUME I

REVIEW OF PROJECTED NAVY USER REQUIREMENTS AND CURRENT VENDOR CAPABILITIES

PRC R-1029

30 August 1967

Prepared for

Department of the Navy
Naval Supply Systems Command

PLANNING RESEARCH CORPORATION
LOS ANGELES, CALIFORNIA WASHINGTON, D.C.

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Universal Building North • Suite 1030 • 1875 Connecticut Avenue N.W. • Washington, D.C. 20009

FOREWORD

This study was conducted taking full advantage of the multidisciplined philosophy of PRC (Planning Research Corporation), whereby the unique capabilities of many individuals were brought to bear upon the problems resolved. Significant contributions were made by Mr. G. B. Bernstein, Project Manager, and the PRC supporting staff, consisting of Drs. H. R. Cort, Jr., R.A. Coyer, and F.M. Nelson, and Messrs. R.D. Beveridge, L.D. Campbell, C.L. Cave, E.C. Ham, D.H. Jermain, K.H. Labiner, R.J. Murawski, D.E. Peterson, E.J. Shaughnessy, and H. L. Walton.

The study was conducted under the guidance of Mr. M.A. Levine, Operations Research Analyst, Research and Development Division, Naval Supply Systems Command, without whose full cooperation and assistance this task could not have been satisfactorily completed. Appreciation is also extended to Mr. R.M. Weiss, Information Systems Program Manager, Research and Development Division, Naval Supply Systems Command, for his technical assistance during the conduct of this study.

ACKNOWLEDGMENTS

The Research and Development Division of the Naval Supply Systems Command and Planning Research Corporation wish to thank the personnel of those organizations whose cooperation and assistance have resulted in the successful conduct of this study. The organizations lending their support include:

Government

Air Force Directorate of Data Automation
Army Missile Command
Army Research Office
Commander Cruiser-Destroyer Force, U.S. Atlantic Fleet
Defense Supply Agency
General Services Administration
Naval Command Control and Communications Center
Naval Material Command
Naval Research Laboratory, Washington
Naval Ship Research and Development Center
Naval Shipyard, Boston
Naval Supply Depot, Newport
Naval Supply Systems Command
Naval Ship Engineering Center
Office of the Assistant Secretary of Defense for Installations and Logistics
Ships Parts Control Center
Social Security Administration

Educational Institutions

George Washington University
Illinois Institute of Technology
Massachusetts Institute of Technology

Vendors

Addressograph-Multilith
Alden Research
American Telephone & Telegraph
Atlantic Microfilm Corp.
Bell & Howell Business Equipment
Bryant Computer Products
Bunker-Ramo
Burroughs Corp.
California Computer Corp.
Carson Laboratories
Collins Radio
Computer Sciences Corp.
Control Data Corp.
Dasa Corp.
Data Disc, Inc.
Datamec Division of Hewlett-Packard
Digital Equipment Corp.
Documentation, Inc.
Eastman Kodak
Electro-Mechanical Research, Inc.
General Electric Company
Honeywell, 3C
Honeywell, EDP
Houston Fearless Corp.
Information Displays, Inc.
Information Handling Services, Inc.
International Business Machines Corp.
International Telephone & Telegraph
ITEK Business Products
Magne-Head
Memory Technology, Inc.
Microcard Corp.

Vendors (Continued)

Midwestern Instruments/ Telex
3M Company
Mosler Safe Co.
National Cash Register
Philco-Ford
Raytheon Company
Raytheon Computer
Radio Corp. of America
Rixon Electronics
Sanders Associates, Inc.
Scientific Data Systems
Stromberg-Carlson
Tasker Industries
Teletype Corp.
UNIVAC Division of Sperry Rand
Uptime Corporation
Xerox Corp.

ABSTRACT

This report represents the initial phase of a research study of Navy user requirements for technical data handling and the ability of the information processing industry to satisfy these requirements 5, 10, and 15 years in the future. This study fulfills a Navy requirement levied by the DOD (Department of Defense) Engineering Data Systems Standardization Committee.

The DOD Engineering Data Systems Standardization Area Assignment was established in August 1960. This program is supported by studies conducted under the auspices of DOD, the military departments, and NASA (National Aeronautics and Space Administration). The purpose of this program is to assist the Department of Defense and NASA in identifying long-range capabilities and formulating standardization goals for technical data handling and data exchange.

This report describes present and projected 5-year capabilities of the information processing industry to meet current and projected Navy user requirements for technical data handling.

Volume I is a detailed discussion of both current and projected requirements for technical data handling within a sampled segment of the Navy Shore Establishment. It also reviews currently existing information processing capabilities which may assist in the satisfaction of these requirements. Volume II contains a 5-year projection of information processing capabilities to meet the technical data handling requirements identified in Volume I. Volume II will receive restricted and limited distribution in order to protect the integrity of proprietary information contained therein.

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I. INTRODUCTION

A. Purpose

The purpose of this study is the performance of 5-year forecasts of user requirements for technical data within the Navy, and a comparison of present and future information processing capabilities available to satisfy these requirements. These forecasts will be compared in order to:

- Highlight unexploited current capabilities.
- Identify gaps and/or deficiencies in the present data processing state-of-the-art.
- Enable the establishment of long-range capabilities and standardization goals for technical data handling and exchange within the Department of Defense.

B. Scope

Until August 1960, systems for the collection, storage, retrieval, publication, and distribution of technical data within the military departments and related contractor facilities had, in general, been developed as solutions to isolated and limited problems. Little regard had been shown for standardization of information processing techniques, input/output formats, uniformity of interrogation, ready exchange of data, future user needs, or prospective advances in the information processing state-of-the-art.

On 5 August 1960, DOD (Department of Defense) established the "DOD EDS (Engineering Data Systems) Area Assignment" for the study and standardization of engineering data documented in support of research and development, design and engineering, procurement and supply, and maintenance of military material. The specific purpose of this Area Assignment was to provide an accurate assessment of then current/proposed methods employed by military activities for the mechanized processing of technical data documentation. The Department of the Army was designated as the coordinating (assignee) activity under this assignment.

Efforts in this area were greatly enhanced by the establishment, on 6 March 1964, of the "DOD Council on Technical Data and Standardization

Policy" with authority and responsibility to approve, initiate, and terminate all principal projects in this area, review the results thereof, recommend organizational structure changes, and formulate policies for promulgation through DOD directives, instructions, and revisions to ASPR (Armed Services Procurement Regulations). Assisting the Council is a working group composed of representatives from each of the military departments and from NASA (National Aeronautics and Space Administration).

Principal projects have been approved by the Council and periodically assigned to "preparing activities" (subordinate commands) within the military departments or NASA for accomplishment. Two such projects have been assigned to the Research and Development Division, Naval Supply Systems Command as "preparing activity," and represent the basis for this Planning Research Corporation study. These projects are the EDS-0007 Communications Study and the EDS-0019 Technological Forecast (5-, 10-, and 15-Year Requirements), Engineering Practice Project.

Effective 13 December 1965, Project Number EDS-0007 was canceled, and the related study to be performed became a part of Project EDS-0019.

Technical data is generated and/or used in the Navy throughout the research and development, fabrication/procurement, maintenance, and operating cycles of each weapon system employed. This study has analyzed the user requirements for such data on a selected sample basis, and has forecast for a 5-year period these requirements and the current and projected information processing technology available to satisfy these requirements.

In this environment, the Navy is being used as a model to develop a methodology for obtaining user requirements for technical data, as well as serving as the source for requirements information.

C. Order of Presentation

This report will present its analysis, synthesis, and subsequent conclusions in two volumes as follows:

1. Volume I will contain a comparison of forecasted user requirements for technical data and current state-of-the-art information processing capabilities available to satisfy those requirements.

- Navy users of technical data will be discussed on a functional basis, and the organizations (activities) selected for study will be identified and described.
- The methodology used to determine user requirements for technical data will be discussed and the forecasted requirements identified.
- The methodology used to determine the current state-of-the-art with respect to information processing techniques will be discussed, and currently available hardware and software items will be identified.
- A comparison of forecasted user requirements and currently available hardware and software items will be made, and unexploited capabilities and gaps will be identified.

2. Volume II will contain a comparison of forecasted user requirements for technical data and a projection of the information processing state-of-the-art for the same period of time and satisfying the same requirements.

- Forecasted data user requirements for technical data, identified in Volume I, will be repeated.
- Forecasted state-of-the-art with respect to information processing techniques will be discussed and hardware and software items identified.
- A comparison of forecasted user requirements and available hardware and software items will be made, and unexploited capabilities and gaps identified.
- In the light of the forecasted state-of-the-art, postulated data systems will be discussed for the year 1972.

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II. TECHNICAL DATA PROCESSING REQUIREMENTS

A. Definition of Technical Data

Technical data is used within DOD throughout the research and development, production/procurement, maintenance, operation, and retirement phases of every military item, and, for the purposes of DOD Technical Data and Standardization Programs, has been defined by DOD as follows:

> Technical data is information contained in original source documents prepared by a design authority for the disclosure and identification of configuration, design form and fit, performance, operation, reliability, maintainability, quality control, or other engineering features of items, materials, methods, practices, procedures, processes, and services. The principal types of engineering information are standards, specifications, engineering drawings, associated lists (lists of materials, parts lists, data lists, and index lists), item data sheets, performance procedures, test procedures or reports, and other documents providing data or design disclosure.

For purposes of this study, implications of the above definition will be identified and included for further definition, as follows:

1. Technical data is related to the natural sciences and engineering activities and does not include accounting, project status, inventory, or personnel information.

2. Technical data serves personnel engaged primarily at the working level in scientific, engineering, procurement, inspection, and technical organizations. Its primary purpose is not to serve supervisory or administrative personnel.

3. Technical data is either instructional (i.e., assists and instructs in maintenance procedures) or informational (i.e., provides the basis for engineering design choices). It is not data which can be manipulated in engineering or scientific calculations.

B. Definition of a Technical Data User

A technical data user, for purposes of this study, is one who participates in collecting, collating, indexing, systematizing, coordinating, integrating, screening, refining, automating, reproducing, retrieving, searching, selecting, utilizing, recording, updating, transmitting, distributing, interchanging, storing, or processing technical data as previously defined.

C. Navy Users of Technical Data

As mentioned earlier, technical data is used throughout the research and development, production/procurement, maintenance, operation, and retirement cycles of every military item. Since the Navy is organized on a functional basis (operating forces, maintenance forces, supply forces, etc.), it is quite obvious that this life cycle includes the efforts of more than one and, at times, many organizations within the Navy. Consequently, technical data users will be found within many organizations and possibly at many levels of responsibility within the Navy.

1. Organizational Levels of Users

For the purpose of identifying the organizational level of technical data users within the Navy, the Naval organization has been stratified into four major levels of activity and responsibility (see Exhibit 1). These levels include:

- Level I - SECNAV, CNO
- Level II - CNM, BUPERS, BUMED
- Level III - Systems Commands
- Level IV - Field Activities

Although the DOD definition of technical data applies to all military items, we shall, for the purpose of this study, restrict our efforts to weapon systems only. This rationale is employed because weapon systems represent an overwhelming percent of all military items and the military departments are generally organized around weapon systems. Within the Navy, weapon systems can be generally classified as missiles, aircraft, and ships.

As noted above, the Navy organization can be stratified on a weapon system basis and consequently, each of the four levels of activity and responsibility identified can be further defined as relating to missiles, aircraft, or ships. The specific action performed at each organization level with respect to each weapon system may be very different, but the functions performed will be identical.

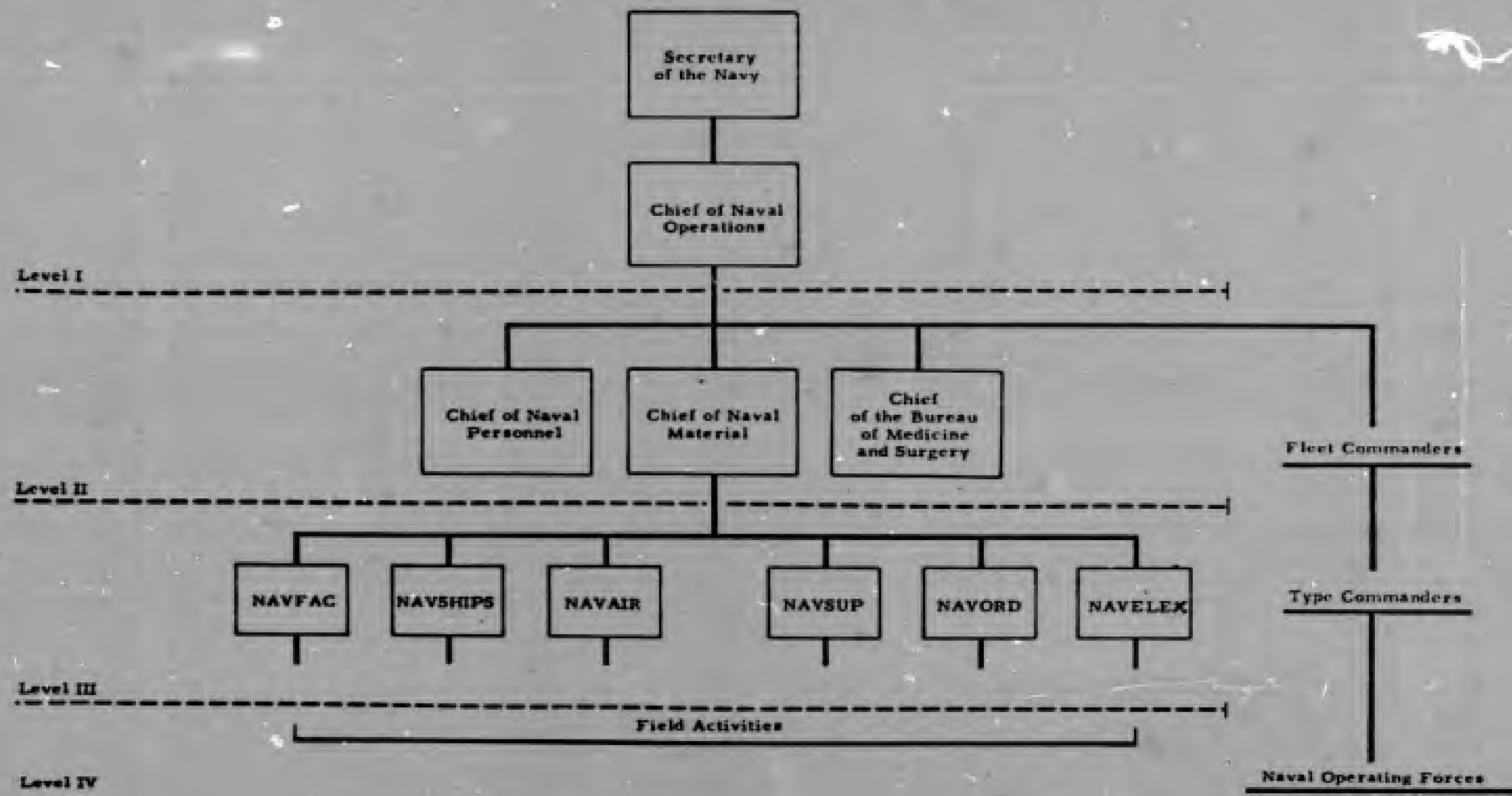

EXHIBIT 1 - U.S. NAVY ORGANIZATION CHART

Due to the limitations of time and resources, this study is devoted solely to the ships' weapon systems. The same limitations prevent this study from exploring the Naval Operating Forces for possible users of technical data. All further discussions and conclusions are so directed.

a. Level I - SECNAV, CNO

This level includes the offices of SECNAV (Secretary of the Navy) and CNO (Chief of Naval Operations). The primary functions performed are the establishment of Navy policy and planning, such as the preparation of ship development objectives, mission analysis, cost-effectiveness analysis of ship weapon system concepts versus competing weapon systems, ship concept determination, specific ship requirements, related program change proposals, and subsequent operating and maintenance patterns.

While it is difficult to determine precisely the amount and/or format of technical data used, it can be assumed that, in most cases, it is of a highly summarized nature.

b. Level II - CNM, BUMED, BUPERS

This level includes the offices of CNM (Chief of Naval Material, BUMED (Chief of the Bureau of Medicine and Surgery), and BUPERS (Chief of Naval Personnel). The primary functions performed are the management of the efforts of all the systems commands and the establishment of personnel and medical policy and programs.

Again, it is difficult to determine precisely the amount and/or format of technical data used. It is assumed that, in this case, also, the data is of a highly summarized nature.

Our definition of technical data, for purposes of this study, precludes accounting, project status, inventory, and personnel information. Technical data, therefore, does not serve supervisory or administrative personnel, and thus Levels I and II will not be considered further.

c. Level III - Systems Commands

This level includes NAVFAC (Naval Facilities Engineering Command), NAVSHIPS (Naval Ship Systems Command), NAVAIR (Naval Air

Systems Command), NAVSUP (Naval Supply Systems Command), NAVORD (Naval Ordnance Systems Command), and NAVELEX (Naval Electronic Systems Command). These commands have prime responsibility for the research and development, procurement/fabrication, maintainability, and reliability of weapon systems. Each systems command has, to some extent, a specific responsibility dependent upon the type of ship under consideration.

Technical data is used extensively throughout the technical commands, both in summary format and in detail.

d. Level IV - Field Activities

Field activities, for the purpose of this study, represent organizations and/or activities subordinate to the systems commands, such as engineering laboratories, shipyards, ship bases, supply depots, and inventory control points. Technical data is used extensively and in great detail throughout the field activities.

2. Functional Levels of Users

Within Levels III and IV, all activities can be related to a phase in the life cycle of a weapon system, and to a specific function performed (see Exhibit 2).

a. Weapon System Life Cycle Phase

While weapon system life cycle phases, for purposes of planning and budgeting, are defined as RDT&E (Research Development, Test, and Evaluation), Procurement, and Operation and Maintenance, these phases have been slightly modified for this study to permit better definition of technical data users, as follows:

- Research Development, Test, and Evaluation (RDT&E).
- Procurement (includes production).
- Deployment (includes maintenance and operations).
- Retirement (inventory, sale, or exchange of equipments declared surplus).

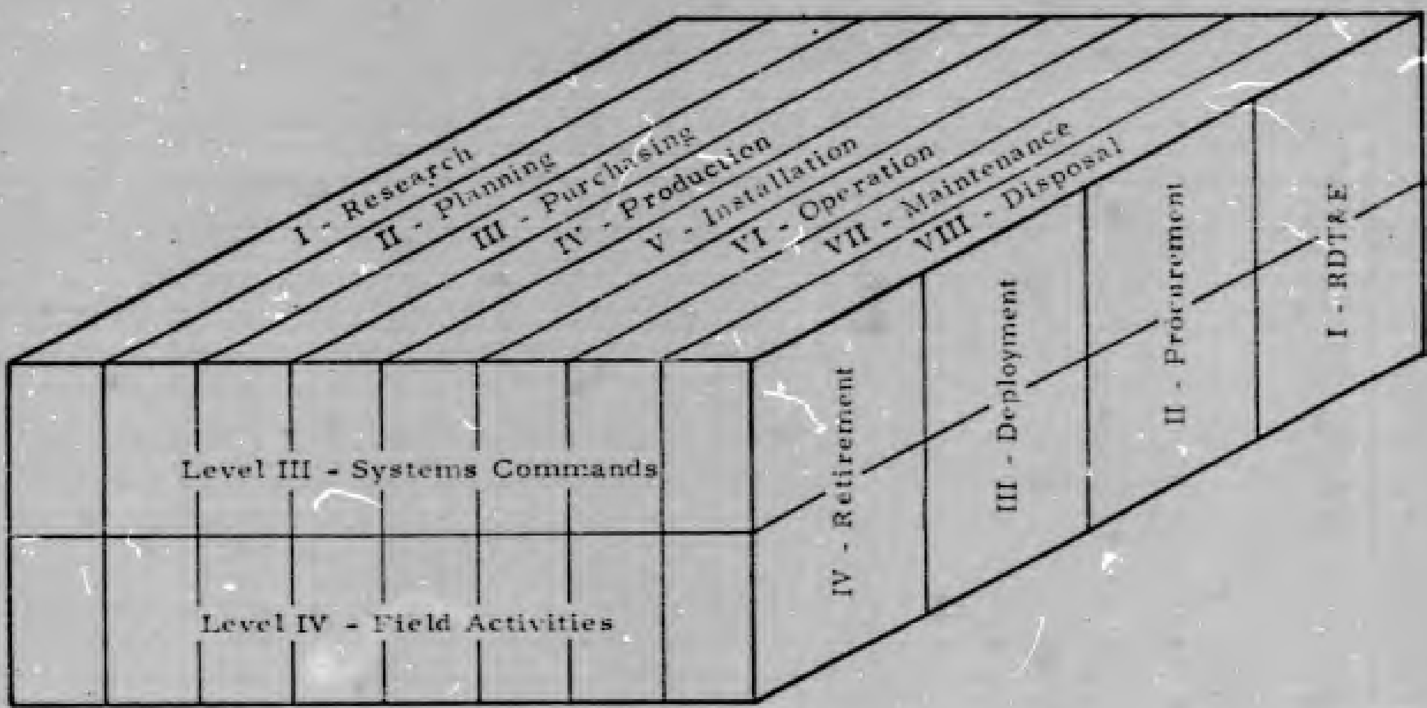

EXHIBIT 2 - TECHNICAL DATA USERS ORGANIZATION, WEAPON SYSTEM LIFE CYCLE, FUNCTION

b. <u>Functions Performed</u>

Within each weapon system life cycle phase, many functions are performed continuously or periodically by the responsible organizations and/or activities. The following list of functions prepared for study purposes is intended to be reasonable, but not all-inclusive: research, planning, purchasing, production, installation, operation, maintenance, and disposal.

Construction of a matrix of organizational and functional levels of technical data users (see Exhibit 2) permits better identification of the total population of such users within the Navy, as defined earlier in this study, and suggests a systematic approach to selection of specific areas for further analysis.

D. <u>Organizations (Activities) Selected for Study</u>

The majority of earlier technical data user requirement studies have concentrated on the functional areas of weapon systems research and planning within the RDT&E phase of the weapon system life cycle. This area appeared to be the appropriate starting place for studies of this nature.

A review of total Navy operations, however, translated into dollars for comparative purposes, indicates that almost two-thirds of all Navy efforts lie in the operations and maintenance area. The balance of Navy efforts represents RDT&E and procurement, as follows:

	Appropriation Bill for FY 1968 (In Billions)	Percent
Personnel	$ 4.1	
O&M	4.6	
Other procurement	2.3	
Subtotal	11.0	64
Procurement	4.4	
RDT&E	1.8	
Subtotal	6.2	36
Total	$17.2	100

Technical information is used extensively in ship maintenance areas, and is especially relative to scheduled repairs, nonscheduled repairs, alterations, and FRAM's (Fleet Repair and Modernization Programs). Consequently, this study has been directed so as to emphasize maintenance activities and yet not ignore the research and planning areas.

The following organizations (activities) were chosen for study:

Area	Organization	Abbreviation
Maintenance	U.S. Naval Ships Parts Control Center Mechanicsburg, Pennsylvania	SPCC
Maintenance	U.S. Naval Supply Depot Newport, Rhode Island	NSD-NPT
Maintenance	Boston Naval Shipyard Boston, Massachusetts	BNSY
Research and Planning.	Naval Ships Research and Development Center, Carderock, Maryland	NSRDC

E. Data Collection

Data was collected by means of (1) a review of literature available from previous and contemporary user requirement studies, and (2) interviewing personnel from the organizations (activities) selected for study.

1. Literature Review

Available documentation was reviewed for techniques, ideas, and viewpoints having project application. In so doing, it was possible to identify potential problems and define study constraints. It was the general consensus of many authors that user needs for technical data are neither broadly known nor well understood despite the wealth of studies on this subject.

Significant findings from the literature review are broadly categorized under the headings of: (a) Identification of Users, (b) Environment of Users, (c) Characteristics of Users, and (d) Conclusions.

a. Identification of Users

Several papers emphasized that there is no such person as the "user." It was pointed out that in considering the requirements and needs of the "user," one deals with an abstraction, and as an abstraction, "user" means different things to different people. Users, therefore, are many-faceted individuals with real requirements, arising from real problems, and requiring real solutions. This probably explains why user needs are neither broadly known nor well understood. Under these circumstances, it appears that user requirements must be determined by placing the user in his operational context (i.e., as an interacting component in an information storage and retrieval system).

In numerous instances, user studies suffered from the weakness of data based solely on the opinions of users. The deficiency here lies in the generally accepted thesis that the user may not, and probably does not, have an adequate basis for rendering a reliable opinion as to the type or characteristics of information services required, since he may have little, if any, appreciation of the total operational system. As a result, reliability and validity of such user inputs may be suspect. Individual papers admitted this possibility and endeavored to offset these shortcomings in various ways. Recognition of the problem's existence with its many ramifications was generally considered to be sufficient warning for the reader.

One paper reports that, in many cases, the designer of an information storage and retrieval system gathers data on user needs for information by introspecting his own needs and by collecting the introspective reports of a few people. In general, some researchers noted that users are characterized by their value to their office or agency and are selected from such highly ranked individuals as R&D scientists, engineers with advanced degrees, specialists, and lower management. Further, it is assumed that the higher the user's level and value to his organization, the more complex his task and its information requirements. This leads to one substantial conclusion--that the term "user" is an abstraction and must be handled accordingly.

b. Environment of Users

The majority of papers concentrated on the technical data requirements associated with the RDT&E phase of weapon system development. The premise adopted is that the RDT&E population is quite heterogeneous in that it is engaged in a variety of tasks which are encompassed by the broad range of this phase. The charter for the DOD User Needs Phase I Study prescribed that efforts be limited to the information needs of DOD personnel engaged in RDT&E activities. This charter authorized the performance of a comprehensive survey of RDT&E personnel in DOD to determine how these individuals acquire and utilize technical and scientific information in the specific tasks associated with their work. It also sought answers to the manner in which scientific and technical information is processed, packaged, and delivered to engineers and scientists. This study was intended to be exploratory in nature and attempted to structure and describe the nebulous process of the flow of scientific and technical information within DOD.

The DOD User Needs Phase II Study was limited to an investigation of the Nation's defense industry to determine its information needs and flow of scientific and technical information inherent in satisfying user needs in research, development, and production. DOD considered that the combined in-house and industry population represented the universe of originators and users of DOD scientific and technical information. It appears that DOD considers the tasks to be more complex in the RDT&E phase of the cycle; that information is needed in greater formality and detail during this phase; and that such information takes longer to acquire. Significant results of these two DOD studies will be provided later in this review.

It is pertinent to note that one paper gave cognizance to a weapon system life cycle phase downstream from RDT&E. This study mentioned briefly the user needs associated with the logistics cycle phase. The logistics cycle, in this instance, incorporated the tasks involved in the production, supply, and maintenance areas. However, other than a brief mention of user needs in this context, little penetration was made.

Still another study reported that priority of effort in the study of user needs should be assigned to the development phase of the RDT&E cycle. It is taken for granted that the universal use of technical data throughout the RDT&E effort is a measure of its importance. The use of technical data during life cycle phases following RDT&E has not been investigated to any great extent.

c. Characteristics of Users

Information gathering habit studies reveal that a significant portion of scientists maintain personal files of technical data. Between one-half to two-thirds of the surveyed technical data users had and/or used personal files. Another study concluded that nearly every technical data user surveyed kept a personal file in the form of reprints, abstracts, or notes on cards. The average rate of growth of the 26 collections investigated was 330 items per year. Still another study, pertaining to the information needs of DOD scientists and engineers, advised that close to 20 percent of the interviewees utilized personal files as their first source of information, while over one-half relied on their local environment personal files, departmental files, and colleagues as a first source of information.

The DOD User Needs Phase II Study reported that technical data users first searched for information within their local environment. Thus, it can be concluded that informal information systems consisting of the user's personal files, his colleagues, and other local sources of information are the norm rather than the exception for initial technical data searches.

The literature also supports the conclusion that the need for an orderly arrangement of technical data for users is universally accepted. This arrangement should be constructed in a manner consistent with operational experience. However, it appears probable that improvements and expansion in accessibility, scope, standardization, and efficiency of information services will not completely supplant the need for building and maintaining personal collections that reflect unique individual requirements and habits of work.

Several studies disclosed that with more time available for a task and for the acquisition of information, the user tends to be more demanding in regard to the organization of the media conveying the information and the volume of information required.

Various surveys raised questions regarding the education, experience, and job characteristics of the users of technical data. Researchers wanted to know the nature of the user's tasks and the information wanted and used to perform these tasks.

Ongoing studies are raising similar questions. While answers are not available at this writing, it is expected that results will confirm many of the general conclusions reached in preceding surveys.

d. Conclusions

Six conclusions emerge as guideposts from the literature reviewed, particularly Phases I and II of the DOD User Needs Study:

- Considerable spadework has been done in the field of user requirements, but much more remains to be done.
- Users are many-faceted individuals with real requirements, arising from real problems, and requiring real solutions.
- There will continue to be a desire for building and maintaining personal collections of technical data that reflect individual requirements.
- The user considers his local work environment his most important first source for information.
- Data analysis prior to the distribution of information is important in a technical program.
- The user is never completely satisfied with his ability to obtain information.

2. Interviews of Personnel at Selected Organizations

An objective of this study is to obtain user requirements data from operational and data surveying personnel by discussing their current functions and by placing them in hypothetical situations. The responses to such leading questions concerning actual and postulated backgrounds could then be used to provide the basis for forecasting future user requirements.

a. Interview Guide - Phase I

Consultation with PRC human factors specialists indicated that sampled personnel are likely to be significantly more motivated in their start that questionnaires would not be employed; it was assumed that the probability of success in gathering data would be heightened by evolving a project-oriented interview guide. During each stage of the guide's development, proven effective interviewing techniques were to be utilized.

A loosely structured interview guide was developed by the human factors team, and was designed primarily to remind the interviewer of the purpose behind each question asked. This required the interviewer to explain the intent of the question in the context of its application to the interviewee's functions. The layout of the guide was designed to facilitate response categorization and recording.

The first generation guide (see Exhibit 3) was developed both as an aid in training the interviewers and as a model for pilot testing under actual field conditions. In its original form, ample room was provided between questions to record answers. Subsection C, File Specification Data, was repeated for each file related to the interviewee's function.

b. Qualifications of Interviewers

It was considered essential that those persons selected to perform the interviews demonstrate the following specific qualities: high intelligence, technical background, interviewing experience, pleasing personality, tasteful appearance, dependability, diplomacy, self-sufficiency, and empathy.

It was also necessary for the human factors specialists to train the interviewing team in the specific techniques to be employed. This training program was substantially formalized, having been developed and applied on previous large-scale PRC survey projects, and spanned 1 week. It consisted of 3 days of classroom training and 2 days of practice interviewing under simulated field conditions. The classroom training was provided to four candidate interviewers and discussed such topics as:

- How to negotiate interview appointments.
- A detailed explanation and clarification of each question.
- How to establish rapport with an interviewee.

EXHIBIT 3 - USER INTERVIEW GUIDE (FIRST GENERATION)

Interview Code ____________
Date, NN, Initials

A. Identification

Activity Name ____________ Location ________ Date ____________
Day-Month-Year

Respondent ____________________________ Interviewer ____________
Name Rank/Grade Initials

Position ____________________________ Phone ____________
Title Code

Initial Interview? ________ Yes ________ No ____________

(If No, Cross-Reference Prior Interview Code(s)) ____________

Number of Personnel Assigned ____________

Organization Chart Requested? ____________ Obtained? ____________

Overall Activity Mission Description Requested? ______ Obtained? ______

Job or Billet Description Requested? ________ Obtained? ____________

Telephone Directory Requested? ____________ Obtained? ____________

Future Action ____________

Remarks:

References ____
Name Title/Code Location/Phone

____
Name Title/Code Location/Phone

____
Name Title/Code Location/Phone

____
Name Title/Code Location/Phone

EXHIBIT 3 (Continued)

B. Activity Function

Principal Mission or Function:

(Checks)

Inventory Control Point ____

Naval Supply Center ____

Naval Supply Depot ____

Naval Supply Facility ____

Type Commander ____

Repair Facility ____

Data Processing Installation ____

Research Laboratory ____

Management ____

Planning ____

Other (Describe) ____

Interviewed?

Mission(s) or Function(s) Supported: ____

____

____

____

____

Interviewed?

Activities Supporting This Activity ____

____

____

____

How long is this activity in existence? ____ (Years)

What, if any, are proposed changes in function, and when are these expected? ____

____

Remarks: ____

____

____

EXHIBIT 3 (Continued)

C. File Specification Data

1. File name, including a brief description of its purpose.

2. File status: operational, in development, or in planning stage.

3. File location.

4. Number of personnel responsible for file's maintenance. Includes a description of maintenance activities, skill levels, training status, and percent of time spent on maintenance activity.

5. Number of man-hours per month spent on file maintenance.

6. Identification of processes requiring this file as input.

7. Hours per day of file use.

8. Number of accessions to file per day.

9. Identify inputs to this file, including rate of intake.

10. Identify outputs created from this file, including rate of output.

11. Number of records per accession.

12. Average number of records continuously on file and the rate at which the file is growing.

13. Unit record media: cards, tape, drum, bound volume, index file, film, aperture cards, etc.

14. Average record length: bits, characters, groups, lines, pages, cards, tapes, etc.

15. File format: fixed, variable, or unformatted.

16. Record format: fixed, variable, or unformatted.

17. Indexing parameters: federal stock number, federal item identification number, requisition number, activity code, drawing number, etc.

- How to direct the train of conversation.
- A complete explanation of the purpose of each question in the guide.
- Background material on each question to facilitate communication with the interviewee.

c. Pilot Test Methodology

A pilot test was conducted under field conditions at SPCC, Mechanicsburg, Pennsylvania. Evaluation of the results of this test led to three conclusions:

- The degree of success in obtaining the desired information was due to the exceptionally fine understanding of present and future files and file interrelationships by SPCC personnel. This understanding has been promoted by their extensive participation in the UICP (Uniform Inventory Control Point) program. The interviewers suspected that personnel at most of the selected activities would not be in this enviable position, thus bringing into question the future effectiveness of the first generation interview guide.
- It was also noted that the first generation guide did not fully satisfy its intended purpose. A significant percentage of the desired information was gathered outside the scope of the guide. These additional items of information were noted because of an unusually intimate knowledge of SPCC files and operations possessed by several members of the interviewin staff.
- Experience showed Section C of the first generation interview guide to be too highly oriented to data processing for activity-wide usage, but not providing all of the data processing type of inputs required.

These conclusions led to several sweeping changes in the structure of the interview guide. The development of the second generation version (see Exhibit 4) was based on the following decisions:

- Section A, Identification, and Section B, Activity Function, were considered to require no change.
- Section C, File Specification Data, was considered satisfactory for eliciting file-oriented data from data processing personnel,

EXHIBIT 4 - USER INTERVIEW GUIDE (SECOND GENERATION)

Interview Code ______________
Date, NN, Initials

A. Identification

Activity Name ______________ Location ____________ Date ______________
Day-Month-Year

Respondent ______________________________ Interviewer ____________
Name Rank/Grade Initials

Position ______________________________ Phone ______________
Title Code

Initial Interview? __________ Yes __________ No ______________

(If No, Cross-Reference Prior Interview Code(s)) ______________

Number of Personnel Assigned ______________________________

Organization Chart Requested? ______________ Obtained? ______________

Overall Activity Mission Description Requested? ______ Obtained? ______

Job or Billet Description Requested? ______________ Obtained? ______________

Telephone Directory Requested? ______________ Obtained? ______________

Future Action ______________________

Remarks:

References ____
Name Title/Code Location/Phone

____
Name Title/Code Location/Phone

____
Name Title/Code Location/Phone

____
Name Title/Code Location/Phone

EXHIBIT 4 (Continued)

B. Activity Function

Principal Mission or Function: (Checks)

Inventory Control Point ________

Naval Supply Center ________

Naval Supply Depot ________

Naval Supply Facility ________

Type Commander ________

Repair Facility ________

Data Processing Installation ________

Research Laboratory ________

Management ________

Planning ________

Other (Describe) ________

Interviewed?

Mission(s) or Function(s) Supported: ________

____

____

____

____

Interviewed?

Activities Supporting This Activity ________

____

____

____

How long is this activity in existence? ________ (Years)

What, if any, are proposed changes in function, and when are these expected? ________

____

Remarks: ________

____

____

EXHIBIT 4 (Continued)

C. Data Processing Personnel

1. File Specification Data

a. File name, including a brief description of its purpose.

b. File status: operational, in development, or in planning stage.

c. File location.

d. Number of personnel responsible for file's maintenance. Includes a description of maintenance activities, skill levels, training status, and percent of time spent on maintenance activity.

e. Number of man-hours per month spent on file maintenance.

f. Identification of processes requiring this file as input.

g. Hours per day of file use.

h. Number of accessions to file per day.

i. Identify inputs to this file, including rate of intake.

j. Identify outputs created from this file, including rate of output.

k. Number of records per accession.

l. Average number of records continuously on file and the rate at which the file is growing.

m. Unit record media: cards, tape, drum, bound volume, index file, film, aperture cards, etc.

n. Average record length: bits, characters, groups, lines pages, cards, tapes, etc.

o. File format: fixed, variable, or unformatted.

p. Record format: fixed, variable, or unformatted.

q. Indexing parameters: federal stock number, federal item identification number, requisition number, activity code, drawing number, etc.

EXHIBIT 4 (Continued)

2. Resources (Continue on additional sheets if necessary)

a. Hardware

Computers - Mainframe

Manufacturer	Model	Status	Increase or Decrease Planned		Replace By	
			Number	Projected Date	Manufacturer	Model Number
1.						
2.						
3.						
4.						
5.						

Peripheral - By Line Numbers Above

Tape Drives		Disks			Drums			Auxiliary Random Storage			
Model	Number	Model	Number	Capacity	Model	Number	Capacity	Model	Number	Capacity	Type
1.											
2.											
3.											
4.											
5.											

Terminals - Displays - Printers - Typewriters

Type	Manufacturer	Model	Number	If Remote, Specify Where	Status
1.					
2.					
3.					
4.					
5.					

Special Devices - OCR, Microfilm, etc.

Type	Manufacturer	Model	Number	Principal Application	Status
1.					
2.					
3.					
4.					
5.					

EXHIBIT 4 (Continued)

Third Generation Equipment Installed__________ Planned__________

Improved Third Generation Equipment Installed__________ Planned______

Fourth Generation Equipment Installed__________ Planned__________

EAM - Support Equipment

Manufacturer	Model	Description	Number Installed	Number Planned	Principal Application	Use	Status

Remarks:

b. Software

MCS - Operating Systems Used

Computer	Operating System	Language	Percent Used	Principal Application	Developed By

Programing Languages

Language	Type	Percent of Use	Applications	Computers	Status

EXHIBIT 4 (Continued)

b. Software (Continued)

Utility and Service Routines

Computer	Language	Applications	Developed By

c. Inputs to Activity:

Sources

Name	Location	Present or Future Data Link	Reason for Sending These Data	Type of Information

Items

Input	Item	Source	Format	Form Received	Volume/ Time	Frequency	Automatic Status	Data Base?	Description Obtained

EXHIBIT 4 (Continued)

d. Procedures and Processes

File Maintenance and Retrieval

File	Maintenance and Retrieval Program	Computer	Status	Usage Frequency			Volumes	
				Update	Retrieval	Purge	Update	Retrieval

Applications Programs

Name	Language	Purpose	Computer	Status	Developed By	Percent of Overall Usage

What redesign, addition, or conversion of program repertoire is contemplated?

Program Name	Application	Type Change	Expected Date	By Whom

e. Products of Facility

Product	Initiation (Cause)	Type Output	User/ Requester	Frequency	Volume of Product	Form	File or Data Base(s)

User

Name	Location	Present or Future Data Link	Final Dissemination or Input to Other Process	Status	Anticipated Changes

Remarks:

EXHIBIT 4 (Continued)

D. Operational Personnel

1. What is the principal function of your work group?

2. a. What are some of the tasks performed?
   b. What data are you involved with?

3. a. Who are the present/expected customers?
   b. Are present/future products adequate for customer needs?
   c. Are customers equipped to handle product?

4. a. Do you currently have an established data base?
   b. If so, what techniques are available for extracting information from it?
      (1) What percentage manual retrieval?
      (2) What percentage automated retrieval?
   c. Are available techniques adequate?
   d. What would you like concerning data and retrieval?

5. a. What kind of response time do you get from your system, and response time for what?
   b. What sort of response time do/(will) you need from system?
   c. What other users are there/will there be for system? Are they customers or competitors for machine time?
   d. What is the priority system, if any?

6. Do you have any special security considerations?

7. What are your reporting requirements?
   a. Kind?
   b. Frequency?
   c. General content?
   d. Recipient?
   e. Are reports part of a larger system?

8. What are the constraints on your operations?

9. What reference material do you use?
   a. Industrial?
   b. In-house or special?

10. What percent of your activity's time is spent referencing source material?

11. Given a referenced data base(s), what time factors are involved for updating?

12. Would you find historical data useful (e.g., procurement history, costs, demand, requisition, and status file)?
    a. What timeframe maintained if you have/had a historical file?
    b. How often updated if you have/had file?

EXHIBIT 4 (Continued)

13. Do you maintain a hard-copy file?

14. Name some of your biggest headaches.
    a. Volume?
    b. Variety?
    c. Turnaround?

15. Can you identify interface problems with personnel, environmental conditions, etc.?

16. Have you evolved any measures of performance to assist you in scheduling/planning?

17. What technological developments do you believe would help you solve your problems and how (e.g., could you use a system with centralized computer, remotes, AUTODIN, VSMF for interactive communications, or any other system in existence or development)?

18. How would standardization help you and in what areas (e.g., reporting formats)?

19. Do you expect any changes in your function or facilities?

Supply-Oriented Questions - Discussion Topics

1. Stock availability list.
2. How often must item be requested before it is stocked as standard?
3. When is item ordered in bulk?
4. Part delivery.
5. More accurate allowance lists.
6. Disposal of over-ordered items, shelf time.
7. Program library for access or exchange with other activities.

but was not applicable for operational personnel, and now appears as item 1 of Section C, Data Processing Personnel. Here again, in actual practice Item 1 was repeated for each file.

- Item 2 of Section C, Resources, was designed to quantify information about present and anticipated activity data processing resources. Item 2 segregates data processing resources into five elements: hardware, software, inputs, processes and procedures, and products.

- Section D, Operational Personnel, was designed considering the Navy model previously described. This segment of the interview guide follows a functional approach. It is intended to elicit information about the volume and variety of technical data required by operational personnel in performing their primary functions. It asks detailed questions concerning operational response time requirements, reference materials, security considerations, etc. Note that a special series of questions appears at the end of this section reserved for supply personnel. Here again, this section of the exhibit has been consolidated to conserve space. In actual practice, the questions appeared with sufficient space between them to record answers. Section D was repeated for each operational type interviewed.

The second generation interview guide was utilized at Naval Shipyard, Boston; Naval Ship Research and Development Center, Carderock, Maryland; and Navy Supply Depot, Newport, Rhode Island. All of the activities interviewed extended substantial cooperation to the interviewers, which, coupled with an interview guide modified to consider field experience, made possible the collection of a reasonably reliable data bank upon which to base our conclusions.

F. Technical Data User Requirements Determined

As noted earlier, the following organizations (activities) were chosen for study: (1) U.S. Naval Ships Parts Control Center, Mechanicsburg, Pennsylvania; (2) U.S. Naval Supply Depot, Newport, Rhode Island; (3) U.S. Naval Shipyard, Boston, Massachusetts; and (4) U.S. Naval Ship Research and Development Center, Carderock, Maryland.

The Research and Development Division, Naval Supply Systems Command, made arrangements for PRC personnel to visit each activity. A selected audience of function managers was determined at each activity and given a presentation outlining the purpose, scope, and desired results of this study. Subsequent to this presentation, PRC personnel, working with the Navy planning personnel at each activity, determined a list of appropriate personnel in selected Navy functions to be interviewed and a schedule for these interviews. PRC performed the interviews at a later date, making full use of the qualified personnel and "User Interview Guide" described earlier in this study.

The data collected through these interviews indicated that the activities surveyed have a substantial involvement with technical data, especially in the areas of engineering drawings, technical or instruction manuals, and parts information (see Appendix A). These data are discussed in detail for each activity in the following subsections.

1. U.S. Naval Ships Parts Control Center

a. Current

(1) Introduction

SPCC (Ships Parts Control Center) is an ICP (Inventory Control Point) and a field activity under the administrative control of NAVSUP and the technical direction of both NAVSHIPS and NAVORD. SPCC supports the maintenance of ships' hull, mechanical, and electrical systems and equipment throughout the deployment life cycle phase. The principal mission of SPCC is: (1) to project spare parts requirements, Navy-wide, in support of a variety of hull, mechanical, and electrical equipment and weapons; (2) to direct distribution and procure material to satisfy the present and future Navy-wide requirements for equipment and weapons; and (3) to develop the technical documentation required to insure continuous and effective operation and readiness of the U.S. Fleet. In addition, SPCC also directs a worldwide distribution system for items needed to support the operating fleet, naval shipyards, tenders and repair ships, and other governmental agencies, as well as navies of friendly nations.

From the organization chart (Exhibit 5), it can be seen that SPCC is composed of 13 operational and administrative divisions. The scope of this

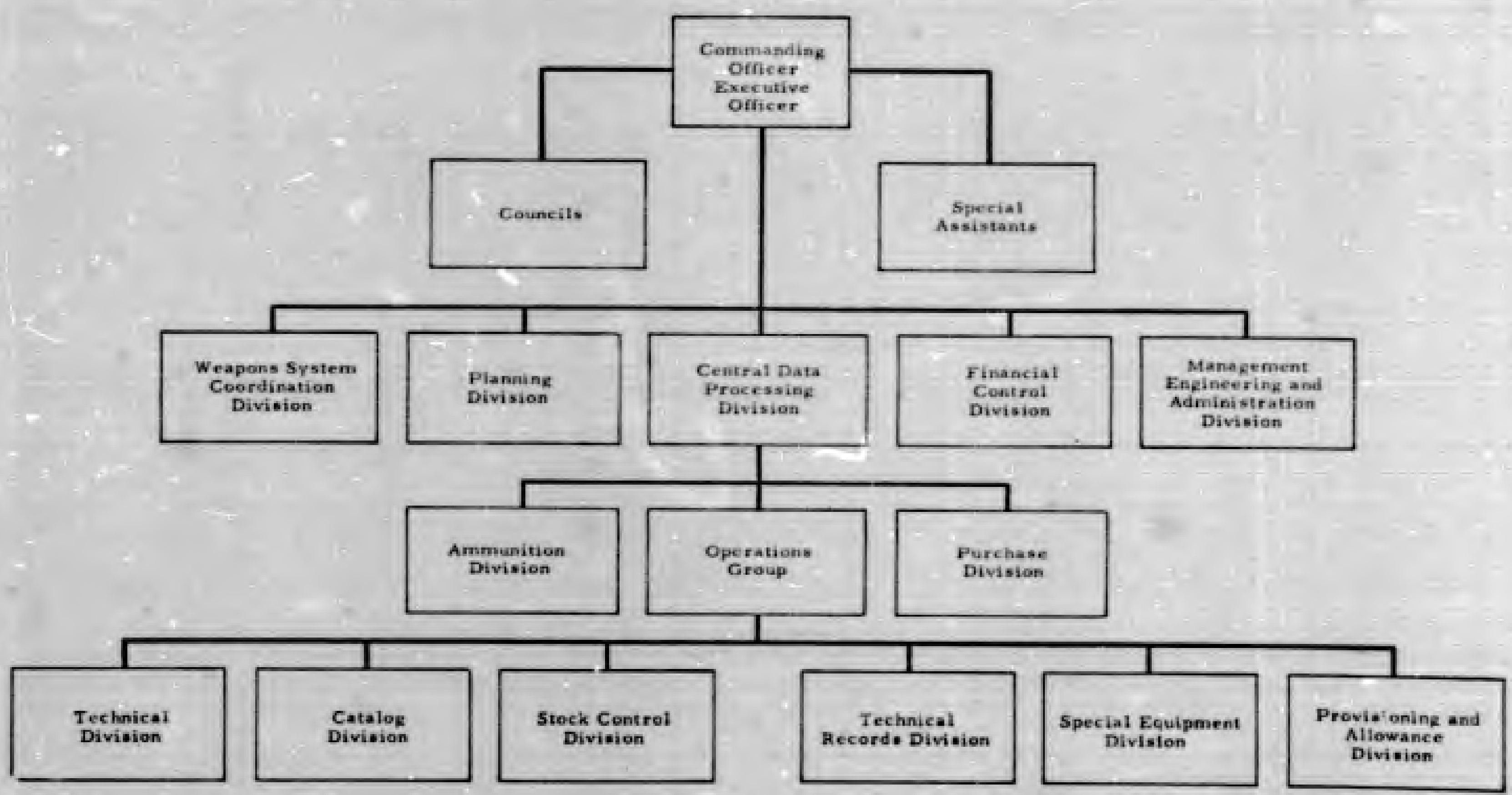

EXHIBIT 5 - SHIPS PARTS CONTROL CENTER ORGANIZATION CHART

effort can be appreciated from the fact that the inventory managed by SPCC consists of over 273,700 items, with a total value approximating $2.6 billion. Last year, this facility identified and processed requirements for an estimated 3 million parts.

In order to assist SPCC in the processing of this vast amount of information, the Central Data Processing Division (Code 710) operates and provides an in-house ADP facility consisting of two UNIVAC 490 systems with associated printers, drums, Fastrand, and tape drives, together with a Burroughs B283 system and its satellite equipment. This division also operates an IBM System/360 Mod 30 and a Mod 65, as well as an IBM 7080 and 1410, in support of other onsite Naval activities and some of the SPCC technical files. The Central Data Processing Division provides programs, records, files, reports, and statistical information to all other divisions of SPCC, in addition to NSD (Naval Supply Depot), Mechanicsburg, FMSO (Fleet Material Support Office), and MSO (Maintenance Support Office). In this regard, Code 710 maintains approximately 50 separate files, comprising in excess of 350 tape reels and consisting of more than 20 million records which must be updated on a schedule varying from weekly to quarterly.

The Technical Records Division (Code 850) maintains the technical records and files and provides inputs to Code 710. Among the more important files and records maintained (discussed more fully in the following sections) are the CCR (Component Characteristic Record), CPR (Component-to-Part Record), APL's (Allowance Parts Lists), COSAL (Coordinated Shipboard Allowance List), TPCR (Technical Parts Change Record), CSCR (Composite Ship-to-Component Record), MVSR (Master Vessel Status Record), and the Component/Accessory File. These files are maintained in various states of automation, ranging from 5- by 8-inch index and EAM cards to fully automated systems utilizing magnetic tape inputs.

The Technical Records Division also maintains an extensive technical library, containing over 7 million engineering drawings on microfilm, more than 1 million paper drawings, 200,000 instruction manuals, and 11,000 volumes of Ship Allowance Lists, in addition to thousands of specifications, indexes, etc. The growth rate of these documents is in itself impressive, with more than 145,000 drawings and 6,000 instruction manuals added yearly.

In the accomplishment of its stated mission, SPCC performs a variety of functions utilizing many different types of data. With respect to this study, and within the definition of technical data employed here, the functions of the Technical, Purchase, and Catalog Divisions will be considered and analyzed as users of technical data within SPCC. It is pertinent to note that SPCC is also an originator of technical data in that it develops allowance lists for ship repair parts and components, prepares equipment descriptions, and furnishes input to federal catalog programs.

The impact of technical data availability upon the standardization of component/equipment, and the projected requirements for this technical information, are considered to fall within the scope of this study. The impact of the standardization of technical data in support of the research/development, design/engineering, procurement/supply, and maintenance functions, as they apply to SPCC, cannot be ignored. Finally, the utilization of technical data as it applies to the functional requirements of SPCC in the area of configuration identification/configuration management will be discussed in a later section.

(2) Technical Division (830)

(a) Introduction

The Technical Division conducts special equipment and parts analysis studies and value engineering reviews, furnishes identification and source data for nonstandard item requisitions, prepares purchase order descriptions, and furnishes technical support to DOD supply centers as related to hull, mechanical, and electrical spare parts informational requirements. Technical information from manufacturers' specifications and engineering data obtained from the technical Navy systems commands are condensed and provided to stock control commodity managers and requisition personnel for use in performing spot buys and preparing information packages on sole source items for competitive purposes. Information is then forwarded to procurement personnel who make stock purchases.

(b) Data Base

The Technical Records Division manually maintains hard-copy purchase description files, descriptive manuals, and drawings (hard copy and microfilm), and utilizes the following files and records (see Exhibit 6).

- Component-to-Part Record
- Cross-Reference Deck
- Component Characteristic Record
- Allowance Parts List
- Technical Parts Change Record
- Composite Ship-to-Component Record

The purchase description file is unformatted and comprises approximately 300,000 folders, containing between one and 50 sheets of information. Information is filed according to FIIN (federal item identification number) part number sequence and stored in the Technical Division.

In reviewing the techniques available for extracting information from the data base, it was determined that the procurement packages (military specifications and technical information files) used by both the Technical and Purchase Divisions, are maintained entirely by manual methods.

(c) Requirements

Present procedures for the creation, storage, or retrieval of data from files and records utilized by the Technical Division are largely considered to be inadequate. Generally, products and information cannot be obtained within the optimal timeframe and, in addition, information is not always complete. Definite requirements are the automation of the purchase description and procurement package information (with complete procurement history), a procedure for purging and updating the files to insure less redundancy, and a more complete and current data base. A formatted file should be established with a random access capability to provide adequate storage and retrieval for these data.

EXHIBIT 6 - DESCRIPTION OF SPCC RECORDS/FILES REFERENCED IN STUDY

Record/File Name	Abbreviation	Medium	Comments
Component Characteristic Record	CCR	5- by 8-Inch Cards and Magnetic Tape	Contains record of all components (approximately 220,000) in CID number sequence, with this identifying electrical, mechanical, and operational characteristics. Also known as Deck D.
Allowance Parts List	APL	Hard Copy	Prepared for each component to describe its electrical, mechanical, and operational characteristics and to list all repair parts applicable to the component.
Component-to-Part Record	CPR	Record Cards and Magnetic Tape	A technical item record of repair parts which apply to the components in the CCR, plus items covered in support of components under cognizance of other ICP's. Also known as Deck A.
Coordinated Shipboard Allowance List	COSAL	Hard Copy	Contains index of components on equipage group for which SPCC is responsible, the APL for each group, and a stock number sequence listing of each repair part item onboard.
Technical Parts Change Record	TPCR	EAM Cards	A cross-reference item record which enables one to proceed from a reference number to a stock number.
Composite Ship-to-Component Record	CSCR	5- by 8-Inch Cards and Magnetic Tape	A basic source for information covering component and equipment category application. Also known as Deck E.
CID/EC Number-Cancellation/ Supersession Record	None	Magnetic Tape	Contains the canceled CID/EC number (deleted from Deck E) and the old and new superseded CID numbers.
Master Vessel Status Record	MVSR	EAM Cards and Magnetic Tape	Contains vessel type, class, hull number, status code, user code, and fleet assignment code. Established as a means of processing coded OPNAV information into Deck E.
Component/Accessory File	None	5- by 8-Inch Cards	Contains a card for each component which lists among its repair parts other items which qualify as components; contains CID number, quantity, and allowance item code.
Master-APL-to-Follower-APL Record File	None	5- by 8-Inch Cards EAM Cards	Lists the Master-APL's which have been registered with NAVSHIPS and those which fall into the same category.
United Kingdom File	UK	Magnetic Tape	Comprised of tape files on all Polaris ships in United Kingdom hands.

EXHIBIT 6 (Continued)

Record/File Name	Abbreviation	Medium	Comments
SPCC Master Item File	MIF	Magnetic Tape	Master file of items under SPCC cognizance.
Federal Item Identification Number File	FIIN	Drum	An index of FIIN and file addresses.
Change Notice Suspense File	CNS	Drum	Record of pending change notice actions.
Requisition Status File	RSF	Drum	Status of each requisition for management control and response.
Back Order File	BF	Magnetic Tape	Record of back orders.
Planned Program Record File	PPR	Drum	Record of future requirements above normal demand and program protected assets.
Demand History File	HF	Magnetic Tape	Record of demand experience.
Contract Status File	CSF	Magnetic Tape	Record of current contracts and preliminary documents leading up to contract execution.
Contract History File	CHF	Hard Copy and Magnetic Tape	Record of past procurement information on suppliers.
Supplier Data File	SDF	Magnetic Tape	Requires a manual search for six-digit key to access manufacturers' information from automated file.
Price Catalog File	PCF	Magnetic Tape	Price history file used to determine item price trend.
Due-In/Due-Out File	DF	Drum	Procurements due-in plus activities acknowledgment of stock receipt.
Master Data File	MDF	Drum	Master file of all SPCC managed FIIN's with asset and management information.

(3) Purchase Division (770)

(a) Introduction

The Purchase Division procures the material and services for which SPCC has the procurement responsibility, and performs general contract administration functions including expediting, invoice processing, contract modification, and termination. Although, by arrangement, the Technical Division essentially holds the procurement package files, the Purchase Division is a prime user of this information, as well as the contract administration data.

(b) Data Base

The Purchase Division utilizes all data required to support a procurement package. This includes in-house files of MILSPECS (military specifications) and technical information supplied by the Technical and Technical Records Divisions. In contract administration, the following primary data files are used (see Exhibit 6 for additional information).

- Contract Status File
- Contract History File
- Suppliers Data File
- Price Catalog File
- Due-In/Due-Out File

All of the above automated contract related files feed into the Master Data File.

Reporting requirements of SPCC are part of the UICP procedure. Specifically, the Purchase Division has reporting requirements related to contract status and history, supplier data, and price catalog data on a transaction occurrence basis. In general, the information reported includes technical part information, FSN (federal stock number) changes, FIIN (federal item identification number) changes, and item additions. Information is forwarded to the Central Data Processing Division and, when approved, entered in the SPCC MIF (Master Item File).

In contrast to the procurement package files maintained entirely by manual means, the contract administration files are essentially 100 percent automated. Present techniques, however, are not considered entirely adequate as data are not complete and often are not current.

(c) Requirements

As indicated earlier, the Purchase Division also requires an automated system for processing current and complete procurement package information on a more timely basis. The volume of data which must be processed in each purchase and procurement action is substantial, and is aggravated by the lack of required technical data in the procurement packages. Time is lost in proceeding from one procurement to another because the packages are incomplete. The lack of adequate technical data creates delays in procurement package development which, in turn, increases the total time required for procurement actions.

(4) Catalog Division (820)

(a) Introduction

The primary functions of the Catalog Division are (1) to satisfy the federal catalog program requirements by instituting, preparing, maintaining, and disseminating catalogs containing part and component information on a Navy-wide basis; (2) to determine packaging and preservation requirements; and (3) to implement the DOD standardization and simplification program. This division writes hard-copy transactions, reports, catalogs, etc., when requested by internal action from the Provisioning and Allowance Division, Special Equipment Division, and other internal codes, as well as from external sources such as the Army and DOD.

(b) Data Base

The Catalog Division is primarily concerned with the SPCC MIF mentioned above, and the additional forms and files listed below.

- DD 1460 (transactions which affect the MIF)
- DD 635 (transactions which affect the UK [United Kingdom] File)
- Master FIIN File

- Master Data File
- Change Notice Suspense File

Upon receiving authorization from DLSC (Defense Logistics Services Center), the transaction data is recorded in magnetic tape format and processed into an updated SPCC MIF. The Catalog Division is also required to furnish transaction information to update the DLSC MIF. Transactions are created manually as authorization is received from DLSC and converted to punchcards. These card decks are accumulated and batch processed on a monthly basis to update the master tape files.

(c) Requirements

File size, volume, and current growth rate contribute to most of the problems in the Catalog Division, and improved file maintenance and interface procedures and programs are required. If a 48-hour response time could be maintained from an automated central data base, item identification problems would be substantially reduced. Response time from the current system is relatively slow and causes internal delays in procurement lead time, contract administration, purchase order description, and MIF updating. Biweekly interrogation of DLSC can be tolerated provided response time is within a 48-hour period.

b. Projected

(1) Introduction

The current requirements discussed in the preceding section are expected to continue to pose an ever-increasing problem to SPCC if improved techniques for handling the increased volume of technical data on a timely basis are not implemented. All three divisions previously mentioned have projected requirements which justify the consideration of a new generation of hardware input/output and data processing devices, software packages, and advanced communication capability.

Management consideration must be given to future file format, maintenance, and processing requirements with respect to information entered, information retained, indexing techniques, query capability, etc. The interface problems which currently exist between the SPCC divisions and DLSC will persist until more positive and rapid methods of communication and information display are introduced. AUTODIN is a beginning. Possible solutions to projected increasing requirements could be a consolidated data bank held at a central facility, with remote interrogation capability at various sites, or a fully compatible data base held and maintained by each cognizant user facility, capable of mutual interrogation by all users in a common data query format and language.

(2) Standardization

Paralleling the development of a common data base and query capability is the requirement for standardization. This may take the form of standard data packages, equipments, data elements and identifiers, etc. Item standardization at SPCC would reduce contract administration requirements by a reduction in volume. The standardization of technical data would simplify the problem of developing procurement packages and assist in maintaining a current and complete data base with minimum redundancy. Programs can be developed which would provide component priority/preference listings, interchangeability, etc.

Additionally, equipment standardization will effect a reduction in the number of repair parts, test equipment, maintenance technical data, manuals, etc., required. For example, even a 10-percent reduction in Navy APL's through component standardization would potentially eliminate 2,500 to 5,000 components and repair parts required for Navy support. Moreover, achieving greater equipage standardization will potentially increase operational readiness by decreasing equipment downtime.

(3) Configuration Management

The Navy currently has a program underway in the area of component/equipment standardization. Consideration must be given not only to achieving a greater degree of standardization, but also to the means by which it is maintained once it has been achieved. Configuration Management is a discipline which applies technical and administrative direction to identifying functional and physical item characteristics, controlling the identification and changes made to the characteristics, and recording change processing and implementation status throughout the life cycle of the item. As the Configuration Management Program accelerates throughout the DOD, the Navy, and SPCC in particular, will become increasingly involved and must plan accordingly.

The three basic techniques of Configuration Management are Configuration Identification, Configuration Control, and Configuration Status Accounting. The projected requirements in the area of Configuration Identification fall primarily within the scope and definition of this study. Configuration Identification is the complete technical description (e.g., specifications, engineering drawings, data lists, technical manuals, and other related technical data and information) of the hardware. In responding to its anticipated requirements, SPCC should consider the development and implementation of a system to provide accurate, complete, and current technical information of the type indicated above in the area of Configuration Identification. An example of the type of data involved, originating from NAVMATINST 4000, is shown as Exhibit 7.

2. U.S. Naval Supply Depot, Newport, Rhode Island

a. Current

(1) Introduction

NSD Newport is an activity under the administrative control of NAVSUP. It is a Level IV user of technical data, supporting the maintenance of ships' weapon systems and equipments throughout the deployment life cycle phase. In addition, upon the retirement of weapon systems and equipments, NSD Newport disposes of excess and obsolete parts and materials during the retirement life cycle phase. Exhibit 8 presents the activity's organization chart.

The principal mission of NSD Newport is to support the fleet by furnishing required materials, supplies, and services. Many functions are performed in implementing the mission; the following are considered major:

- Receive, store, issue, and deliver materials.
- Dispose of excess, obsolete, and returned material.
- Procure nonstandard items and make spot buys.

EXHIBIT 7 - CONFIGURATION MANAGEMENT DATA MATRIX

Intended Uses	Types of Data															
	Design Development Data: Engineering Reports	Test Results	Engineering Drawings	Engineering Changes and Controls	Lists	Test Procedures	Specifications	Standards	Technical Manuals	Technical Orders	Provisioning Lists	Item Identification	Pictorial Reproductions	Sound Recordings	Manufacturing Support Data	Other Data As Required
1. Research	X	X	X			X	X						X	X		
2. Development	X	X	X			X	X						X	X		
3. Design Approval	X	X	X	X	X	X	X	X		X			X	X		
4. Initial Procurement			X	X	X	X	X	X	X		X				X	
5. Production			X		X	X									X	
6. Quality Assurance (Including Inspection)			X	X		X	X	X							X	
7. Installation			X						X	X						
8. Operation			X						X	X						
9. Maintenance			X						X	X						
10. Repair and Overhaul			X						X	X					X	
11. Personnel and Training									X	X			X	X		
12. Provisioning			X	X	X		X	X	X	X	X	X				
13. Cataloging			X									X				
14. Standardization			X				X	X				X				
15. Reprocurement			X	X	X	X	X	X	X	X	X	X			X	

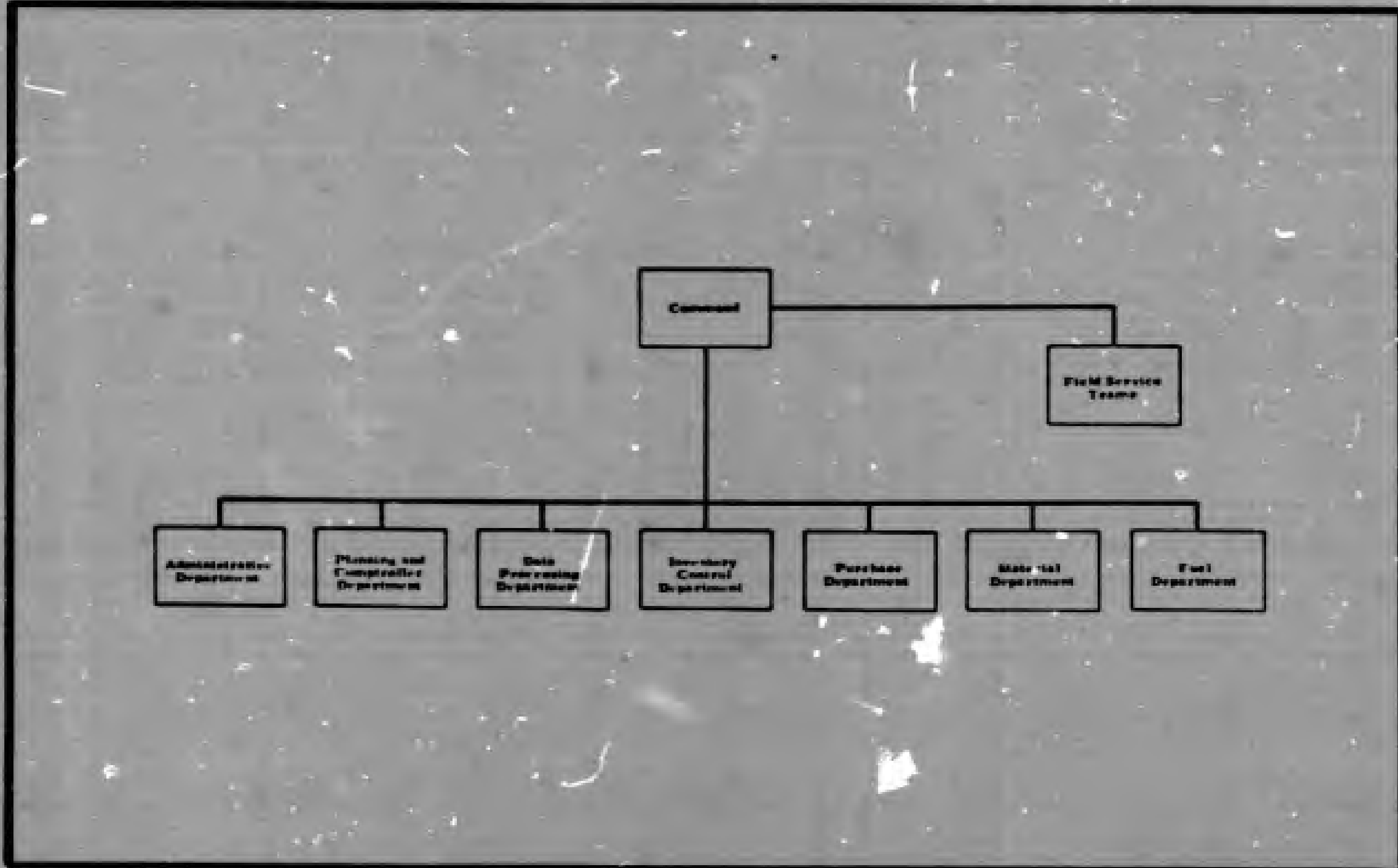

EXHIBIT 8 - U.S. NAVAL SUPPLY DEPOT, NEWPORT ORGANIZATION CHART

- Identify parts and development procurement packages.
- Provide ADP (automatic data processing) support in requisition processing, inventory control, and accounting.

The tasks associated with the major functions include:

- Maintaining files and transaction reports.
- Preparing and processing purchase orders.
- Identifying parts and components.
- Establishing new items, assessing stock, replenishing material, and reconciling back orders.
- Screening and identifying items.
- Preparing and disseminating screening lists.

NSD Newport operates seven departments: Administrative Department, Planning and Comptroller Department, Data Processing Department, Inventory Control Department, Purchase Department, and the Material Department.

From an ADP standpoint, NSD Newport is a user of technical data. For the purpose of this study, the information processing requirements associated with NSD Newport have been considered from the functional aspect of the Data Processing Department and the Purchase Department. Requirements for technical data exist primarily in the areas of supply, parts procurement, and item identification. The primary users of this data are NSD Newport, all fleet units, military activities in the area, and other governmental agencies.

The inventory control data base is mechanized, whereas the creation, storage, and retrieval from the existing technical data base are manual operations.

(2) Inventory Control Department

(a) Introduction

The Inventory Control Department is comprised of two divisions, Requirements and Technical. The Technical Division is involved with APL's, FOCSL's (Fleet Operational Consolidated Stock Lists), Navy and manufacturers' catalogs, and drawings.

(b) Data Bank

The current access and updating methodology applied to the technical data base used by the Technical Division is manual. The data base includes hard copy reports, catalogs, instruction books, APL's FOCSL's, and manufacturers' parts lists.

(c) Requirement

Although the data handling procedures presently considered are adequate, a requirement exists for improving access to reference material. This type of material includes programing and operating manuals, manufacturers' catalogs and parts lists, and engineering drawings and specifications, as well as Navy catalogs. The Technical Division utilizes almost 100 percent of its available clerical time in referencing source material.

(3) Purchase Department

(a) Introduction

The principal function of the Purchase Department is to procure nonstandard items and to make spot buys.

(b) Data Base

The current data base is comprised of past purchase records, APL's, and purchase histories. In addition, the Purchase Department uses reference materials such as engineering drawings and specifications and Navy catalogs. Storage and retrieval of technical data is entirely manual, requiring 1,800 man-hours per year to support major purchases only, with additional time required to support all other purchases.

(c) Requirement

Although current data and techniques are considered adequate, the Purchase Department could use some form of automation to assist in the technical data retrieval process. Needs exist for obtaining source data from prior procurements and for access to MILSCAP (Military Standard Contract Administrative Procedures) data. The Purchase Department is also a user of reference material, thereby requiring the development of automated techniques for improving access time for retrieval of such data.

(4) ADP Support

(a) Introduction

The ADP Support Activity is primarily concerned with requisition processing, inventory control, and payroll, and serves NSD Newport, fleet units, and military activities in the area. Currently nine files are automated, with most of the retrieval being automated through the use of the FFS (File Format System).

(b) Data Base

The ADP Department maintains nine major files, six of which are disk resident. The file titles, contents, and purging requirements are shown in Exhibit 9. Other data sources include a past purchase history file, hard copy catalogs, and instruction books.

A formatted file system is used for the retrieval of information, with only a small percentage of information extraction performed manually. However, manual retrieval is used for other portions of the data base (i.e., reference material).

The data base in the ADP Division is updated by change tapes received monthly from the ICP's and FMSO. These tapes contain from 15,000 to 30,000 line item entries such as adds, deletes, and changes, with adds and deletes accounting for approximately 1,000 line items. With a total of some 68,000 items in stock, updating assumes an important consideration in determining volume and variety of data.

(c) Requirement

A continuing requirement exists in cross-referencing part numbers to stock numbers. Such a system would prove valuable to many divisions at NSD Newport. Other requirements for improvements in the ADP operations are the need for more disk storage, more commonality of data, faster response times, data transfer compatibility, program compatibility, and real-time access to information on contract administration.

EXHIBIT 9 - ADP FILE LISTING

File Title	Content	Remarks
DISK RESIDENT FILES		
Requisition and Status	Random Order by Requisition File Number	Purged Monthly
MSIR (Master Stock Item Record)	FSN Is Prime Sort Key	Purged Monthly
Receipt Due	Document Number Within Stock Number	Purged Monthly
Back Order	Document Number Within Stock Number	No Purge
FICL (Financial Inventory Control Ledgers)	Stores Account Number, COG (Cognizance Code), Group, and Class When Required	No Purge
Name and Address File	UIC (Account Number)	No Purge
TAPE RESIDENT FILES		
Payroll Master Records	Maintained by Activity and Badge Number (5,500 Items Plus Tables)	Created Weekly
Job Order Mail	By Job Order Number (One Tape Reel)	Updated Weekly or Biweekly, Monthly. 3-Year File Purged Annually.
Naval Stock Fund (2NW-2ND)	By Document Number About 70,000 Records (3/4 of Tape Reel).	Updated Weekly Purged Monthly

b. Projected

(1) Introduction

A significant growth in data processing requirements is envisioned since NSD Newport will assume a large portion of NSC Bayonne supply responsibilities. This is expected to result in a greater demand for computer time. In addition, NSD Newport will assume some of the tasks of the SOAP (Supply Overhaul Assistance Program) at NSY Boston, which will cause an increase in the volume of documents being handled.

(2) Inventory Control Department

As stated earlier, it would be highly desirable to provide an automated means for referencing technical data. Efficient use could be made of a document storage and retrieval system which could improve access time and reduce the clerical time required to reference material. Other savings would also accrue from having a more complete data base, such as making "best buy" information available or, where appropriate, to facilitate sole source procurement with its saving in lead time.

(3) Purchase Department

The Purchase Department could also use an automated means for retrieving data. Access, on a timely basis, to source data on prior procurements of similar items and to MILSCAP data could provide Purchase with an opportunity to affect savings in this effort.

(4) ADP Support

Increased activity is projected for the computer system as the result of the normal growth pattern and, also, due to the fact that NSD Newport will assume a large portion of NSC Bayonne supply responsibilities. It would be desirable and beneficial for the ADP Support Activity to obtain more disk storage, to be capable of reducing response time required for data retrieval, and to standardize methods and data.

3. U.S. Naval Shipyard, Boston, Massachusetts

a. Current

(1) Introduction

The U.S. Naval Shipyard, Boston is an activity under the administrative control of NAVSHIPS, with its principal mission to convert, overhaul, and repair ships in accordance with operational plans determined by the CNO. It maintains ships' weapon systems and equipment throughout the deployment life cycle phase. Exhibit 10 presents the activity's organization chart.

Departments within the shipyard may be conveniently grouped according to their outputs (i.e., primarily industrial effort or industrial support). Design, planning, estimating, and production are the principal departments concerned with industrial effort. The Supply Department, for the purposes of this study, furnishes major industrial support.

From the ADP standpoint, NSY Boston functions as both an originator and user of technical data. The information processing requirements associated with NSY Boston have been considered from the functional aspect of the industrial effort departments and the industrial support departments. Requirements for technical data exist in both areas. The primary users of these data are all departments at the shipyard, ships and stations in the 1st Naval District, other shipyards, and NAVSHIPS. Potential users or customers find the furnished documentation to be adequate for their needs, and encounter little difficulty in handling these data. One form of information storage and retrieval utilized is a 35mm aperture card system. This system contains information in the form of drawings and specifications. Information is extracted from the technical data bank manually, for the most part. However, reports on the costs of material used, progress reports on jobs being done, and workload forecasts are computerized with regularly scheduled printouts.

(2) Industrial Effort Departments

(a) Introduction

The Industrial Effort Departments at NSY Boston perform a number of functions. Some of these are:

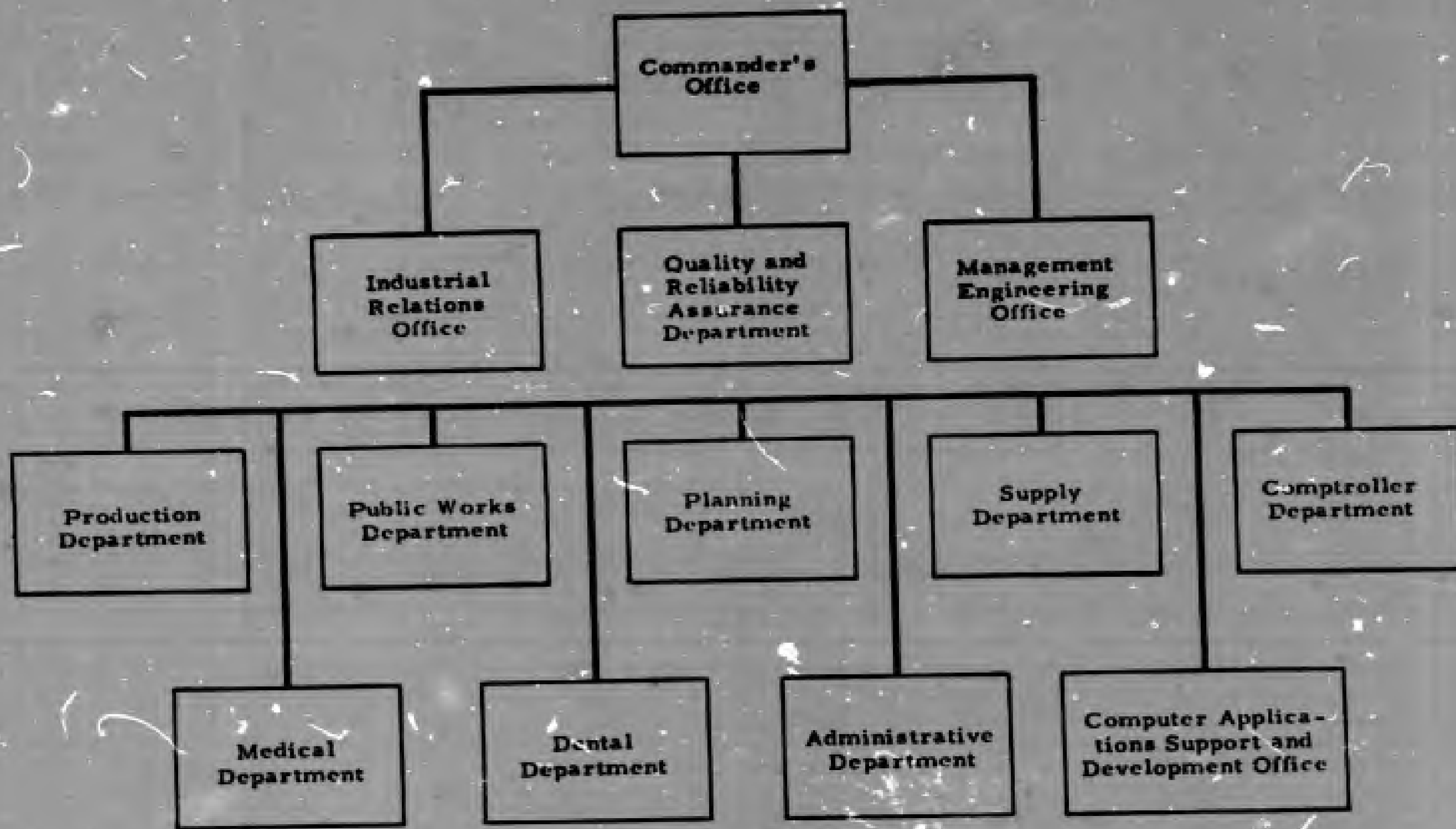

EXHIBIT 10 - U.S. NAVAL SHIPYARD, BOSTON ORGANIZATION CHART

- Designing services for the conversion, overhaul, and repair of ships.
- Field engineering testing of mechanical, hull, machinery, and electronic equipments.
- Preparing specifications, instruction books, drawings, allowance parts lists changes, and other documentation required by the labor force.
- Establishing work schedules, job priorities, and directions for the installation of equipment on ships.
- Engineering services for the industrial effort and the establishment of standards and man-hour allowances.

(b) Data Bank

The Industrial Effort Departments utilize a 35mm aperture card system installed for drawings and specifications. Other data bases include copies of test results, test memoranda, prints, drawing lists, fabrication procedures, FSN catalogs, workload forecasts, repairs, material used reports, and load reports. A large part of the data base is in hard-copy form and information is extracted manually. The data handling needs are related to reporting requirements and the reference material used. Some of these reporting requirements involve: publishing lists of drawings necessary for jobs, updating and disseminating drawings, preparing and disseminating test reports, generating work effectiveness graphs, planning work reports, and publishing monthly progress reports. These documents are then forwarded to NAVSHIPS and various sections within the shipyard.

(c) Requirement

Although the data and data handling procedures are presently considered adequate, a possible requirement is the more rapid access to a better indexed and more comprehensive aperture card system. This requirement stems from the high percentage of clerical time spent in referencing source material. Information relating to historical data files would also be useful for job estimating, manpower and material changes, repetitive procurements, repetitive work efforts, and testing. Such historical data are currently either nonexistent or, if present, prove to be inadequate.

(3) Industrial Support Departments

(a) Introduction

The functions of the Industrial Support Departments include supply support, procurement of supplies for outfitting, service as a wholesale stock point, disposal, and maintenance of a technical supply library. Currently, the Supply Department handles an inventory of 50,000 line items, with an issue rate of 15,000 items per month. The technical data of primary concern are APL's, PAMD's (price and management data), FOCSL's, stock lists, and manufacturers catalogs. The inventory control functions are automated.

(b) Data Base

The Industrial Support Departments utilize a variety of data in the course of their operations. The inventory control system is automated. Other data bases are comprised of hard-copy reports and documents such as APL's, PAMD's, FOCSL's, stock lists, and manufacturers catalogs. Storage and retrieval of the hard-copy documents are entirely manual and require almost 100 percent of the total departmental clerical time available. In addition, a parts history file is maintained on 3- by 5-inch cards in FIIN sequence. Approximately 100,000 of these cards concern electrical items, and about 150,000 concern mechanical and hull items.

(c) Requirement

Although current techniques are considered adequate, the Industrial Support Departments could effectively utilize a mechanized file containing the data that is manually recorded in the 3- by 5-inch index card file. This file contains approximately 250,000 index cards. In addition, a requirement exists for a means of improving the storage and retrieval of hard-copy documents. A document storage and retrieval system could reduce man-hours required for referencing material and could provide a more effective method of data control.

b. Projected

(1) Introduction

The NSY Boston workload has changed from 40 percent structural work to 55 percent electronics effort during the past 1-1/2 years. Overhauls which formerly averaged 13 weeks now average 17 weeks. In previous years, the shipyard was formerly a repair yard for destroyers; now, however, the activity is working on guided missile destroyers, cruisers, and auxiliary ships. A significant growth in technical data files and data processing requirements is envisioned because of an expected specialization in ASW (Antisubmarine Warfare) ships and related equipments. Planning should be initiated to make more use of computer files and document/storage retrieval techniques.

(2) Industrial Effort Departments

As stated earlier, it would be desirable to extend the 35mm aperture card capability into a more sophisticated document storage and retrieval system. In such a case, more technical data could be incorporated into the system (e.g., test results, test memoranda, prints, and fabrication procedures). If efficient use is to be made of this system, however, more positive procedures for maintenance and update must be defined. A more rapid response to requests for technical data would frequently make it possible to reduce the time required for and improve the efficiency of the performance of the shipyard's mission.

(3) Industrial Support Departments

Increased use of computer files by the Industrial Support Departments is also projected, particularly if the files can be expanded to contain the data now stored on 3- by 5-inch index cards. In addition, increased requirements for an automated document storage and retrieval system exist in an effort to reduce the clerical time involved in referencing hard-copy documents.

4. U.S. Naval Ship Research and Development Center, Carderock, Maryland

a. Current

(1) Introduction

NSRDC is a field activity of the Naval Ship Systems Command (see Exhibit 11). It provides equipment and weapon system support primarily in the research and planning function of the RDT&E life cycle phase. NSRDC was established to provide a facility for the U.S. Navy, government, and private ship builders to test their ship designs by means of scale models. The center conducts fundamental and applied research to develop designs of naval ships, propellers, structures, and other related ship components. It operates six laboratories: Hydromechanics, Aerodynamics, Structural Mechanics, Applied Mathematics, Acoustics/Vibration, and the Annapolis Division (formerly Marine Engineering Laboratory). The Applied Mathematics Laboratory provides programing assistance to other NSRDC laboratories and operates an extensive digital ADP facility comprised of an IBM 7090 and several 1401's, a UNIVAC LARC, an SDS 910, and a GE 225 capability. In addition, the Acoustics and Vibration Laboratory maintains and operates two analog computers for engineering research.

From the ADP standpoint, NSRDC functions as both an originator and user of technical data. For the purposes of this study, the information processing requirements associated with NSRDC have been considered from the functional aspect of supply, design/fabrication, and technical laboratory support. Requirements for technical data exist primarily in the areas of supply, parts procurement, and item identification. NSRDC and its field units create and utilize such data in-house and provide its use by other R&D facilities of the U.S. Navy. Supply data are used primarily by the laboratories and test facilities.

A large, Navy-wide R&D data system, NARDIS (Navy Automated Research and Development Information System), is supported by NSRDC. Although this system is primarily oriented toward providing information to management, certain project information contained in the file could be useful

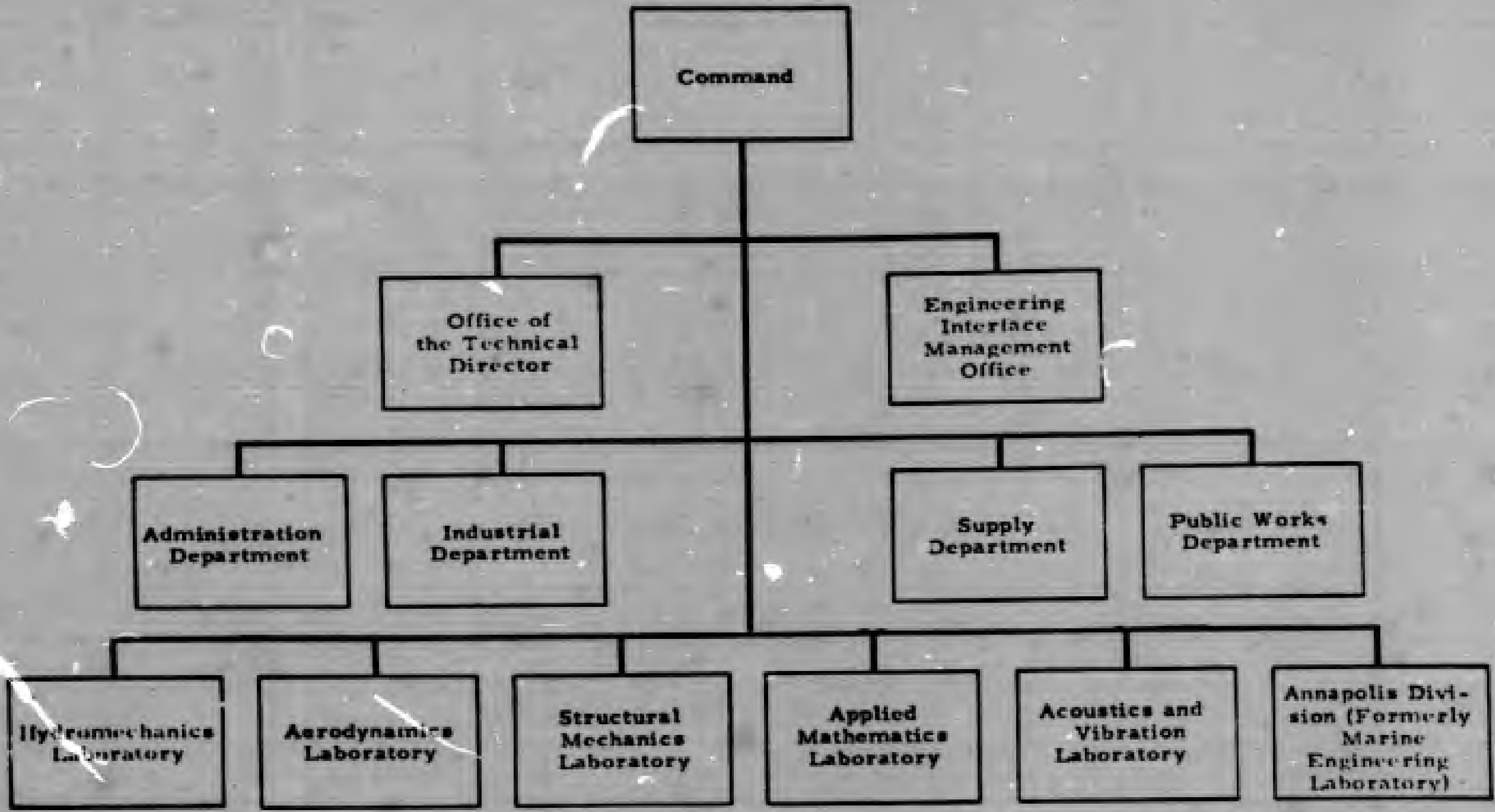

EXHIBIT 11 - U.S. NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER ORGANIZATION CHART

to design engineers. The creation, storage, and retrieval from the existing technical data base is, for the most part, a manual operation.

An additional form of information storage and retrieval utilized is the VSMF (Visual Search Microfilm File) Defense Design File which contains catalog data, specifications, drawings, and test reports concerning parts, materials, services, and equipment. The indexing of this file, by product, vendor, and design parameters, is entirely a manual operation. The file is vendor maintained and provides only limited coverage of industry. In addition, it may contain old or obsolete data since specific requirements for purging or updating are not provided. File update, in itself, is rather difficult in that the files exist as self-contained film cartridges, and supplementary cartridges must be issued for updating and purging information as required.

(2) Design/Fabrication

(a) Introduction

The design/fabrication function concerns the planning and construction of equipment utilized primarily for the collection and recording of research data in support of NSRDC experimental tests. This function is potentially involved with all types of data relating to the design and development of ships' systems.

(b) Data Bank

Design/fabrication utilizes the VSMF system, and also maintains a limited inventory of material on EAM (electronic accounting machine) cards which are updated quarterly, semiannually, or as required. Engineering records and notebooks are also retained and researched for reference material, in addition to a limited file of local manufacturer and Navy parts catalogs.

(c) Requirement

Although the data handling procedures are presently considered adequate, the requirement for more rapid access to a better indexed and more comprehensive VSMF-type file exists. In addition, the creation and maintenance of a parts specification file (indexed by manufacturer's part number) and a parts identification file (indexed by FSN) would provide ready access to information relating to the availability of standard stock items. This would also provide a capability to cross-reference the information contained in both files. Information related to the capabilities of commercial sources and their anticipated production lead times could also be included in the file.

(3) Supply

(a) Introduction

The supply function at NSRDC is to stock and procure items in support of the facility and its one-field location. Approximately 15,000 line items are stocked, of which 50 percent are estimated to be outside of the Navy Supply System. The technical data of primary concern are the parts lists contained in manufacturers' and Navy parts catalogs on file at NSRDC.

(b) Data Base

The current data base is comprised entirely of hard-copy manufacturer and standard Navy parts catalogs, literature on new products, copies of purchase orders, and past procurement information. Storage and retrieval is entirely manual and requires an estimated 30 percent of the total clerical time available.

(c) Requirement

Although current techniques are considered adequate, supply could effectively utilize a file containing up-to-date information concerning the most recent materials available. This information could be used in product development. Similar to design/fabrication, supply could also implement cross-referenced manufacturers' part number and Navy stock number files. A need exists for parts data that are more descriptive, and also for additional information regarding parts and components presently available on the open market. Files containing those data, and manual or automated techniques for processing them, would enhance the scope of information which could be readily accessed to better satisfy the requirements of this function.

(4) Technical Laboratories

(a) Introduction

The primary function of the five technical laboratories and the Annapolis Division of NSRDC is the performance of the research, test, and development tasks which support the NSRDC mission. These laboratories are involved with ship design, construction of ship models, model testing, and overall advancement of the current state-of-the-art.

(b) Data Base

Most of the technical data currently available to the technical laboratories are comprised of hard-copy material in the form of text books, manuals, and reports. These materials are received from other laboratories, universities, research institutions, and contractors. Information concerning newly acquired reference materials is disseminated through a library accession list distributed on a biweekly basis. The library, in addition to maintaining standard texts, publications, manuals, etc., is developing a limited microfiche capability.

Code 880 of the Applied Mathematics Laboratory holds the NARDIS data base. In this regard, they maintain and modify the system as required and provide inputs to DDR&E (Director of Defense Research and Engineering) and SECNAV. The primary source of data is an R&D resume, Form DD 1498. Machine readable inputs are provided to DDC (Defense Documentation Center) in the form of cards and magnetic tapes. The principal types of R&D project information provided are task descriptions, objectives, procedures, deficiencies, milestones, status, projections, current work, etc. A data bank is created from which users may obtain information on R&D projects performed for DOD. The UNIVAC LARC is currently being used during one shift to process an estimated 50 queries per month. The current file comprises approximately 10,000 work units and 1,200 planning documents.

An effort is also underway in the development of methods and processes for the utilization of EDP (electronic data processing) and mathematical techniques in CASD (Computer-Aided Ship Design). The requirements and demand for technical data in this area are not now fully defined, but are expected to include information relating to ship design and construction programs, standardization, cost/economic benefits, and system maintainability/reliability.

(c) Requirement

A continuing requirement exists for complete and current technical data related to a specific task. For example, in a stress analysis of a given item, all information which is related to similar or previous projects concerning this item is required. This information might include stress analysis, item dimension/orientation/measurement information, and similar technical data. A major bottleneck in laboratory operations is obtaining detailed sets of engineering drawings and specifications within the desired timeframe. Standardization of data elements and identifiers would assist NSRDC and other R&D installations in communicating requirements for technical data in common terms and language. A central source or library file which relates and cross-references all data elements could be categorized in a similar manner and would provide substantial assistance to the individual researcher.

b. Projected

(1) Introduction

No significant growth technical data files or data processing requirements at NSRDC is envisioned, and no major problems relating to the maintenance and control of stock inventories are projected. However, planning should be initiated to properly locate and utilize the remote inquiry consoles which are scheduled for installation this fiscal year.

(2) Design/Fabrication

As stated earlier, it would be highly desirable to extend a VSMF-type capability to design/fabrication, thereby providing more detailed part and material descriptions (e.g., outline dimensions, mounting information, temperature limitations, shock/vibration tolerances, and additional technical data). If efficient use is to be made of such a system, or if usage increases as anticipated, more positive procedures for maintenance and update must be defined. A more rapid response to requests for technical data would frequently make it possible to purchase items with less delay, either from a sole source on the basis of unique technical qualifications, or on a competitive buy based on the existence of complete and comprehensive data.

(3) Supply

Increased use of the VSMF by supply is also projected, particularly if the system can be expanded to contain a more complete industry file. In addition, increased requirements for the identification and availability of common parts information will tend to hamper procurement unless a more responsive system is developed. The possible use of an AUTODIN terminal for the acquisition of information on a more timely basis should be considered.

(4) Laboratories

An improved VSMF capability would benefit users in this area for reasons similar to those stated for supply and design/fabrication. Consideration should be given to providing a remote inquiry capability for obtaining information from a central source. Also, a capability to internally and externally exchange technical data among NSRDC, the Annapolis Division, and other facilities, such as Main Navy or NWL (Naval Weapons Laboratory) Dahlgren, should be weighed.

III. INFORMATION PROCESSING CAPABILITIES

A primary objective of this study was the investigation of information processing industry capabilities to meet Navy's technical data handling requirements at the present and 5 years in the future. The following discussion of methodology encompasses both present and future capabilities. Volume I of this study presents a description of present capabilities, with forecasted capabilities defined and discussed in Volume II.

A. Information Processing Industry Survey

An investigation of this type could not be inclusive of every vendor in the information processing industry because of the constraints on time and resources allotted to this study. Consequently, a sampling of the industry was necessary. The investigation required selectivity as to which organization would contribute the most to a study of this nature. The first criteria determined for vendor selection are as follows:

- The vendor must be a known innovator in his field.
- The vendor is known to produce reliable equipments.
- The vendor has demonstrated a continuing effort to modify and improve his equipments through research and development.

These criteria facilitated the selection of a sample.

A dynamic industry such as information processing is well documented, thus the current state-of-the-art can be summarily described via several technical journals.

As there is almost no limit to the number and types of equipments, systems, etc., all capabilities have been categorized as follows:

- Digital Central Processors.
- Communications and Related Equipments.
- External Digital Bulk Storage.
- Peripheral Equipments.
- Microforms and Related Equipments.
- Software.

These categories often overlap (e.g., a CRT (cathode ray tube) could sometimes be considered a remote terminal, at other times a peripheral, and is also an integral part of some microform systems). In general, these categories are disjointed enough to allow a fairly comprehensive breakdown of the components of the information processing industry.

Within the constraint of the previously mentioned criteria, and in order to adequately consider each capability category, more than 85 vendors were selected for consideration.

B. Data Collection

Initial contact with selected vendors was through their national sales office or representatives in Washington, D.C. The purpose and scope of this study was presented in each case, and pertinent information was obtained concerning:

- The location of the vendor's research and development facility.
- The names and titles of personnel in marketing who were thoroughly familiar with the complete current line of equipments.
- The names of research and development personnel who were aware of the future plans and products of the organizations.

Literature on current equipment was collected from each selected vendor in depth sufficient to gain a general understanding of equipment capabilities and functions. Several technical conferences were attended, such as the Spring Joint Computer Conference and the National Microfilm Association Convention. Academicians from the Massachusetts Institute of Technology, Illinois Institute of Technology, and George Washington University were also interviewed.

1. Vendors Visited

Of the 85 vendors considered, 49 (see Exhibit 12) were visited in order to obtain more complete information. Appointments for interviews were made through the sales representative and confirmed by telephone before the interviewer's visit. In no instance were the interviewers refused entry into the vendor's establishment, and the vendor's representatives proved cordial and efficient in providing their time and arranging itineraries.

EXHIBIT 12 - LIST OF VENDORS VISITED

Addressograph-Multilith
Alden Research
American Telephone & Telegraph
Atlantic Microfilm Corp.
Bell & Howell Business Equipment
Bryant Computer Products
Bunker-Ramo
Burroughs Corp.
California Computer Corp.
Carson Laboratories
Collins Radio
Computer Sciences Corp.
Control Data Corp.
Dasa Corp.
Data Disc, Inc.
Datamec Division of Hewlett-Packard
Digital Equipment Corp.
Documentation, Inc.
Eastman Kodak
Electro-Mechanical Research, Inc.
General Electric Company
Honeywell 3C
Honeywell EDP
Houston Fearless Corp.
Information Displays Incorporated
Information Handling Services, Inc.
International Business Machines
International Telephone & Telegraph
ITEK Business Products
Magne-Head
Memory Technology, Inc.

EXHIBIT 12 (Continued)

Microcard Corp.
Midwestern Instruments/Telex
3M Company
Mosler Safe Co.
National Cash Register
Philco-Ford
Raytheon Company
Raytheon Computer
Radio Corp. of America
Rixon Electronics
Sanders Associates, Inc.
Scientific Data Systems
Stromberg-Carlson
Tasker Industries
Teletype Corp.
UNIVAC Division of Sperry Rand
Uptime Corporation
Xerox Corp.

NAVSUP provided a letter to each vendor describing the tasks to be performed and guaranteeing that proprietary information gathered at the interview would be published only in a restricted distribution report (Volume II), supplementary to the main body discussion (Volume I). PRC also supplied a letter guaranteeing the security of proprietary data while being analyzed by study personnel. In each case, the objective was to assure the vendor that any information concerning his future equipments would be held in confidence.

2. Questionnaire

To aid the interviewer in vendor discussions, a checklist was formulated that was general enough to cover all areas of the information processing industry, yet specific enough in each section to allow detailed data to be documented. The checklist was organized to include both hardware and software areas.

The checklist for hardware (see Exhibit 13) is structured to highlight all the pertinent areas of interest relative to any equipment under discussion, as follows:

I. Processors
II. Auxiliary Storage
III. Input/Output
IV. Reliability
V. Message Switching
VI. Hardware Technology

The software checklist (see Exhibit 14) is designed to highlight all the pertinent areas of interest relative to any software item discussed, as follows:

I. Master Control System
II. Compiler Languages
III. Data Management
IV. Assemblers
V. User-Oriented Application Programs
VI. Other Programing Support
VII. Software User Group
VIII. Conversion Considerations

EXHIBIT 13 - INFORMATION PROCESSING CAPABILITIES CHECKLIST--HARDWARE

I. Processors

A. Number in line, projected new members/lines

B. Speeds
1. Mainframe memory cycle time
2. Clock
3. Instruction

C. Interrupt handling
1. Automatic
2. Programed
3. Priority
4. Number of interrupts

D. Parity checking--I/O failure checking

E. Maintenance assistance features
1. Modularity
2. Front panel access

F. Referenceable I/O clock--real-time clock

G. Number of instructions
1. Hard-wired
2. Microprogram

H. Time-Sharing
1. Multiprograming/processing
2. Direct memory access
3. Simultaneous I/O and process
4. Number of I/O channels

I. Shared memory possibilities

J. Addressing--maximum ability

K. Computer circuitry
1. Discrete
2. Hybrid
3. Integrated circuits
4. Large-scale integration
5. Molecular electrical blocks
6. Self-healing circuitry

L. Logic--light techniques
1. Glass fiber laser
2. Fiber optics
3. Photo diodes
4. Electrically pumped semiconductor lasers

M. Computer organization
   1. Serial
   2. Parallel
   3. Associative processor in information retrieval
   4. Instruction repertoires

N. Modularity of family (expandability)

O. Conversion--six bit to eight bit (ASCII)

P. Mainframe storage
   1. Byte-character
   2. Memory protection
   3. Capacity increase
   4. Access time decrease
   5. Microcircuits; thin films; high-speed flip-flops; improved cores; lasers
   6. Effects on memory computer configuration
   7. Associative memories
   8. Read only (biax type)

II. Auxiliary Storage

A. Random-access storage (disk, drum, RACE, photo-store read only memory, disposable disk)--serial storage (tape, cards)
   1. Access
   2. Density
   3. Data checking (parity checking)
   4. Shipboard usage

B. Nonrotating mass storage

III. Input/Output

A. Channel
   1. Dedicated
   2. Bus

B. Transmission rates (number of simultaneous channels, rate per channel, total transmission rate)
   1. Character
   2. Word
   3. Direct memory access
   4. Register
   5. Both direct memory access and register

C. Assignment flexibility (floating channels)

D. Interface considerations

EXHIBIT 13 (Continued)

E. Devices
   1. Card equipment
      a. Speed (fiber optics)
      b. Mechanical limitations
      c. Code printing (RACE)
   2. Printers
      a. Electrostatic
      b. Online/offline
      c. Magnetic tape film printers
      d. Thermal and laser
      e. Impact printers
      f. Multiple copies on nonimpact
   3. Online remote terminals
      a. CRT displays
         (1) Message creation and correction console
         (2) Rear projection forms
         (3) Hard copy capability
         (4) Decreased phosphor decay
         (5) Digital or analog
         (6) Tube size (flattness)
         (7) Fiber optics
         (8) Shipboard usage
         (9) Alphanumeric-graphic
      b. Printers (same or different than onsite)
      c. Arithmetic units
      d. Facsimile
   4. Pattern recognition equipment
      a. OCR's (optical character readers)
         (1) Single-multiple font
         (2) Hand print ready
         (3) Decentralized OCR scanning
      b. Image erase and replace capability
      c. Micrography
      d. Graphical readers
   5. Prerecorded speech response (touchtone)
   6. Console typewriters
   7. Communication multiplexer
      a. Transmission speeds
         (1) Voice
         (2) Microwave
         (3) Satellite
      b. Number of multiplexers
      c. Interface problems
      d. Switching capabilities
      e. Cryptologic interfaces
      f. Interference

EXHIBIT 13 (Continued)

IV. Reliability

- A. Effect of IC on MTBF
- B. MTBF on peripherals
- C. Method of MTBF determination

V. Message Switching

- A. Computer utility concept
- B. Special purpose
- C. Computer network (AUTODIN)

VI. Hardware Technology

- A. Newness of line
- B. Predicted obsolescence date
- C. Field installable modifications

EXHIBIT 14 - INFORMATION PROCESSING CAPABILITIES CHECKLIST— SOFTWARE

I. Master Control System

A. System configuration required

B. Ease of revision
1. Documentation
2. Modularity
3. Size

C. Capabilities
1. Static or dynamic storage allocation
2. Controls
3. Interrupt handling
4. Task scheduling
5. Multiple processor capabilities
6. System/operator interface
7. Debugging features
8. Accounting capability
9. Programing and data protection
10. Time-sharing (conversational)
11. Foreground/background processors
12. Processors under control of MCS (Master Control System)
13. Device independent

II. Compiler Languages (FORTRAN, PL/1, SIMSCRIPT, COBOL, JOVIAL)

A. Deviation from standard compiler languages

B. Efficiency/compiler object code

C. Debugging features

D. Diagnostic

E. Reenterability/recursiveness

F. Interlanguage features
1. Subroutine linkage
2. Common loader
3. Data linkage

III. Data Management

A. File management
1. File structure flexibility
2. Use of operating system
3. File protection
4. Recovery features
5. Storage utilization

B. Data manipulation
  1. Controls available
  2. Elements accessible

IV. Assemblers

A. Macroassemblers (procedure oriented)

B. Microprograming (firmware)

C. Emulators/simulators

V. User-Oriented Application Programs

VI. Other Programing Support (Compatibility with MCS)(Library, Mathematical Programs, Utility Routines)

A. Extensiveness

B. Compatibility with compilers

C. Loader

D. Reenterability

VII. Software User Group

VIII. Conversion Considerations

These checklists acted more as memory stimulants than as actual questionnaires. In conducting interviews, rapport with the vendor was considered to be of great importance. New questions and topics for discussion were formulated with each interview. The learning process theories held true throughout the series, with the later interviews considerably more complete than the first.

C. Functional Classification of Capabilities

1. Digital Central Processors

Traditionally, digital computers have been classified as either business or scientific; it is, however, becoming increasingly difficult to make this distinction. This is particularly true when considering speed and data format of third generation central processors. Regardless of the application, however, digital computers have a fundamental architecture in common. This architecture consists of five basic sections: input, memory, arithmetic/logic, control, and output. Beyond this basic commonality, computer mainframes do differ substantially.

The design of the five basic sections varies significantly between computers in order to accommodate the special processing and computing requirements of specific applications. Thus, today's wide variety of central processors, supportive peripheral, and software places fewer restrictions on the user's systems analyses and problem solutions. Many of the third generation computers operate well in both business and scientific applications. This is due basically to their software capabilities, internal speeds, and data manipulation techniques.

In today's approach to data processing, high-speed, random access memory is rapidly becoming the single most important element of the computer's internal workings. Most recent computer configurations are placing increased demands on memories, creating a dramatic change in the economic balance between the central processor and the main external memory. In the past, a computer system consisted of a single data processor and a single memory. The modular systems of today may contain two or three processors, and as many as eight to 16 separate memories. Widespread demand has demonstrated the need for increased memory capacity and speed. Typical memory capacities have increased from 4K to 16K words, while word lengths have increased from 24 and 36 bits to 48 and 72 bits. Cycle times have shown a marked decrease from the 10 microseconds typical in the later 1950's to the submicrosecond standard of today. Three major factors have facilitated improvements to memories: (1) improved materials, (2) improved design techniques, and (3) pressures exerted on the industry by systems personnel.

Information processing technology has increased exponentially during the past decade, culminating in the third generation data processing equipments. In terms of central processors, the significant increases have been in size and speed of memories. During the beginning of this timeframe, most of the processors were in the 6 to 12 microsecond cycle time; today, even the slowest of the third generation family of equipments is faster than this. Currently, manufacturers are producing equipments in one or two general classes. One class is composed of families of processors from small-scale to large-scale and with upward compatibility (i.e., IBM 360 series and RCA Spectra 70 series computers). The other class is the so-called multiprocessor consisting of two or more central processors operating simultaneously, such as that produced by Burroughs and UNIVAC. One manufacturer which appears to cover both classes is Control Data Corporation. CDC has the 6000 series computers which, when configured properly, can operate as multiprocessors, and the 3000 series computers which can be considered a family of medium-scale to large-scale computers. The family of computers (e.g., System 360, Spectra 70) normally includes about five different processors ranging from a small-scale processor of about 2 microsecond access time to very large-scale processors in the nanosecond access range. The multiprocessor class of equipments normally ranges in the nanosecond access time with capacity and speed varying with the type of configuration required.

Another class of processors which has recently come into being is the time-shared computer. Many manufacturers and/or users have attempted to use general purpose processors to operate in a time-shared mode. However, the leading manufacturers are producing processors to be used exclusively in time-shared operations such as the IBM 360/67, the RCA 70/46, the SDS 940, and the GE 235.

A comparison of existing central processor equipments is included in Appendix B of this report.

2. Communications and Related Equipments

A general definition of a data communication system is any system which allows information to be exchanged between two or more parties located at different geographical points. This definition is necessarily broad, trivially describing the mail or telephone, but thereby encompassing several kinds of pertinent equipments and systems available in the information processing industry.

There are two types of information of interest, alphanumeric and graphic. The alphanumeric data is usually originated in or associated with a digital computer. Graphic information may be associated with a computer, but is usually a drawing on paper or on a microform such as an aperture card. If this information is to be communicated between the two or more locations, some type of communication link must be present. For purposes of this section of the report, only the equipments at both ends of this link will be considered, not the link itself. These "ends" will be called remote terminals or terminal devices. Some examples of remote terminals are teleprinters, CRT (cathode ray tube) displays, audio response telephones, and facsimile devices. An adequate description of these equipments will, in some cases, require a description of their related systems.

Manufacturers representative of the current state-of-the-art will be discussed in detail with the understanding that other vendors have similar equipments. For ease of comparison of like equipments, these specific model descriptions and tables of equipment characteristics are included in Appendix B.

a. Remote Terminals

(1) Audio Response Devices

Recent years have brought research into the possibilities of receiving an audio response from a computer. Although the preferred methodology would be the development of synthetic speech, allowing the computer to form words from syllables as man does and thereby creating a huge vocabulary, this area is extremely new and current results are academic rather than commercial.

Several working systems have been devised using recorded words interfaced with computer access. The preprogramed vocabulary consists primarily of the integers zero through nine and specific words or short statements relevant to the system. The audio response device transmits programed intelligence in spoken language. Control is managed by a computer and the remote terminal is a touchtone telephone, also used for keying-in the inquiry. The device is essentially a rotating drum with a recorded word or phrase on each track.

A typical example of an application for the audio response unit is in supply. If, for example, a mechanic requires a part, he keys-in the system, the part number, and order quantity on the touchtone telephone. The computer is programed to determine if the specific part is in stock and, if so, in what quantity. If the order can be filled, the prerecorded phrase "order okay" will respond; if not, the phrase may be "do not order." This is an example of a simple system, but it can be seen that the performance of an audio response system is a function of the size of the vocabulary and the number of concurrent inquirires.

(2) CRT (Cathode Ray Tube) Displays

Essentially, CRT displays for use as terminals are of two types: (1) remote terminals for inquiry and response, generally used with alphanumerics, and (2) entry and display devices used in conjunction with a computer and capable of handling graphics as well as alphanumerics. The first type of CRT display is generally used only with alphanumeric information and function codes, and presents formatted replies to the user who has queried the central data bank by means of a keyboard. This type of CRT will be called "CRT-remote terminal." A well known example of a CRT-remote terminal is that commonly used by some airlines to confirm reservations.

The second type of CRT display will be referred to as a "CRT-console" and is used predominantly in the area of computer graphics. The CRT-console development was motivated by the desire for better man/machine communications. With this type of CRT, the user can edit, update, or change existing data by means of a light pen which electronically relays these changes to the computer. Graphic information is formed on the console by using short vectors to describe lines.

CRT-remote terminals are inquiry/response data terminals which serve the requirements for a small amount of transmitted data and a high degree of efficiency. The user requests information by keying-in his query on a keyboard with the response transmitted to him and displayed in alphanumerics on the device.

The type of CRT-remote terminal used is generally special purpose and designed in such a way that the user has no control over the message format. Usually a number of such terminals are all tied into a common control which performs multiplexing functions between the terminals and the central processing unit. Data is displayed on the screen by projecting the electronically formed alphanumerics onto the phosphor-coated screen. Longevity of the image is dependent on the retention capability of the phosphor.

The viewing area is usually dependent on the readability of the characters and the purpose of the display. Other features, such as minimum of flicker and degree of brightness, are determined by human factors studies. An important option from most vendors is a hard copy capability. Either the manufacturer provides the necessary interfaces for a teletype printer, or there exists a device with this capability integrated into the terminal.

CRT consoles display alphanumeric and graphic information which originates in a computer. Methodology has been developed for the user to enter data into the computer, either with a keyboard or a light pen. The image on the face of the display is the most important factor in the performance of CRT consoles. There is no storage capability for the image in most tubes, forcing the necessity to regenerate the "picture" 30 to 40 times per second in order to reduce flickering.

Basically, there are two methods for controlling the characters on the screen: (1) by controlling the electron beam with programs, and (2) by generating the shapes directly with a character indication code. The first of these has the disadvantage of requiring considerable computer time.

Two methods also exist for character generating: (1) beam shaping, which is dependent on a mask in the CRT through which the beam is directed, and (2) beam steering, which is electronically controlled. High quality images are formed using beam shaping, but there is a distinct disadvantage associated with the mask, since it cannot be changed without replacing the tube. The electronic methods of beam steering are both economical and versatile, but are not as high in image quality.

The most common electronic approaches to character generation are raster and functional. The raster method generates the character as a collection of lines and dots selected from a fixed array. The functional approach steers the beam through a series of strokes and dots which are the basic image elements.

CRT consoles provide the user with a method for either calling up a display from the computer or for responding to the contents of one. For alphanumeric applications, a keyboard suffices for an entry device. For graphic applications in which information is created by drawing, or in situations where it is necessary for the user to point at an element on the display, either a light pen or a cursor is used.

The light pen contains a photocell which responds to the CRT-generated beam and returns the signal to the computer. As an entry device, the light pen and console act in a different mode. The CRT generates a beam pattern which is acquired by the pen. When the light pen moves the pattern follows, its position within the pattern computed from the pen's response. The time delays involved with the interaction of the light pen and computer are minimal, forming the illusion of instantaneous response. When a fixed array exists, a spot of light which is keyboard-(or "joystick") controlled can be used as a cursor.

Further discussion of special factors involved and pertinent options will be found in the specific vendor sections of Appendix B.

b. Facsimile Device

A facsimile device transmits printed material or graphics over a communications link for purposes of reproduction. Facsimile technology has existed for several decades, and has been used primarily for the transmission of photographs by wire or radio for news media. Recently, the business community has enlarged its use of information processing equipment to such an extent that the facsimile devices and methods developed 30 years ago are unable to keep pace with the modern EDP speeds.

The transmission of alphanumeric intelligence requires that the data received be identical in content with the data transmitted. It is seldom necessary that the information be identical in appearance (i.e., with the same type font). A different situation exists with graphics, in which exactness in form is mandatory.

Graphic communication equipments and systems are more sophisticated today than commonly presumed. The basic ideas of scanning a document or a drawing, digitizing it, transmitting, and reproducing it remain the same as before, but the interfaces now with this system may be computers, microfilm, or any other computer/communication-oriented equipments.

Speed of transmission varies with different systems and different communications links. A common link used for facsimile is the telephone system, usually over a 3KC conditioned circuit. In such a system, no new links must be organized, since existing ones already span the world.

The current innovators in the facsimile field are attempting to form a new concept in the communication of all documents, not only graphics. Their viewpoint is that any information, written, printed, or drawn, should be sent by facsimile rather than by teleprinters. The two systems, facsimile and teleprinting, are basically different in approach. In using teleprinting, alphanumeric data is coded and this digitized code is transmitted over a common or private carrier service. In facsimile, the document is scanned by some intense light beam which moves across the document in a given number of sweeps per inch of the paper or microform. The reflected or nonreflected segments of the document are then translated into electrical impulses. These impulses are transmitted over the carrier service and the facsimile of the document is reproduced at the receiver printer. Basically what is happening is that in teleprinting, the alphanumeric data is coded and the code transmitted in bit stream, with this stream then being decoded at the receiver. In facsimile, however, a picture of the document is being transmitted in a bit stream.

Certain observations can be made about the two systems. If transmission is interrupted in either system, only part of the intelligence is received.

In teleprinting, part of the message is missing; in facsimile, part of the picture of the message is missing. In this situation, either system suffers. More common mishaps in transmission of data are interference, garbling, or dropping of bits from the stream. In these cases, facsimile has an advantage over teleprinting since interference, although it may cause an incomplete image, will generally still allow readability (see Exhibit 15). Teleprinter interference or garbles may result in the complete unintelligibility of a message.

Figure 1

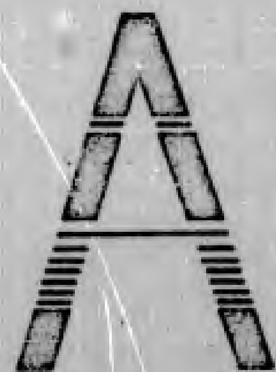

Figure 2

Note: (1) Figure 1 represents a reproduction of the letter A with no interference; Figure 2 represents the same letter with breaks caused by interference.

EXHIBIT 15 - FACSIMILE TRANSMISSION[1]

A major disadvantage to facsimile is the number of bits necessary for transmission. Generally, an 8-1/2- by 11-inch typewritten document requires 10^7 (10 million) bits to be transmitted for facsimile. This may amount to 4 to 6 minutes of transmission time, frequently a costly time interval. Research is presently being performed to reduce the number of bits used and total transmission time required. Representative ideas are discussed in the vendor sections in Appendix B.

c. Data Transmission

(1) Analog Systems

The present state-of-the-art for data and information transmission over long distances is centered around TELPAC, a wideband analog system. TELPAC variations can be characterized according to their capacities. An additional property held by TELPAC is its synchronous or nonsynchronous transmission of data. Standard information transfer rates for TELPAC fall into the following categories:

19.2 kilobits per second	Synchronous or nonsynchronous
40.8 kilobits per second	Synchronous
50.0 kilobits per second	Synchronous or nonsynchronous
230.4 kilobits per second	Synchronous
250.0 kilobits per second	Nonsynchronous

The last four of these have been given the designations of TELPAC A, B, C, and D, respectively. All TELPAC systems offer long-haul capability, usable flexibility, and centralized monitoring. TELPAC A, originally designed to accommodate 12 voice channels (4K bps per channel), is no longer used for voice transmission but is utilized to transmit data. Improvements in equipment capabilities have concomitantly raised the information transfer rates. The highest TELPAC rate is now expected to be 1.38 megabits per second. This rate, however, is insufficient to satisfy the growing data transfer needs; consequently, major changes in concept are being instituted to permit increased rates.

(2) Digital Systems

The principal change in concept is the replacement of the analog carrier signal with a digital carrier. Many advantages can be achieved with this approach. Through multiplexing, it is possible to simultaneously transmit many different varieties of information over a single digital network. Basically, the various sources of information may be sequentially sampled at very high rates to construct a dense pulse stream that is transmitted through the information channel. A receiving station decodes the pulse stream synchronously and, by means of properly designed filters, reconstructs replicas of the information from the several sources. This technique is useful for voice, digital data, facsimile, picturephone, and television, in addition to others.

(a) Digital Transmission Network Characteristics

Although the above brief description presents a view of digital transmission systems, it is too generalized to describe characteristics of real networks. Because of varying demands upon networks by multiple users, it is necessary to consider the need and use of switching circuits for distribution of data, as well as the movement of data from a sending point to a receiver. Developmental work has concentrated first on the movement of data in digital form, rather than on the acceptance and distribution of data at the sending and receiving ends of the data transmission channel.

When analog-information is to be sent through a digital channel, it must first be sampled; that is, discrete values must be assigned to specific parts of the analog data, according to an established pattern. The known pattern is either simultaneously or subsequently arranged into a time sequence for translation into the digital transmission code, sample-by-sample. Source data already in digital form, like that from a digital computer or an optical encoder, are also arranged in time sequence and translated piece-by-piece into the digital transmission code. Such encoded data are then sent through the information channel.

It is clear from the above discussion that data from analog sources are processed like that from digital sources after first being sampled.

The digital data transmission code, in most cases, is binary in form (e.g., the code uses two values as ON and OFF or ZERO and ONE). By increasing the number of binary digits represented by code pulses, it is clear that increased accuracy of representation is possible. It is equally clear, however, that the use of an increased number of pulses requires some adjustment in the operation of the channel to be able to pass the necessary information in a short time. As pulses are increased in number for greater digital accuracy, they must be pushed closer together in time to achieve the same throughput of data packages. The increased accuracy of higher level digital coding permits better fidelity in the translation (decoding) of binary pulses back to the original analog or digital form, provided all network functions are properly matched and possess adequate capacity.

(b) Time Division Multiplexing

To increase the throughput of data packages or messages, the pulses from several digitally coded sources are interleaved in time. The pulses representing different signals are switched, in turn, into the high-speed pulse stream sent through the channel. In comparison with frequency multiplexing, time division multiplexing is less troubled with amplitude and delay distortions arising from the mixing of widely separated signal frequencies. In the digital system, the digital or sampled analog data may be interleaved before or after the encoding for transmission. In AT & T's advanced digital transmission system (T1), the data is interleaved prior to encoding, thereby achieving the economics of a single, common encoder. After encoding, the interleaved pulse stream may also be interleaved with other such high-speed pulse streams produced by similar processes. Several tiers of interleaving are possible to produce a final, very high-speed stream of pulses from a great number of original signal sources. Of course, each higher level of time division multiplexing requires sufficiently increased band width capacity to pass the combined capacities of the lesser multiplexing systems. Although the various channels may be passing greatly different information, multiplexing at the higher levels requires no further encoding and eliminates almost all chance for interference of one channel with another.

(c) Signal Regeneration in Digital Channels

One of the advantages of digital transmission systems is the inherent ability of the system to discriminate against noise interference, provided that the digital signal levels are maintained well above ambient channel noise levels. This discrimination against noise, as well as other degrading factors encountered as delay distortion during transmission, is achieved through the regeneration of the high-speed pulse stream at approximate 1-mile intervals along the transmission line. The transmission line repeaters serve in an entirely different capacity than do the repeaters in an analog system, where the incoming signal is given a boost in power and retransmitted as a more powerful replica. In the analog system, distortions accumulate along the length of the transmission line. In contrast, the repeaters in the digital system transmit reconstituted signals that duplicate the original signal entering the line. This is possible by taking advantage of the nature of the individual digital pulses. Distortions which arise between repeaters can be detected, and new, correctly shaped pulses can be generated, provided the repeaters are sufficiently close together and sensitive. Consequently, the performance of digital transmission systems can be virtually independent of length.

(3) Objectives of Long-Range Digital Networks.

Four basic objectives are served in the design of the hierarchy of time multiplexed digital transmission systems:

- All types of signals will be handled.
- The various signals transmitted will be time division multiplexed to derive the inherent benefits of digital signals.
- Individual transmission systems will be completely compatible with each other.
- Switching of channels will be performed digitally.

In order to achieve these objectives, careful selection of system parameters, supported by advanced engineering practice, was necessary. The major decision to be made in the formulation of a highly coordinated, flexible hierarchy of data channels is the setting of bit rates for each channel of the entire system. Such a decision imposes a minimum bit rate requirement on all elements of the system. In addition to selecting standard bit rates for the various levels of the system, selections must be made of other parameters and techniques of criteria for control and accuracy. Control is achieved by incorporation of control bits into the stream of pulses. Accuracy is governed by the binary word length of the code; thus, a seven-digit binary code has an intrinsic accuracy capability of one part in 127 parts (2^7-1). Bit rates and binary word lengths are directly connected with the normal type of information to be transmitted. In the T1 system, voice signals are to be sampled at 8,000 times per second. In higher level transmission systems (i.e., picturephone) requirements are much greater in order to accommodate the picture. At the upper end of the scale is television, with a requirement of about 60 times that for a T1 voice channel. To enable proper balancing of the various tiers of multiplexing, the combined lower level channels must match the bit rates of the higher level channels. At each multiplexing of channels, additional control bits (pulses) must be inserted so that the combination has a higher bit rate than the sum of the input pulse streams. Control pulses perform another important service in the time division multiplex systems; they are used to maintain synchronism at the receiver for decoding and for switching to the intended destinations.

(4) T1 Through T4 Long-Range Digital Networks

As stated earlier, digital signals are to be multiplexed in time in several stages. The transmission system existing at the several levels is characterized principally by the rate of information transfer in bps (bits per second) (see Exhibit 16). Thus, a T1 channel has a transmission rate of about 1.3×10^6 bps. A T2 pulse stream is the result of multiplexing four T1 channel output pulse streams, and with the addition of control pulses, a T2 signal has a pulse rate of 6×10^6 bps. A T3 signal is formed by multiplexing seven T2 signals, and the resulting information rate is $4^6 \times 10^6$ bps, the same rate needed by a mastergroup output signal. To form a T4 pulse train, six T3 or mastergroup pulse trains may be multiplexed, or five T3 and one digital television signal of 92.5×10^6 bps may be used. Other combinations are also possible in forming a T4 signal.

(a) T1 Channel

The T1 carrier is the first digital transmission system to be designed and is now used commercially in many of the more heavily populated areas. It is a short-haul carrier with a recommended range of 10 to 50 miles. The line transmission rate for the T1 system is approximately 1.3M bps.

As the digital carrier is introduced, advantages should be obtained by users in the form of lower rates. This is evident when it is considered that, while digital lines cost nearly the same per channel mile as analog lines, a 50K bps data circuit (T1) displaces only three voice channels on a digital

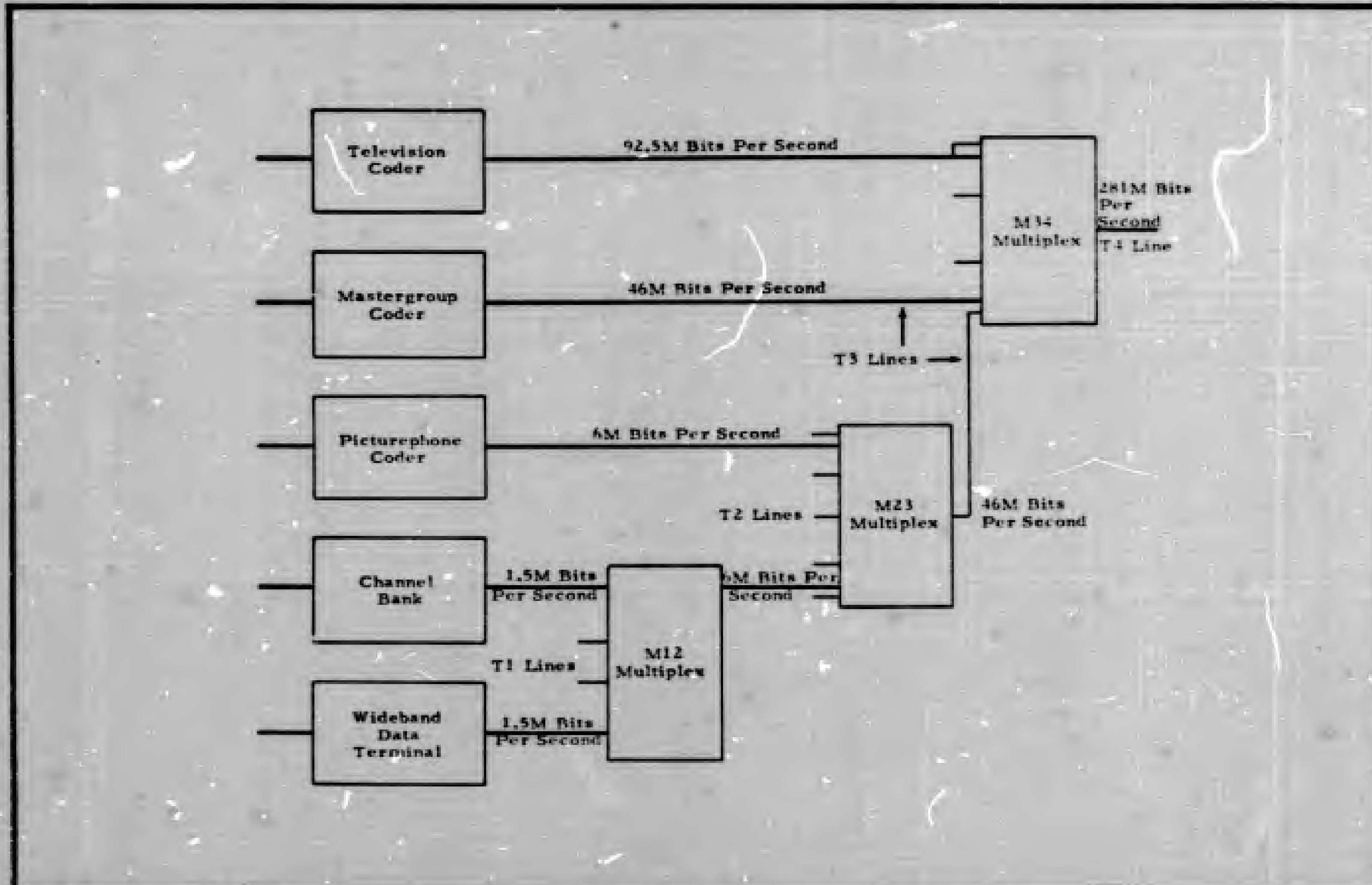

EXHIBIT 16 - T1-T4 DIGITAL MULTIPLEXING

line but displaces 12 voice channels on an analog line. In spite of this, the data terminals developed are quite inefficient. Theoretically, three times as many 50K bps channels could be transmitted on a digital line. The present arrangement allows transmission of asynchronous as well as synchronous signals. More efficient terminals for synchronous data will be developed as the need arises and as the digital network begins to grow.

(b) T2 Channel

The T2 channel is a short-haul toll system that transmits approximately 6.3M bps on paired cables. The T2 system will be used for distances less than 500 miles and should be available in early 1969.

(c) T3 Channel

The T3 is an intermediate system with a line transmission rate of approximately 46M bps, and is expected to be available late in 1969. However, present plans do not include the development of a system to transmit the intermediate (internal) 46M bps signal.

(d) T4 Channel

The T4 is a long-haul toll system that transmits 281M bps on coaxial cable. This "cross-country" system is expected to be commercially available in 1972.

T4 mastergroup and television coders are also being developed. The first is expected to ease the introduction of high-speed digital transmission systems into the present network, while the second provides for the high-grade transmission of standard color TV over long distances.

(5) Miscellaneous Items

(a) Voice Lines

At present, on dial-up voice lines, transmission is limited to 2,000 bps and 2,400 bps on a private line. It is estimated that these rates will increase to approximately 3,600 to 5,400 bps within the next 5-year period, with an outside possibility of extending this rate to 7,600 to 9,600 bps. The test units for the 3,600- to 5,400-bps systems are currently being built.

(b) Analog Channels

A major problem associated with analog channels is the considerable amount of noise picked up along with the signal. In the digital system, the noise is wiped out by repeaters located about a mile apart along the transmission lines.

(c) Rates

There will be higher bit rates in the future, but lower line costs. An approximate reduction in the magnitude of 10:1 in line haul is projected within the next 10 years, resulting from the availability of the digital plant. This is due primarily to the displacement of voice channels, although there will be some increases in equipment costs. It is expected that there will not be any dramatic reduction in terminal equipment costs since the capability is not yet available to attain dramatic improvements.

(d) Equipment

It is recommended that transmission equipment manufacturers design their hardware in accordance with these criteria: produce serial bit stream equipment, since it can utilize the bandwidth most effectively; and convert from a nonsynchronous signal to a synchronous signal because, when forced to do so, it is necessary to use almost three bits to one bit, whereas in straight synchronous it is closer to 1:1. It is generally more efficient for a specialized equipment manufacturer to produce this equipment, rather than a common carrier. In order to send analog data on digital lines, it would be necessary to design an encoder that is not readily marketable.

(e) Telegraph

Telegraph speed is limited to 150 words per minute.

3. External Digital Bulk Storage

A minimum of two, and often more, levels of storage are utilized in any data processor to realize an efficient balance between capacity, cost, and access. Fast-access storage is more costly per unit than its slower counterparts. Most data processors currently have fast-access storage in limited amounts and considerable amounts of slow-access bulk storage.

All digital systems are required to store information in digital form. The selection of storage media for a given application should be made with full knowledge of the relationships and interfaces existing among the various types of digital electronic memories.

External digital bulk storage devices may be categorized into two fundamental techniques, rotating memories and magnetic tape. Each of these techniques displays its own capacity, access, and cost-per-bit characteristics. Approximations of these characteristics in terms of the present state-of-the-art are:

Technique	Access Time	Bit Capacity	Bit Cost
Rotating Memories	10 millisecond-1 second	50K-10G	$0.05-0.001
Magnetic Tape	10 second-1 kilosecond	32M-1G	$0.001

The selection of a memory or an array of memories is dependent upon the design considerations of the particular system in question. However, it is possible to make some empirical statements concerning cost versus performance trade-offs in the choice of a memory.

a. Rotating Memories

This category includes data storage devices, such as drum memories, and random access storage, such as disk storage devices. The majority of the current bulk storage devices are disk devices; however, some third generation equipments are utilizing drum storage for intermediate storage requirements. UNIVAC is currently using two types of drum memories with their 1108 processor. One has the capacity of 262,000 words with a 4-millisecond access, and the other possesses a 22-million word capacity and 92-millisecond access time. RCA, with its Spectra 70 series computers, is using a drum memory device with a 1.8-million byte capacity and 816-millisecond access time. There are several disk storage devices currently available, with the IBM 2311 disk being the most predominant. The largest of the recently announced disk storage devices is IBM's 2314. Control Data Corporation is currently utilizing several types of disk systems, such as the 853 and 854 disk files used with their 3000 series equipments, and the 6,638 disk files used for the 6000 series equipments. The disks used with the 6000 series provide nominal storage of 500 million bits. The characteristics of the various disk files currently being used in the third generation processing equipments are presented in Appendix B of this report.

Memory requirements in the range of 10 to 10^9 bits, and access times in the 0.01 to 1.0-second range, have usually been satisfied via rotating memories utilizing a magnetic surface as the storage medium. In such devices, a thin magnetic coating is applied to a tape, disk, drum, or card, and the magnetic surface rotated past magnetic heads used to read or write on the surface. The functional parameters of access time and storage capacity will be used to categorize the mechanisms. Consideration will be restricted to those storage systems with subsecond access times. Within these constraints, two major categories may be delineated: (1) devices with one or multiple fixed-position heads per track, and (2) devices with movable mechanisms to position the heads over any one of a group of tracks.

The second category is generally slower in access time than the first. This is due primarily to the time required to manipulate the head-positioning mechanism. It should also be noted that the second category will generally provide large storage capacity at less expense, due to the lower number of heads required.

A number of operational characteristics are of importance in selecting a memory device. These include: storage capacity, storage capacity per data cylinder, medium (removable or fixed), access time to any given location, transfer rate, bits per track, bit recording density, data recording and clocking methodology, number of recording surfaces, storage medium (drum, disk, tape, or card), overlap capability, number of tracks per recording surface, total number of tracks, and track density.

(1) Magnetic Disk File

The memory elements are metal disks, magnetically coated on both flat sides. These disks are rotated about an axis perpendicular to the center of their flat sides. The disks are stacked on the axis and rotate on a common shaft. Fixed heads are mounted so that they cover all tracks on all disk surfaces in the fixed-head version. Several movable-head versions have been implemented, including one which has a single pair of heads able to move to any position on the disk. Another version has one or more heads per disk surface, all moving parallel to the recording surface.

(2) Magnetic Drum

The memory element is a metal cylinder, magnetically coated over its curved surface. It rotates about the axis through its circular ends. In the fixed-head version, the heads are fixed in the drum housing, always sweeping the same circular track, one head per track. In the movable-head version, a head exists for each group of tracks, and all heads are moved within their groups by a mechanical positioner. Drum memory is a fixed medium.

(3) Magnetic Card Memory

The memory element is a thin, flexible, magnetically coated Mylar card, stored in large groups within a cartridge. For a given access, one card is selected from the stack and wrapped around a drum, with fixed heads for reading or writing on the card while it is on the drum. This device may be considered a drum with a changeable surface. Magnetic card memories are removable media.

(4) Magnetic Tape Loop Memory

The memory element is an endless loop of magnetic tape, driven past a read/write station. Many loops make up a cartridge, and there are one or more read/write heads per loop, which are positionable across the tape. The cartridge is usually removable. A cylinder consists of the contents of all the tracks under heads at any position of the head positioner.

(5) Optical Rotating Memories

A variety of optical memories using photographic film disks, cards, or chips are in use. These are read-only memories. No efficient process for changing the information on the film has yet been developed.

A compilation of the characteristics of current state-of-the-art rotating memories is presented in Appendix B. These memories are separated into two groups, devices with one fixed head per track and devices with positionable heads.

b. Digital Magnetic Tape

There are many manufacturers of magnetic tape units, and most of them produce excellent equipment. Today the user is able to select a unit according to his special requirements, instead of adjusting his requirements to the hardware available.

Data transfer rate is a major criterion used in the selection of a magnetic tape unit. If the unit is merely to be used for computer input/output, the user need only select a unit with a transfer rate compatible with that of the computer. However, an increasing number of magnetic tape applications can be found in specialized systems in which the tape unit acts as an interface between the computer and data transmission and acquisition devices.

The data transfer rate of a tape unit is calculated as the product of the packing density and the speed at which the tape is read or written. The packing densities and speeds available have become standardized at specified increments; therefore, the data transfer rates have also become correspondingly standardized.

Tape units with transfer rates in the range 96KC to 120KC (thousand characters per second) using standard recording techniques (NRZ or NRZI) are classified as high-speed. Those units with transfer rates in the range 50KC to 90KC are classified as medium-speed. Such units are quite versatile, capable of operating with a wide variety of medium- and large-scale computers. They are also usually capable of meeting the recording and storage requirements of most offline applications. Some of these units are also capable of higher transfer rates made possible by the use of special recording techniques or special formats.

Units operating under 50KC are called low-speed. Most low-speed units are suitable for use with small- and medium-scale computers, and usually offer a considerable saving in costs. Low-speed units are usually appropriate for offline applications which do not directly involve the computer. These applications include data transmission, storage, and conversion.

Incremental tape units differ from other types because the tape is started and stopped for each character. The prime advantage of this technique is in applications where input data are received at a highly variable rate but must be recorded at regular spacing and in a standardized format. Examples of such applications include computer input, offline processing, and transmission. These units are often used as communications rate changers in conjunction with dataphone, teletype, or similar devices. In these instances, data received on one line at one rate are recorded for transmission on another line at another rate.

Incremental magnetic tape bridges the gap between paper tape and synchronous magnetic tape. Although paper tape is preferred for numerous low-speed applications, the price rises dramatically as speed requirements increase. Problems, also, tend to rise almost as dramatically. Incremental magnetic tape offers higher speeds with corresponding increases in reliability and economy. Furthermore, it also provides advantages in high-packing densities, reusability, and high-speed computer entry where necessary.

All incremental tape units are basically stepping recorders, with some also offering stepping data playback. Some units have been further refined to permit synchronous as well as asynchronous operation. Finally, some units offer direct computer compatibility in the recording format used. Incremental tape units currently on the market offer these features in a variety of combinations. The potential user must carefully evaluate his own requirements to determine his exact needs. The various magnetic tape equipments currently being manufactured, along with functional descriptions, are included in Appendix B.

4. Peripheral Equipments

Peripheral equipments are those equipments which are necessary to convey data in and out of a computer in order to obtain results required for a particular process. These equipments include, but are not limited to, input/output typewriter, paper tape reader, paper tape punch, card punch, card reader, printer, and document reader. Every equipment manufacturer has several sets of peripheral devices of various speeds and capacities. For example, depending on a particular application, one may need a standard printer which produces approximately 600 lines per minute or a high-speed printer which is capable of 1,000 to 1,500 lines per minute.

In this manner, peripheral equipments are primarily application oriented and current technology exists for having a peripheral device capable of satisfying most data processing requirements. The various peripheral equipments currently being manufactured, along with functional descriptions, are included in Appendix B.

a. Input Typewriters and Keyboards

Input typewriters and keyboards provide a means of direct manual input to the central processor necessary in most applications. This input may take the dynamic form of real time inquiry, or the static form of establishing constants and operational parameters. The dynamic form of input is usually entered via a keyboard unit which may also produce a hard copy for operator convenience.

An input typewriter is a keyboard unit. It produces hard copy in a standard typewriter mode, and simultaneously generates an electrical signal fed directly to the central processor. The user normally provides electrical buffering for the signals to the computer because of noise contamination of the coded signals. Input typewriters currently available are summarized in the product summary tables appearing in Appendix B.

An increasing number of units have recently been introduced for applications not requiring hard copy. These units are simpler, smaller, and generate less electrical noise. These pushbutton switches are often built into special-purpose keyboard control panels. However, the tables in Appendix B only include complete keyboard units designed for manual operation.

b. Digital Printers

Printers perform two types of functions: data monitoring and high-speed data accumulation. Data monitoring provides a permanent, human-readable record. High-speed data accumulation is the recording of data at rates beyond human acceptance.

There are three common application areas for digital printers: computers, communications, and logging. Printers designed for these applications therefore fall into three general types.

- A computer-oriented printer records data resulting from data processing operations. These are high-speed, wide-format printers which accept data in character-serial format. They are usually driven from the computer. Thus, high speeds are required to maintain system throughputs. Since the computer feeds data to the printer at an incompatible rate, a character-serial line buffer is usually provided.
- Communications line printers interface to a communication channel and therefore usually utilize bit-serial entry. Speeds of about 10 characters per second are sufficient where human communications are involved. Speeds in excess of 300 characters per second are normally required when the computer is feeding data over telephone lines.
- A data-logging printer records transient data on events collected from data acquisition systems. Since these printers are involved with analog-to-digital conversion, they fall outside the scope of this report.

External considerations involved in the selection of digital printers include:

- Throughput - This is the capacity of the printer in terms of characters or lines printed per unit-time required. This characteristic normally determines the type unit required and highly influences cost.
- Interface - This includes problems of a formatting, device control, electrical, mechanical, and timing nature.
- Number of Columns - This requirement is usually based upon printout organization and directly affects machine and throughput costs.

Printer internal design features affect reliability, maintainability, and operating costs. These features include the print mechanisms, paper feed, and transfer medium used. Reliability is usually expressed as MTBF (Mean

Time Between Failure). Unfortunately, little in the way of documented mechanical component failure rates exist; thus, MTBF figures are usually based on sample life tests.

Incidental factors to be considered in selecting a printer include: ease and frequency of paper loading and ribbon replacement, access to components, requirements for special tools, and ease of trouble-shooting. A comparison of digital printing equipment appears in Appendix B.

c. Document Readers

Document readers are systems designed to read printed or marked data from paper or card forms and translate it into computer input form. These systems also read graphic data which meet strict requirements concerning format, location, and legibility. Normally, document readers are designed to accommodate specific types of documents, marked or imprinted with specified type fonts. However, flexibility in input media can usually be provided at an additional cost. The three basic typographic forms accepted by document readers are type fonts, hand printing, and mark sensing.

The performance of document readers is usually measured in terms of documents read per minute, flexibility in reading fonts, and the ability to correctly interpret imperfect printing. The document reader's speed is expressed in documents read per minute. This rating considers both paper handling ability and the ability to avoid scanning blank areas of documents. Flexibility in being able to read several fonts and/or handle documents of various sizes and formats is only of value if required to perform the user's function. However, the ability to handle imperfections in printing is an important feature because it affects the rate of reading.

Document readers are made up of five basic sections:

- The document transport conveys documents from the feed hopper, through the reading system, and deposits them in the output stackers. Movement is accomplished via belts, friction, and vacuum techniques.
- The reading system contains a device for scanning the document and sensing the presence of images. Scanning may be accomplished via such techniques as flying spot scanners, vidicons, or arrays of photocells designed for high character reading rates.

- The recognition system analyzes the data sensed by the scanner and indicates which character has been read. This is accomplished via optical matching or electronic techniques.
- The recording unit or computer interface receives the data stream of recognized characters.
- The control section of the reader may be self-contained or may depend upon the execution of stored program functions in the computer.

A comparison of document reader common functions appears in Appendix B.

d. Punched Card Equipment

(1) Automatic Card Readers, Card Punches, and Card Reader-Punch

The selection factors of primary interest for an automatic card reader include reading speed, number of hoppers, hopper capacity, checking features (i.e., reading check, validity check, misfeed), and reading method (i.e., contact, non-contact). Character-read cards are scanned one column (character) at a time, while row-read cards are scanned a row at a time.

The product summary tables appearing in Appendix B list the primary characteristics of currently available automatic card readers, punches, and reader-punch combinations.

(2) Static Card Readers

The static card reader is primarily utilized as a programing device. The card functions as a read-only 80- by 12-bit memory for which it acts as a replaceable storage element. These readers invariably utilize contact reading and normally read all 960 positions simultaneously. Since significant difficulty has been experienced in the attempt to tabulate static card reader characteristics, further description will be restricted to selected company information.

e. Punched Tape Equipment

(1) Readers

Punched tape readers can be classified as either mechanical or photoelectric, depending upon the methodology used for hole sensing. The internal organization of most readers is constructed with similar logic design and amplification principles. However, other substantial differences do exist between these two classes of readers.

Mechanical readers are used in low-speed reading applications, usually less than 30 cps (characters per second). Sprocket wheels are used for tape alinement and guiding. Perforations are detected when electrical contacts are made through the holes. Most mechanical readers operate more reliably at slow speed because of inertia, contact bounce, and sprocket-guiding methods used. Due to wear, moving parts should be constructed of special alloys. Tape life is an important consideration and is measured by the number of passes through the reading head. Paper tape life on mechanical readers is usually about 300 passes. Tape life is much longer for paper-coated Mylar tapes, and substantially longer for Mylar-coated foil (as high as 50,000 passes).

Photoelectric readers are primarily utilized for high-speed applications, where the tape is usually edge-guided. Punched holes are detected via light-sensitive elements. In some readers, the sensing elements are triggered by light transmitted through hole areas, whereas in others, activation occurs when light is reflected from no-hole areas. The elements which normally restrict the reading speeds of these devices are tape transport mechanisms and photocell response. Photoelectric readers have been designed for speeds up to 1,000 cps. However, most current units of this type operate in the 200-cps to 500-cps range. Cost increases with speed, and many applications find high speed unwarranted.

Block readers are capable of reading a large number of bits simultaneously. Block reading requires no buffering, no accumulation of data in registers, and no storage devices. Block readers are frequently employed in automatic test systems.

(2) Tape Punches

Almost all paper tape punches currently available are capable of punching other materials, including Mylar and paper-coated Mylar. Major applications for punches include computer output, data logging and acquisition, data communications systems, and automatic testing operations. Its advantages over other recording media include low cost and low susceptibility to variations in temperature and moisture. Depending upon the application, its nonerasability may be considered an advantage or a disadvantage.

Tape punches of widely differing design are being marketed today; however, the hole codes, tape dimensions, and channel capacities remain standard. The punch's primary function is to react to pulses, activating punch pins which are forced through the tape. The perforating action of tape punches necessitates electromechanical design. With such design come the problems of noise, inertia, wear, and vibration. These design problems tend to become substantially more accute as speed is increased.

Punching speed is one of the more important characteristics considered in selecting a punch. Contemporary speeds range from 10 cps to 300 cps. Slow speed units are usually interfaced with page printers, typewriters, and other such keyboard-human operator interfaced devices. Medium- and high-speed devices (60 cps to 300 cps) are used for computer output, data acquisition, and data logging.

Until recently, five-level codes were extensively used in communications equipment. Now the eight-level ASCII code is becoming standard, and six-level tapes with advanced feed holes are being widely used in the graphic arts industry.

5. Microforms and Related Equipments

For the purpose of this study, the term "microform" encompasses all reproduction media that reduce the size of a document or a drawing without loss of the document's intelligence. This means that by using enlarging device, the image will become readable or recognizable to the naked eye. Some of the more common microforms are roll mocrofilm, microfiche, and aperture cards. Equipments related to microforms are, for example, readers and reader-printers.

Definitions will be given of the primary components of an elementary microform system (i.e., film, camera, processor, and viewer). Study constraints of time and money did not, however, permit detailed consideration of commercial cameras and processors.

Film will also be discussed, but only as background information. If a type of film or film process is particularly singular and represents a new concept in the industry, it will be discussed under its appropriate vendor. Indexing, which is an essential part of any microform storage and retrieval system, will be described in the software section of this volume.

This section will summarily review the expanding microphotography industry. Comparisons of capabilities in the reader and reader-printer areas will be made. The types of film used will also be described since there has been great concern about the reliability of some of the newer film processes.

The idea of microfilming documents for storage and retrieval has existed almost since the invention of microfilm in England in 1839. In that year, John B. Dancer photographed a document through a mircoscope lens. The first use of microfilm as something more than a novelty occurred in France in 1870 when Rene Dagron photographed messages on narrow film strips and sent them by carrier pigeon during the siege of Paris. When the messages were received, the miniature images were read with a magnifying glass.

The first practical microfilming camera was not invented until the 1920's. George L. McCarthy, who was concerned with the banking industry's lack of concise recordkeeping, invented a photographic apparatus and called it the "Checkograph." The sole purpose of the Checkograph was to photograph personal checks before they were returned to customers. In this way, the bank would have evidence that a transaction had taken place.

In 1928, the Recordak Corporation was formed with Eastman-Kodak's backing and with McCarthy as president. An entirely new industry had begun. The Checkograph was a success as an archival protection device.

The next 40 years produced an ever greater demand for microfilm. Banks and department stores were its first primary users. The Social Security Administration began using it for protection of its accounts in 1936 and has continually increased its utilization of microfilm. World War II created demands for great quantities of engineering drawings with the necessary condition that they be readily available for repair and maintenance of ships, etc. This condition required the use of microfilm, since it was not unusual to have a ton of blueprints for a single ship. Other boosts to the industry were the Federal Government's legalizing the destruction of documents after filming the V-mail program, and, in 1960, the DOD specification requiring contractors to submit copies of engineering drawings on aperture cards.

A dramatic increase in the usage of microfilm began with the need for high-speed computer printouts. The line printer onto paper could not keep pace with computer speeds, causing considerable time problems. In addition, the conventional line printer was unable to provide a sufficient number of good quality copies. Today there are microform equipments capable of solving either one or both of these problems. Computer output directly onto microfilm is possible, and reproducing machines exist which take an ordinary printout, reduce it from its usual 11- by 14-inch size, and produce as many copies as required.

Other advances have been in the area of retrieval. No longer only a storage medium, microforms have become an integral part of modern office referencing systems. The science of indexing has improved considerably and it is now possible to access one document out of millions in seconds.

a. Reduction Ratios

The ratio of the size of the original document to its miniaturized size on film or paper is called the reduction ratio and is usually expressed as A:1 or Ax where A is the length in inches of the original. For example, 20:1 or 20x represents the reduction of a document 20 inches long to 1 inch of film. This measure is also used, somewhat ambiguously, to describe the amount of enlargement capability in a reader.

Reduction ratio is the most meaningful measure of the storage capacity of film, but equally important is the resolution. The resolving power of the eye at normal reading distance (from seven to 12 lines per millimeter) is acceptable for reduction ratios of from 16x to 30x. This means that if a test target is printed on the film, it will be possible to discern through a microscope the lines of the pattern which have 100 lines per millimeter. The relationship between the eye resolution and film resolution is best explained by an example. Ordinary typewriter print is 1.6 millimeters high; a film with resolving power of 100 lines per millimeter will produce eight resolution lines on 0.08 millimeters of film. Therefore, using a reduction ratio of 20x, an ordinary 1.6mm character will be reduced to 0.08mm on film with eight resolution lines, and will be readable upon viewing through a microscope since the eye is capable of resolving seven to 12 lines per millimeter.

It is clear that the eye's resolving power and the film resolution are definite constraints on a microform system. This is particularly evident in the effects of successive regenerations. Normally, a document is microphotographed on a high-quality film and then duplicated repeatedly from this master copy. Another method is to duplicate the entire file onto a lower grade of film, the so-called second generation. It is possible that even a third or more generations can be formed. It has been found that each succeeding generation decreases the readability of the preceding generation by 80 percent. Therefore, for best results a high resolution film should be used for a master, with a reduction ratio set up that will allow third generation copies to be readable. A typical film resolution is 250 lines per millimeter on Kodak microfilm. For error-free reading at seven resolution lines per character, the maximum reduction ratio is 37x.

b. Film

There are essentially three different types of microfilm in common use: silver halide, diazo, and Kalvar (registered trademark of the Kalvar Corporation).

Silver halide is identical with film used by a photography enthusiast. Its history of reliability is well-known and it is considered the safest film type for archival storage, although it is also very susceptible to scratching. For these reasons, silver halide is usually the medium for master copies but is not normally used for working files.

Diazo is a slower film than silver halide, but development can take place rapidly in the light. Although a diazo image is less susceptible to scratching than silver halide, it has the disadvantage of an image that fades with time. Diazo is well-suited for making duplicates from silver halide masters.

Kalvar is a thermal developing film; that is, the process required for development of an image is heat alone. Exposure is relatively simple and it retains images well under proper environmental conditions. Its history is not well-known since it has only been in existence a relatively short time. It is presently being used primarily for second or third generation working copies.

c. Cameras

There are two types of microfilm cameras, rotary and planetary. The rotary camera is based on a rotating drum system. Documents are fed into the machine and photographed, while in motion, by the camera on film that is advanced synchronously with the document. A manual operation can film approximately 50 8-1/2- by 11-inch documents per minute, while an automated feeding device will film approximately 500 check-size items per minute. Shutter speed, aperture opening, exposure time, focusing, and other photography factors are performed automatically by the rotary camera, making it ideal for use by a nonprofessional operator.

Planetary cameras are more precise than the rotary type. The document to be filmed is placed on a flat surface with the camera on a column over it. The adjustment for the amount of reduction is made by raising or lowering the camera; exposure is controlled by varying light intensity. The planetary camera is used for high-quality reproduction and requires a trained and experienced operator.

One function that is available on some models of either type camera is a step-and-repeat capability. A step-and-repeat camera is used to position images on a sheet of film to form a microfiche card. By using such a camera, cutting and pasting is unnecessary since the camera will automatically move from row to row in sequential order.

d. Types of Microforms

The three most common types of microforms in use today are roll film, aperture cards, and microfiche. There are many others, utilizing either film or paper, which will be referred to in specific vendor sections, but these three are dominant in the field.

(1) Roll Film

Roll film is 16mm or 35mm film wound on a spool. It is usually enclosed in a cassette which permits self-threading in the reader mechanism. Sixteen-millimeter roll film is used primarily to record documents 8-1/2 by 11 inches or less (e.g., book pages or personnel records), while 35mm film records documents from 16 inches to 35 inches (e.g., engineering drawings). The approximate number of documents on a standard 100-foot roll of film is from 1,200 to 2,400, dependent on the reduction ratio.

Roll film is easy to file and duplicate. A particular feature of 35mm film is its capability of being cut from the roll and mounted in an aperture card. There is some difficulty in indexing a roll of film, and locating a specific image may be a slow process.

(2) Aperture Card

An aperture card is a standard EAM 3-1/4- by 7-3/8-inch card with a frame of 35mm film mounted in it. The card may be processed through ordinary EAM equipment (see Exhibit 17).

Aperture cards were invented in 1940 by John Langan. In 1949, Arthur H. Rau of the General Electric Company suggested that engineering drawings be placed in this format, and several working systems quickly developed. The card is used for recording documents 8-1/2 by 11 inches to 36 by 48 inches in size, such as drawings, charts, or tables. It is easily integrated into data processing systems.

(3) Microfiche

A microfiche is a negative or positive sheet of film on which microimages are placed systematically in a matrix format. The three sizes currently in common use are:

- 105mm x 148mm (approximately 4 by 6 inches), the Federal Government standard size (see Exhibit 18).
- 3-1/4 by 7-3/8 inches, the size of an EAM card (see Exhibit 19).
- 5 by 8 inches, which is report size.

The number of images on a fiche card varies from the usual five rows by 12 columns (60 images) on the 4- by 6-inch card to five rows by 18 columns

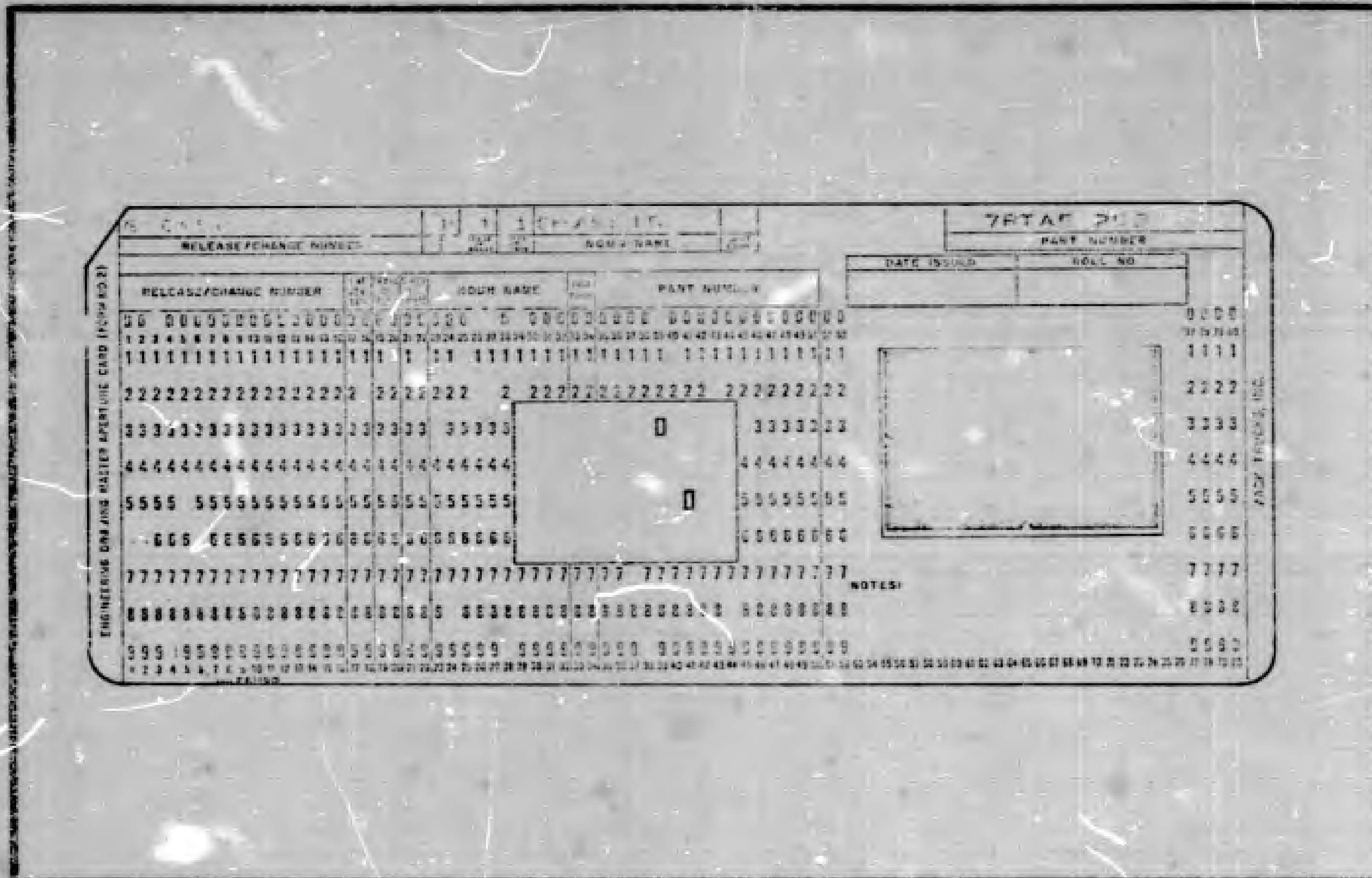

EXHIBIT 17 - SAMPLE APERTURE CARD

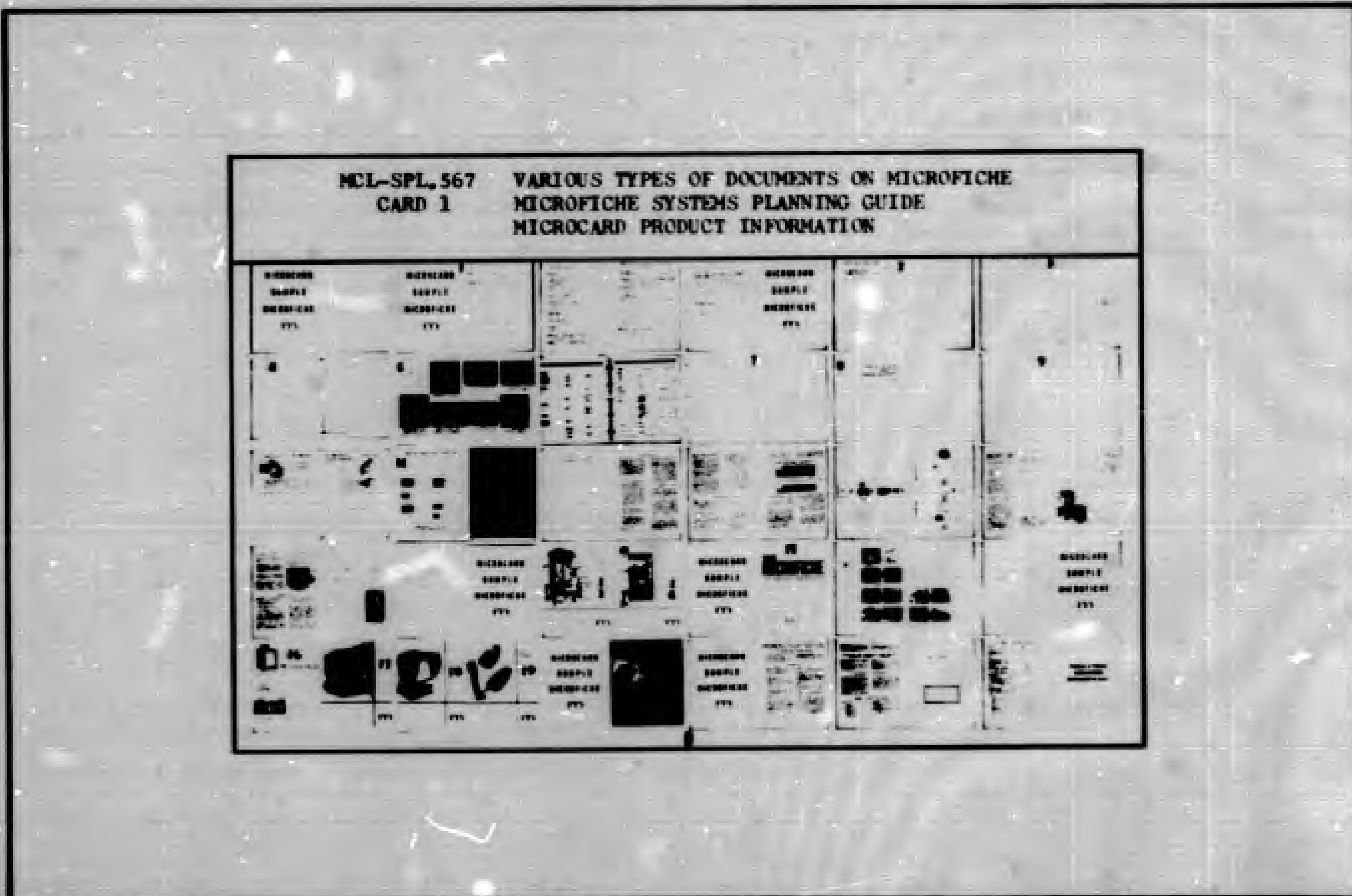

EXHIBIT 18 - SAMPLE MICROFICHE

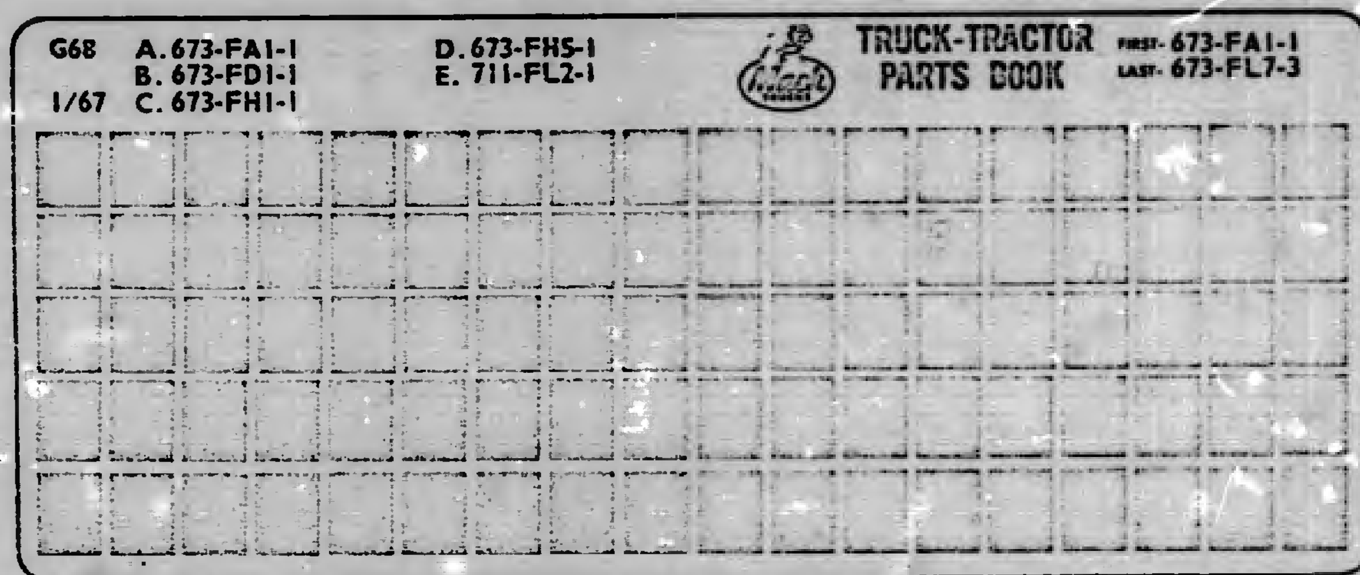

EXHIBIT 19 - SAMPLE EAM SIZE MICROFICHE CARD

(90 images) on the EAM-size film sheet. The cards are produced either by cutting and pasting strips of 16mm roll film, or by a direct process with a step-and-repeat camera which automatically positions the image in the correct row and column.

Several studies have been performed recently by NASA, the Defense Documentation Center, and other Government agencies to determine the best approach for a storage and retrieval microform system. These studies have concluded that microfiche is the best concept for such applications.

e. Types of Related Equipments

Equipments related to microforms are varied. For purposes of this study, the areas and equipments which were stressed were those components of a system that are user oriented. The user is more interested in retrieving information than in the camera or film that produced it. He would like to view it on a reader and perhaps obtain a hard-copy print. He is also interested in computer-interfaced equipments that reproduce output on microfilm or paper. Thus, his areas of concern are:

- Retrieval consoles and indexing systems.
- Readers and reader-printers.
- Computer output recorders.
- Plotters.
- Reproduction and reduction equipment.

The development of the reader-printer in the late 1950's was one of the most important advances in the history of microphotography. Microfilm was no longer restricted to being a storage medium for obsolete or passive data. Instead, active records could be stored, retrieved, and a copy made in seconds. Frequent updating became inexpensive. New splicing techniques and the introduction of self-threading magazines eliminated an extensive amount of roll film handling. The microfiche card, with 60 images per card, provided a readily accessible medium for active records. Since 90 percent of most technical reports and similar items with consecutive pages are less than 300 pages in length, such documents could be stored on five or less cards. Coupled with a suitable reader-printer, microfiche has become a practical and reliable tool for active records management.

Computer output recorders are the latest advancement in the microform industry. Printing online onto microfilm at computer speeds, the recorders have distinct advantages over the ordinary line printing onto tab sheets. Speed, of course, is the first advantage; average line printers are capable of 1,000 lines per minute, while some microfilm recorders have a rate of 5.4 million characters per minute. Another advantage is the relative ease of producing legible copies. Printers sometimes require additional runs to obtain more than three or four legible copies.

Another answer to bulky tab-sheet runs is a new reproduction device that copies and reduces the size of the first copy run from the standard 11- by 14-inch size to a more easily used and filed 8-1/2- by 11-inch size. Other sophisticated equipments are capable of producing graphics on microfilm at computer printout rates. The marriage of the computer to microfilm has created an entirely new concept in information handling.

6. Software

Software is normally defined as computer programs and techniques required to effectively utilize an electronic computer to produce the required results of a particular data processing application. Electronic computers are only as good as the software used to operate the computer. Software is normally considered to be of two types: system software and user software.

System level softwares are those programs which are peculiar to a specific computer and normally act as a management system for all other programs in residence within the computer. In third generation equipments these are referred to as operating systems. This system normally includes an executive which exercises complete control over all programs and the data within the system. User level software consists of specific processors and application programs of higher level programing languages such as FORTRAN, COBOL, JOVIAL, etc. The majority of the third generation equipments include total operating systems which enable the user to operate the computer and more easily construct and debug those application programs required to satisfy his particular requirements.

a. Procedure-Oriented Languages

FORTRAN (FORmula TRANslation) is a procedure-oriented language developed for use in scientific problem solving. Its first widely utilized version was called FORTRAN II and, although this version is still in use on some late model computers, a more recent version called FORTRAN IV is available. Presently, FORTRAN is the most widely used of the procedure-oriented languages.

FORTRAN is essentially machine independent; however, due to the lack of standardization in its early development, certain adjustments must be made to move it from one computer to another. It consists of several types of source statements which basically fall into the following categories: arithmetic control, specification, subprogram control, and input/output. A variety of rules govern the design of such features as data layout in memory and expression composition. These rules change from one implementation to another; thus, source statements must be expressed in slightly different terms for different language dialects. The basic concepts remain constant among the various dialects; however, the mode in which they are implemented may be substantially different. In addition, the rules and restrictions on the use of specific parts of the language may differ.

ALGOL (ALGOrithmic Language) is a rigidly defined language utilized in the description of computational processes to facilitate mode translation to machine code. The basic element in describing calculations is the arithmetic expression which is compounded by the operator into formulas called assignment statements. Additional language elements are made available for the control of loops, alternatives, and other problem logic. In addition, the attributes of variables are defined via declaratives. These basic elements have functions similar to corresponding elements in other languages, but are distinct because of the structure and power of ALGOL statements.

JOVIAL (Jewel's Own Version of the International Algorithmic Language) is a procedure-oriented language based on ALGOL. It is particularly suited to command and control and other applications in which a large, real-time processing program is to be written.

Other specialized procedure-oriented languages include BALGOL, LISP, and SIMSCRIPT. These and other similar type languages have been implemented for special applications.

COBOL (COmmon Business-Oriented Language) is an important procedure-oriented language developed for business applications. It evolved primarily through the efforts of computer manufacturers and DOD. The first widely implemented version was called COBOL '61. The latest version is COBOL, Edition 1965, which has altered the language in order to take advantage of recent hardware developments.

COBOL is designed to be a machine-independent language, thus its syntax and vocabulary are not dependent upon the peculiarities of particular hardware. Instead, it reflects the logic commonly encountered in business data processing. It is concerned with the files, records, constants, and the logic and arithmetic relationships between the input and the output of a program. The statements of a COBOL program are reduced to machine language instructions via the implementor's compiler. The compiler translating the source language to machine language relieves the programer of the necessity of becoming intimately familiar with the operation of the hardware, which is a major benefit of COBOL and of other procedure-oriented languages. The source program written in this high-level language closely follows the logic of the business problem. This means that a COBOL program is more easily understood by other people and can be followed, to a substantial extent, by someone with a minimum of training. COBOL is more self-documenting than machine-oriented programs.

One of the major complaints about COBOL is that is does not always utilize the hardware as efficiently as would an experienced programer using as assembly language. More storage is required and running time is longer. The programer is so removed from the hardware logic that he performs some operations inefficiently. Other shortcomings appear to be inherent in the nature of the language. One complaint is the excessive amount of writing involved in COBOL coding. The shorthand methods of other languages are not usually available, forcing the programer to write, have keypunched, and verify lengthy data structures, verbs, and names. Compilation times are relatively high due to extensive analysis required to decode and translate a substantially flexible language with many variations. These shortcomings are greatly outweighed, however, by the advantages of COBOL. It is therefore becoming an increasingly important and valuable language.

PL/1 is a new language designed for use in both data processing and scientific programs. It has application in real-time and systems programing. PL/1 attempts to incorporate the best features of previous languages such as FORTRAN, COBOL, and ALGOL. It also takes into consideration new hardware features such as mass storage and data communications interfaces. It attempts to incorporate techniques to allow for all possibilities for a widely mixed group of applications. However, few PL/1 compilers are available as yet, and user experience with it has been extremely limited.

Report generators are usually considered to be languages. They are collections of prewritten routines designed to permit rapid writing of relatively uncomplicated programs in problem-oriented terms. Such systems provide the capability to perform common data processing functions. These functions require a relatively large amount of data handling and a limited amount of logic and calculation. Each report generator specifies its own language; there has been no attempt to standardize. Some report generators are interpretive, with no object program being produced; some are languages, in the sense that they have their own operation codes and operants; others use control cards which the user completes in a preprescribed manner. Common to all report generators is their design to perform simple jobs with a minimum of user effort.

b. <u>Assembly Languages</u>

The most widely used type of programing language today is the assembly language. This form gives the programer complete access to all machine facilities, yet relieves him of most of the clerical tasks of keeping records of instructions and storage locations. Assembly languages usually have three types of statements:

- Processor control statements which signal the language processor of significant events.
- Imperative statements which are translated by the machine into machine instructions, which are then executed at object time.

- Declarative statements which define program constants, relationships between data fields, the size of data fields, and symbolic names.

Each assembly defines a set of mnemonic operation codes translated into numeric machine codes prior to program execution. The purpose of these names is to simplify identification of each step in the program.

Many assembly languages extend the programer's power by providing more sophisticated features. The macroinstruction is coded by the programer much like any other imperative statement. Its purpose is to perform a higher level task which would require several machine instructions. These machine instructions are generated by the assembly program.

c. I/O (Input/Output) Routines

Many software systems have evolved with standardized subroutines that perform I/O tasks. This results in standardized handling of data and error conditions and insures compatibility when more than one programer works on the system. In addition, it conserves substantial programing time since it eliminates the necessity of having to solve a problem individually. Standardized I/O routines range from simple read/write programs to intricate systems of file control including object time device assignment.

Some basic I/O routines handle only magnetic tapes, while more elaborate routines process cards, tapes, disk files, display devices, and communications channels. Such intricate systems usually operate under the control of an operating system. Simpler I/O routines operate as part of the assembly processor. These are usually confined to magnetic tape and card units, where error detection and correction are performed via standardized subroutines.

d. Utility Programs

Most software systems include a variety of programs to perform miscellaneous functions. Some of these programs only provide minor conveniences, while others are essential to daily operations. This assortment of routines is referred to collectively as utility or service routines. Examples of utility routines include:

- Sort - A program which rearranges records stored on tape or other auxiliary storage into a desired order based upon key fields in the record.
- Merge - A program which takes several previously ordered files and combines them into a single ordered file.
- Debugging and Test - Programs designed to aid the programer in locating programing errors and making certain that programs operate under worst-case conditions.
- Linkage Editor - A program which combines several segments of coding into one routine, permitting repeated use of subroutines for different applications.

e. Operating Systems

Operating systems have come into wide use to counteract the degradation of system performance caused by manual intervention. The purpose of these systems is automation of manual procedures while providing a standard and helpful machine environment for the programer, installation manager, and machine operator. The environment of the operating system is designed to relieve programers and installation managers of many non-essential details of their functions.

Most operating systems have three major tasks: language translation, job control, and data control. They can accept properly identified programs in several languages and call on the proper translator to reduce the statements to a given form of machine language.

An operating system provides a uniform language and procedure for communicating with the computer operator. Since all programs operate under its control, its facilities are used to inform the operator of program status. This standard operating environment also assists the programer, since he no longer has to decide when each new program overlay is required. In addition, operating standards are maintained with minimum programer supervision and indoctrination.

Significant time saving advantages are provided by the miltiprogram features of some of the more recent advanced operating systems. This capability permits two or more tasks to be processed concurrently. Multiprograming increases the throughput capability of the computer by more fully utilizing available resources. Thus, when one task cannot utilize the central processor because it is waiting for the availability of a given device, another task takes over.

Some operating systems provide complete facilities for handling various types of data sets. Others provide only partial facilities. Still other schemes have data control facilities built into language translators. A potential user should consider which of these schemes is the best method for his purposes.

Some of the functions this type of software offers include:

- Dynamic scheduling of I/O devices.
- Detection and correction of errors associated with data transfer.
- Logical handling of data sets without reference to physical characteristics of the storage devices.
- Control of physical movement of data between central storage and auxiliary storage or external data sets.
- Data buffering, blocking and deblocking, overlapping data operations with computing, and data set label processing.

f. <u>Indexing</u>

An index is an ordered listing of names and subjects, so arranged to enable the inquirer to locate information about specific topics from a store of information. Additional functions of an index are the facilitation of information storage and retrieval.

There are two general types of indexing, name and subject. Name indexing is strictly alphabetical and is fairly inflexible. Subjects may be indexed in many different ways, but there are three major forms--classification, subject, and coordinate--all of which may be used singularly or in combination with another.

Classification indexing is hierarchical and is arranged from the most general to the most specific. An example of this type of indexing is the Dewey Decimal System, most commonly used by libraries. In such a system, subjects are arranged according to a predetermined list of categories. For example, biology would be listed under the general category of science, botany and zoology under biology, and under botany and zoology would be listed more specialized sciences such as marine biology, etc. Indexing of this form is advantageous in that it lends itself easily to mechanical retrieval and storage, and to fields where many of the terms used are multilingual.

However, the classification system of indexing, when used singularly, has some failing. It is necessary to have an alphabetic index to find where topics are filed. Furthermore, most categories, with the exception of some like biology, do not lend themselves to logical arrangement. This type of indexing is best suited for already-determined subjects with little expansion or change envisioned.

A second type of indexing is by subject headings and is generally used to catalog and index items for alphabetic reference. Access to each term is direct, except that the vocabularies used and meanings of a term must coincide. Adequate cross-referencing must be provided in order to clarify terms. If some system classification were desired, this form of indexing could allow for the grouping of terms into limited, small classifications. However, each type of indexing must provide for every level and every approach possible.

The third type of indexing is coordinate. Various fields are set up to accommodate all the information. These fields may then be combined and searched for a specific piece of information which meets the qualifications desired. This type of indexing is often used in indexing personnel records where the subjects may be cross-referenced with regard for age, salary, education, etc. Coordinate indexing is more suited to a mechanized system than an individual system because information is readily stored on punched cards. There would be as many cards per document as there are terms or fields used to index the document. Perhaps the greatest difficulty of this type of indexing is the need to show relationships (i.e., logical, spatial, etc.) or make comparisons before the specific document is located.

Besides the three basic types of indexing, there are various types of special indexing such as using words without regard for their meaning, and KWIC (Key Word In Context) indexing, in which the keyword in a title or subject is alphabetized with regard to other titles. In all cases, in order to select the proper method of indexing, the desired end result must be analyzed.

The systems discussed in Appendix B illustrate several methods of indexing and retrieval. There are two types of mechanized retrieval, serial and random access. In serial retrieval, the whole store of information is read and the selection of needed material made. Random access is simply a look-up procedure. Most of the indexing systems discussed in Appendix B use coordinate indexing and the random access form.

Although automatic indexing has many advantages, several problems remain to be solved. The volume of new information being published necessitates a rapid form of classification and storage. Further problems arise when classified material is encountered in the store of information. A method must be devised whereby the general store of information may be available to all, but classified information in the store made accessible to authorized personnel only.

IV. APPLICATIONS OF CURRENT INFORMATION PROCESSING CAPABILITIES TO TECHNICAL DATA PROCESSING REQUIREMENTS

A. Introduction

The basic requirements for the storage, maintenance, transfer, display, and processing of the technical data described in this study may be considered under the following general categories:

- Document storage, indexing, and retrieval.
- Standardization of data packages, elements, identifiers, formats, hardware, and software.
- Data communication and display.
- Information interface, file generation, format, software, queries, and reporting requirements as related to other systems.

These categories will be discussed and developed from the aspect of the data processing techniques and capabilities currently available for application to the requirement areas specified above. A comparison of user requirements and these capabilities will be made in order to identify gaps which exist between requirements and technological developments. Consideration will be given to areas where current capabilities are inadequate (require an advancement in the state-of-the-art), adequate, or possibly exceed the requirements. In addition, consideration will be given to cost-effectiveness factors where decisions must be made relative to trade-offs required with respect to advancing the current state-of-the-art. Future developments and projections of anticipated capabilities determined from numerous vendor contacts during the course of this study are provided in Volume II of this report. In addition, detailed information supplemental to the overall discussion and summary given in this section may be found in Appendix B.

B. Information Control

1. Introduction

The fundamental objective of any information storage and retrieval system, automated or otherwise, is to provide the most rapid access to the complete file of required data, resulting in the acquisition of the information desired within the time limitation imposed. It is implied in this objective that requests for information will be satisfied with usable material. One of the most important requirements to place on any selection or retrieval system is that it yield a high degree of relevant material while excluding selection of the irrelevant.

An equally significant requirement exists for the simplest and most direct procedures available, which will maintain the information file in a current, up-to-date status. New information must be capable of being inserted easily, and old, damaged, or irrelevant information and records should be readily deleted. To insure that the required file deletion and renewal process is performed, definite procedures for operational use must be instituted. One systematic method, particularly useful for hard-copy files, is the maintenance of file utilization statistics which permit realistic consideration to be given to the purging of material. Failure to provide for periodic purging, or the relegation of little-used information to inactive files, will result in the accumulation of deadwood. Such a policy would increase the scope of file maintenance required, along with a likely increase in material retrieval time.

Although periodic purging will tend to keep file size from increasing at an inordinate rate, the growth of files, as well as changes in user requirements, is to be expected. This implies the consideration of a modular system design which can meet the growing and changing demands of evolutional system requirements. This modular and evolutionary point of view must be borne in mind not only in the specification of procedures, but of equipment as well. In summary, some of the most important overall requirements that must be satisfied to adequately control the information storage and retrieval process are:

- Rapid access to information.
- Capability to select specific information.
- Simplified insertion and deletion of data.
- Provision for current information.
- Provision for usage statistics.
- Modular system design.

2. Storage

One of the major problems facing Government and industry today is the adequate storage of vast amounts of technical data being generated at an ever-increasing rate. This requirement has been evidenced at all activities surveyed in this study. Modern technology, in attempting to keep pace with this information explosion, is pressing to advance the state-of-the-art simultaneously on many fronts. As previously mentioned, however, this section of the report will be limited to consideration of off-the-shelf capabilities. The following discussion will be primarily concerned with available procedures and resources. Magnetic tape continues as the most universal data processing storage medium, and improvements to its durability and recording characteristics are being made continuously. Tape characteristics and capabilities, already fairly well-known, will not be discussed in this section. A detailed description of tapes and other memory devices not mentioned in this section can be found in Appendix B of this report.

a. Microforms

Considerable effort has been devoted to the development of these media as elements of total information storage and retrieval systems. Equipment is currently available which can convert engineering drawings, specifications, and other technical data to either aperture cards or microfilm with a high degree of resolution. In addition, information which is capable of being exhibited on a CRT or display device can be microfilmed directly from the CRT. Operating at computer speeds, the output, in digital form, can be translated into alphanumerics. Graphics can also be created by joining line segments under program control. The alphanumerics or graphics can then be photographed directly from the CRT onto 16mm roll film, with options for 35mm or microfiche. Output speeds are stated to be as high as 10,000 pages per hour with input at 90,000 characters per second. Another system with the capability to record data directly from tape to microfilm was recently introduced. For example, a technique for 16mm microfilm can accommodate 20 frames per second, with 64 lines per frame, where each line may contain 132 columns.

Even greater degrees of miniaturization are possible. PCMI (Photo-Chromic Micro-Image), a recently developed technique, provides a 4- by 6-inch transparency comprised of approximately 3,200 images represented in matrix form. Each transparency can be reproduced for dissemination copies. In this manner, approximately 1 million document pages can be stored in microimage form on 400 cards, creating a stack less than 6 inches high.

b. Hardware Components

(1) Drums

In the area of random access drum memories which can be used for general or auxiliary storage, systems are currently available with a storage capacity of 3.4×10^8 bits and a maximum access time of 50 milliseconds. In this system, the read/write heads are in fixed position and are capable of recording or retrieving a single track of digital data from the rotating drum surface. The "flying" head principle (the head rides on a layer of air) is used and the heads never come in contact with the actual drum surface. Simultaneous read/write access can be provided through four independently positionable channels. Several small drums of this type are currently used on Polaris submarines with good results, although they were not designed for military specification.

Among the larger random access mass storage devices available is the FASTRAND mass storage subsystem. Each unit in the system contains two magnetic drums, and as many as eight units may be connected to an available I/O channel. The total storage capacity is 13×10^6 computer words per unit, or about 65×10^6 characters. All functions of the FASTRAND are buffered from the central processor and the computer can continue processing while records are being accessed on the unit. All read operations are parity-checked and flying read/write heads are also employed in this system. In addition, a rather unique search and read function is featured with the system.

Alternately, smaller types of magnetic drum storage units can provide single drum capacity of 6 million characters, with capability for an additional 6-million-character expansion. The transfer rate is given as 370,000 six-bit characters per second, with an average data access time of 8.5 milliseconds. If desired, dual channels are available for access by two processors.

(2) Disks/Data Cells

One current line of disk files provides modular systems which range from system memory files, having capacities of from 1 to 4 million bytes, to massive bulk storage devices with capacities in billions of characters. Combinations of two or more disk file subsystems are also available and are stated to have a maximum average access time of 60 milliseconds. In addition, system memory units are available as small, fast additions to the computer main memory. Control programs, operating software, and program libraries are stored in system memory and can be accessed as needed.

As another example, modular disk storage units are available which permit the storage of from 8 million to 800 million characters with simultaneous access. Modularity permits storage to be added in increments of 50 million characters. In the largest configurations, there may be 32 disks per unit with four units connected to a single controller. The processor communicates with the controller through one to four processor I/O channels. Four channels may be used for simultaneous read/write operations, attaining an effective character transfer rate of 980KC, with a single channel transfer rate of 300KC. In a random positioning environment, each of 16 independent positioning arms can position in an average time of 90 milliseconds.

Direct access storage facilities are provided by another manufacturer and can store up to 207 million bytes on eight removable disk packs. A single unit provides its own control and has eight independent storage drives. As many as eight units can be attached to each of six selector channels on the mainframe. Nearly 10 billion bytes can be online at one time. Average access time is given as 75 milliseconds. Multiple records can be read and written by a sequence of channel commands, with no rotational delay between records. In addition, a data cell drive is also available which provides a solution to the storage of large, sequentially organized data files requiring random reference.

Ten data cells, each with a capacity of 40 million bytes, provide a 400-million-byte capacity for each data cell drive. Up to eight drives may be attached to a single storage control unit for a total direct access capability of more than 3 billion bytes. Each of the 10 data cells is removable and interchangeable so that offline storage capacity is virtually unlimited.

3. Indexing

Independent of the manual or automated techniques employed for the storage of information, detailed procedures are also required for indexing the material stored. The indexing procedure may be generally described by two basic steps:

- Specifying terms which identify the item for the purpose of later retrieval.
- Associating the identifying mark with the item itself and/or recording on a separate item substitute the tags or labels representing these items.

The first step in indexing depends on the capability to determine the informational categories which are meaningful to the user. The degree to which these are correctly resolved will determine the utility of the system. The second step is more routine or clerical in nature. Whether the indexing identifier is recorded on the item itself, or recorded in a separate table or catalog with a means of translation for actual item location, is dependent on the retrieval technique and devices used.

Associating the index directly with the items and searching the items directly has the advantage of the simultaneity of item identification and actual item selection. Search speed, flexibility, and item accounting capability can often be increased, however, if the search process is carried out independently of the actual items, particularly if a computer is employed. Consideration of the particular attributes possessed by each of these techniques and the devices available for their implementation form a significant segment of the alternative selection and cost/benefit analysis efforts of a design study.

The logging, summarization, and coding of each item in a log and/or file catalog is necessary for item accounting, as well as for item retrieval if the item file catalog serves as the item table for the retrieval process. In all cases, the log and/or file catalog serves as the source of information on the current content of the complete item file.

The assignment of the physical storage location for an item could be made either directly from the item index assignment, independently of the index assignment, or indirectly from the index assignment by means of a translation function relating the index of the item to a specific physical storage location. Again, the particular attributes offered by each of these possibilities, and the devices available for their application, must be evaluated in a design study.

With respect to some of the indexing schemes employed in the microform areas previously discussed, the MIRACODE (Microfilm Information Retrieval Access Code) system is an automatic file, storage, and retrieval system using microfilm as the storage media. Documents are identified by assigned numbers and/or descriptive keywords. As the source information is being processed, either from aperture cards or CRT, the equipment automatically generates the MIRACODE indexing format on the microfilm. The source document can then be retrieved by the characteristics or numbers assigned in the MIRACODE system.

4. Retrieval

Information is usually retrieved in response to a user query. Query requests can be initiated for a single item, a general category of items, or for particular items and/or categories of items suggested by a previous query response. In any case, the coding of the item or categories requested, utilizing some form of indexing previously mentioned, is necessary before item retrieval can occur. As mentioned earlier, the search for the item identifiers matching the coded requests or queries can be accomplished by searching a catalog file of the items or by searching the items themselves.

Some of the microform retrieval systems currently available are the MIRACODE and PCMI systems. For system automation requiring the storage and retrieval of millions of document pages, the PCMI system contains a computer-driven file and viewer. In this system, a search can be initiated within the computer for documents matching specific search parameters. When a match occurs, the document location is transmitted to the system for automatic retrieval of the card and automatic positioning of the viewer.

Viewers currently available provide for the enlargement of the microimage to the approximate size of the original document for screen viewing. Additionally, where desired, a full size hard-copy printout and/or standard microfilm (16mm or 35mm) of the microimage may be obtained.

A different type of system is the SELECTRIEVER, a random access retrieval system which can accommodate up to 200,000 individual documents of EAM card size (3-1/4 by 7-3/8 inches). The documents may be either aperture, microfiche, or ordinary cards with information written on them. The methodology for access is based on notches along the bottom edge of the card. In a maximum of 10 seconds, the SELECTRIEVER can access a specific document, present it to the operator, display it, or prepare a hard copy of the information. Average access time is 6.5 seconds. The equipment can be interfaced to a computer and operate on computer command.

Mass memories are another example of large-capacity, high-speed, random access information storage and retrieval systems which can be used in conjunction with existing data processing systems. One type of mass memory consists of two principal elements: a mass memory unit to provide data storage; and a controller unit that provides the necessary interface, control, and read/write functions. In this system, the technique of information retrieval is either fixed-address-search or search-by-record-content, depending on the master control used. Average access time is 35 milliseconds. Search by record content is a specialized technique which permits any desired field to be used as the access key. It is not necessary to know where the data are stored, but only what type of data is desired. This obviates the need for flagging and table look-up, conserves space in the CPU mainframe memory, and allows for simultaneous offline search.

C. Standardization

1. Introduction

Historically, efforts in the field of standardization were greatly enhanced in 1964 by two important events:

- Establishment of the DOD Council on Technical Data and Standardization Policy.
- Promulgation of DOD Directive 5000.11 establishing the DOD Data Elements and Data Codes Standardization Program.

Within the purview of the Council is the authority to approve and initiate major standardization projects. This report was prepared under the charter of one such project. The stated objective of the Data Element and Data Codes Standardization Program is to facilitate data interchange and compatibility among the data systems of DOD by providing for optimum standardization of data elements and codes and for their utilization, through centralized guidance, control, and direction. A discussion of the current capability to meet this objective will comprise a large part of this section of this report.

Additionally, the utilization of standardized data elements in the overall Navy Component/Equipment Standardization and Configuration Management Programs will be discussed. Specific areas of application will be identified and several possible files and lists utilizing standardized technical data elements will be mentioned.

2. Data Elements/Codes

Standardization of data elements and codes will:

- Facilitate interchange and compatibility of data among different ADP systems and DOD agencies.
- Reduce the total number of data elements and codes.
- Reduce data processing costs by using standard codes in lieu of full data descriptors.
- Facilitate the development of standard information and data systems by standardizing the data elements and codes which are system building blocks.
- Facilitate integration of systems and direct computer-to-computer communication.

The capability and expertise currently exist to identify, define, and systematically record informational elements now used in vocabulary formats suitable for maintenance by the office or agency having primary functional interest. These vocabulary formats would be capable of accommodating both automated and manual maintenance, be susceptible for use in standardizing informational elements and codes, and permit series grouping in order to form a complete vocabulary of operational and management data bases.

In the initial identification of informational elements, criteria and procedures which may be useful in developing recommendations for standard data elements and codes include:

- Is the data element limited to a single generic class of data?
- Is the data element name or title unique?
- Does the data element have a single, precise definition?
- Is each data item under a given data element mutually exclusive?
- Does each data element have a set of data items which is different from those of any other data element?
- Does the code assigned to each data item under a data element accommodate all known requirements for use of the code?
- Is it necessary to use any data element and its associated data items more than once within a given data system?
- Is each bit of information within a data code significant?
- Does each significant bit actually denote something different from all other significant bits used in other codes?

A discussion of significant criteria can extend almost ad infinitum. As an example of the consideration given to the first question listed above, if more than a single class of data is represented in combination, then more than one unique data element exists and should be established. The FSN is a prime example; it is composed of at least three generic classes of data (viz., Federal Supply Group, Federal Stock Class, and Federal Item Identification).

In addition to establishing the criteria for the identification of data elements, it is also necessary to determine descriptors for those information elements that constitute the system data base. Examples of these descriptors are element name, brief description, length and characteristics of any data codes used, name(s) of systems which use the element, security, classification according to DOD data standardization terminology, etc.

3. Equipage

Technical data are, in themselves, the primary means for the communication of instructions, plans, and descriptions relating to technical projects, material, and systems. This data may encompass specifications, standards, engineering drawings, lists, etc., and may be in the form of documents, displays, EAM cards, or magnetic tape. When these data are applied and used in a systematic and orderly manner, following a well-defined series of steps and decision rules to produce definite design decisions, then the configuration identification aspect of the total configuration management task has been established.

The NAVLOGSIP (Navy Logistic Support Improvement Plan) contains objectives related significantly to standardization configuration management. These include increasing the standardization of ship types and equipment and a plan for configuration control. Standardization planning will provide for: (1) the use of a minimum number of sizes, types, varieties, and kinds of components, equipments, and parts, and (2) the use of identical components and equipments wherever complete functional interchangeability exists. Standardized component/equipments will be included and controlled in master configuration listings and indices. The overall Configuration Management Plan will include procedures and criteria for a thorough evaluation and demonstration of the cost-effectiveness of proposed engineering changes, alterations, or improvements. The Navy Configuration Management Program provides for the development and maintenance of uniform policies, procedures, and implementing instructions for the attainment of these objectives.

The extension and utilization of standardized technical data elements and codes in the overall Navy Component/Equipment Standardization and Configuration Management Program are immediate. Lists of standardized data elements can be utilized in the determination and identification of common types of components and/or those components and equipments which may be functionally interchangeable. Combined with costing data elements and operational or reliability characteristics (which may possibly be provided by the Navy 3M system utilizing the MDCS (Maintenance Data Collection System)), a priority or preference list of components could be determined with respect to the cost-effectiveness factors involved.

Components which have only one or two functional applications will be highlighted and, based on operational and economic considerations, may possibly be replaced by those having greater utility. Moreover, various standardized catalog files can be produced based upon the standardized parts and components information determined. Several files which have been discussed during the course of this study are as follows:

- FSN to Manufacturer Stock Number cross-reference file.
- Part number to component application cross-reference file.
- Component application to EIC cross-reference file.

D. Data Communications

1. Introduction

In the survey conducted at the sampled activities, a number of requirements were highlighted which could receive some degree of satisfaction through the utilization of data communication products now available. Requirements relating to the data communication area can be generally categorized as follows:

- Faster response time.
- Real time capability.
- Data transfer compatibility.
- Centralized data banks.
- Improved inputting techniques.
- Interrogation capability.
- Remote inquiry capability.
- Improved means of transferring data.

The remainder of this subsection will discuss some of the currently available data communication products which could be considered in meeting some of the aforementioned requirements.

2. Remote Terminal Devices

Remote terminal devices may be divided into two major categories, manually operated devices and higher speed devices. As is generally the case, certain devices overlap into both categories.

a. Manually Operated Devices

(1) Numeric Devices

One form of data input that is growing in popularity is the numeric keyboard device, often coupled with a form of card reader. A good example is IBM's 1001, which has a punched card reader and a 10-key keyboard. The 1001 operates at 12 digits per second over leased lines or over the voice grade dial network using a data set. It is possible to transmit alphabetic information from the card, but the keyboard is limited to numeric data.

A similar type of operation can be achieved with Bell System's new touch-tone telephone. This device can be a simple 10-key keyboard, or a plastic card reader utilizing the cards that are used in card dialing, or can have a 12-key keyboard. The plastic cards cost about 5 cents each and can be easily punched with a stylus. Fixed numeric data can be punched into a plastic card, and variable data can be entered via the keyboard.

Bolt, Beranek and Neuman, Inc., Cambridge, Massachusetts, has developed a system that provides two-way communication with a computer using ordinary dial telephones and requiring no additional attachments. After the connection has been dialed, the dial is then utilized for data input.

IBM provides "programed keyboard" models 1092 and 1093 that can provide a means of manual input. The 1092 has a 10 x 15 (or optionally 10 x 16) array of buttons; each column has 10 buttons for the digits 0 to 9, and there are 15 to 16 columns. The buttons need not be limited to digits, however, as "Keymat" overlays may be laid over the keyboard so as to give coded meaning to the keys. For example, each of the 10 keys in one column can represent a different type of transaction. One model of the 1092 has a sensing device attached to the keyboard which allows the computer to know which overlay is being used. The 1093 is a similar device with a 10 x 10 array. It can be used by itself or with a 1092 so as to handle up to 26 columns of data.

(2) Alphanumeric Devices

The most widely used input devices in this category are the teletypewriter units, offered by Teletype Corp., Western Union, and Kleinschmidt. The general range of speed is 60 to 100 words per minute. However, there are a number of small differences in transmission speeds, character coding, etc. In the past, most of these devices have used a five-level code (generally the Baudot code); now, however, the use of an eight-level ASCII code (seven information bits plus a parity bit) has come into vogue. A major advantage of teletypewriter devices is that they are currently available and relatively inexpensive.

Another form of alphanumeric device is the all-purpose communications console. IBM produces such a device called the 1050, and Honeywell offers a similar device which they call their Multipurpose Console. These devices offer a typewriter keyboard, printer (similar to a typewriter printer, but independent of the keyboard), card reader and punch, punched paper tape reader and punch, and control circuitry. Since most of these features are optional, the user may select those he desires. The IBM 1050 also permits the use of a 1092 or 1093 programed keyboard. The Honeywell Console allows the use of a unique optical scanner (for reading bar code).

The IBM 2740 and 2741 are Selectric typewriters with standard keyboard, upper and lower case. The 2740 can operate on a party line hookup, while the 2741 requires a private line. The terminal can be used as a regular typewriter or can be used to transmit and receive data. Also, the terminal can communicate with other similar terminals or with an IBM 360.

b. Higher Speed Devices

Higher speed devices can be used as I/O terminals connected to a central computer, or as the terminals in point-to-point communication links. Punched paper tape readers and punches operate in the general range of seven to 100 characters per second, depending on the particular devices and the transmission speed of the communication channel. The devices are offered by Digitronics, AT&T, Teletype Corporation, Western Union, General Electric, and Friden and Tally. For bidirectional communication, a reader and a punch are required at each terminal.

Punched card readers and punches can be used as remote terminals to achieve transmission speeds higher than manual keying speeds. Transmission usually is via voice grade lines, with speeds of 100 to 300 characters per second. Manufacturers include IBM, Digitronics, and UNIVAC.

Some communication channels have been set up with punched paper tape or punched card readers at the remote terminals, and with magnetic tape units at the central receiving point. With such systems, the speed of transmission is limited by the slower remote unit, usually in the range of 100 to 300 characters per second. However, if transmission is between two magnetic tape units, or between a computer and a remote tape unit, transmission speeds can be much higher, depending on the capacity of the communications line. For instance, available systems can transmit up to 5,100 characters per second (peak speed) using TELPAC A, or up to 60,000 characters per second using TELPAC D. Manufacturers include IBM and Digitronics.

3. Fast Response Systems

With the advent of the third generation computers and advancements in data communication products, the capability now exists for exploiting fast response systems (i.e., systems aimed at providing a rapid computer service). This type of system is sometimes referred to as real-time and online. The surveys conducted by PRC invariably elicited the comment, "A more rapid response is required." The remainder of this subsection will be devoted to some recent developments in fast response systems.

a. Time-Shared Systems

Time-shared systems are aimed at the question, "How can a fast response computer service be provided to a large number of users?" In essence, time-shared systems commutate a large central computer among a number of users so as to provide fast access and response for each user on an economical basis. By simultaneously sharing the central computer and its powerful software features among a group of users, the cost to each user is kept at a reasonable rate. Further, input to and output from the computer is provided by a terminal located at the user's site, connected to the computer by electrical transmission. Thus, a time-shared system consists of the combination of the computer, communications facilities, local I/O units, and a specially designed software system.

The emphasis in time-shared systems is service to the user. Service is considered to be more important than the highly efficient use of the computer. Expressed another way, faster service to the individual user is achieved at the expense of greater computer running time and memory size than might be required to do the same group of jobs on a batch basis. Time-sharing reduces turnaround in the following ways:

- Queue time waiting for the job to be keypunched.
- Messenger time to and from the computer.
- Queue time waiting for the cards to be put into the computer card reader and read into the computer, including operator inefficiencies.
- Queue of jobs in the computer, waiting to be executed, in a compute-till-complete system. In a time-shared system, each job is worked on for at least one "time slice" every few seconds, and often only one or two time slices are needed to begin producing responses to the users.
- Mass printing needed to answer all the questions the user may ask. With a time-shared system, only the specifically desired information is printed-out on the remote console.

Some important goals of time-shared systems are:

- Improve communications between the user and the computer by the use of powerful software packages.

- Edit the input for errors as it is entered, and notify the user of these errors immediately.
- Aid the user in trial-and-error problem solving.
- Improve utilization of the computer by using "background jobs."

b. Types of Time-Shared Systems

Not all time-shared systems adopt all of the above goals, nor do they always approach the achievement of a specific goal in the same way. Their differences appear to be due to the different environments in which the systems were developed and the points of view adopted by those who developed them.

Some approaches to time-shared systems concern the use of time slices. The microslice philosophy is aimed at providing each user with at least one time slice of computing within 1 or 2 seconds, thus maintaining a "conversational mode" between the user and the computer.

One approach to the time-sharing systems concerns the language that is used to communicate with the system. Some systems communicate via machine-oriented languages, while others communicate via user-oriented languages. Another approach has been the scheduled time of operation for the time-shared systems. Some systems operate practically full-time in the time-shared mode, while others are used only part-time for time-shared activities, with the remainder of the time used for batch processing.

4. Multiprograming

Multiprograming is one of the means by which a capability is provided for achieving fast response systems (see previous subsection). Multiprograming is the concurrent processing of independent programs by a single processing unit, through the overlapping or interweaving of their execution. One feature of multiprograming is that the programs should be written with no assumption of interaction between them; thus, one program would not periodically interrogate another program to see if control should be transferred. In a multiprograming environment, programs can be run either serially or in a concurrent mode, with no changes in the programs. The goal of multiprograming is to provide better computing service and to improve equipment utilization by making use of machine idle time.

In fast response systems, such as time-shared systems and real-time systems, where the total message service time might be compared with the arrival rate, multiprograming plays a key role. Much of the total service time is consumed in retrieving and storing both programs and data in mass storage units. Through the use of multiprograming, when one program initiates an I/O request, control is transferred to another program which is ready for processing. The result is that these systems can service a much larger volume of messages within the time limitations than would otherwise be the case.

Multiprograming is a fundamental component of a time-shared system. It has reached a stage of development where it is well within the state-of-the-art.

E. Generalized File Processing Software

1. Introduction

One method of meeting or satisfying some of the technical data processing requirements may be the more prevalent use of generalized file processing software. Such systems offer a means for converting applications to a computer with much less programing effort than is required by conventional programing methods. This increases the probability that more data may be in machine readable form, and may consequently result in a reduction in manual efforts.

These systems perform most or all of the common file processing functions of file creation, maintenance, sorting, selection, extraction, and report preparation. Equally important, they provide a structure for the solution of file processing problems; that is, they give the systems analyst-programer a start toward the solution of a problem.

There are three major types of generalized file processing software which are similar in many ways, differing more in degree than in concept. They are the generalized programs, file management systems, and select-extract-report systems.

2. Generalized Programs

Generalized programs generally entail the development of basic data processing functions. These functions are usually well-defined and include sort, merge, extract, file, update, match, and summarize. Several of the functions may be linked together in one computer run.

3. File Management Systems

File management systems differ from generalized programs in that they use broader functions. For instance, a file management system might consist of five basic functions: file creation, file maintenance, select-extract, sort, and report. File maintenance in such systems consists mostly of the insertion, deletion, and replacement of records in a file or fields in a record. Limited computation, such as adding transaction amounts to file summary amounts, might be performed in posting transactions to a file. If complex logic is needed to control such posting, or if the calculations are lengthy, these systems provide standard exits for "own coding." A fair amount of logic and arithmetic capability is usually provided in the report function for developing multilevels of controls. Another characteristic of these programs is that retrieval requests are designed so that they can be filled out by persons who know their problems and who normally are not programer personnel.

4. Select-Extract-Report Systems

Select-extract-report systems are really a subset of the file management systems. They do not perform the functions of file creation or file maintenance; however, they do provide easy, flexible data retrieval services from existing files. Such systems usually are limited to fixed-length record and to little or no computation.

F. Conclusions and Recommendations

1. Conclusions

The survey conducted by PRC revealed that improvements can and should be made in the technical data handling area. However, although such improvements could be made, this fact does not denote that there exist gaps between available equipments and technical data processing requirements. In fact, with possibly only one exception (i. e., the input area), it appears that there are sufficient equipments presently available to handle all observed technical data processing requirements.

Substantial gaps do exist in the area of uniformity in equipments and procedures. For example, individual Navy activities often have widely divergent equipments to perform identical tasks, with consequent inefficiencies resulting from duplication, time-lag, syntax errors, and logical errors. Therefore, it is concluded that any gaps that do exist (with the exception of input equipment) lie in the realm of system procedures, rather than in the realm of equipment.

Current and proposed improvements in equipment for technical data processing tend to point to a more efficient utilization of the type of equipment currently available. Little in the way of new, revolutionary equipment that "will be the answer to all problems" is being contemplated. Again, the exception concerns the input area, where significant improvement must be made (e. g., optical scanners).

In summary, the major gaps that were detected during the conduct of this study were primarily in the realm of (1) lack of uniformity in systems and procedures, and (2) lack of uniformity in equipment.

2. Recommendations

It is recommended that the technical data processing gaps highlighted in this report be eliminated. However, it is first necessary that an extensive system analysis study and a pilot model implementation be performed. The objectives of such a system study are threefold: (1) to determine, in detail, the data processing requirements necessary to process technical data in the most efficient manner; (2) to encompass all echelons, both users and generators of technical data, in the Navy/Contractor structure; and (3) to produce a detailed systems design for an advanced system which would utilize the most recent equipments available.

With completion of the study, the next effort of concern is the implementation of a pilot model at a number of selected activities representing the entire Navy/Contractor structure. Once the pilot model, or prototype system, is implemented, it should be subjected to varying stresses. The system, or those features of the system that are viewed with favor, should then be implemented by other activities throughout that portion of the Navy Establishment concerned with technical data processing.

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APPENDIX A

A. Technical Data User Requirements

For the purposes of this study, the Research and Development Division, Naval Supply Systems Command, made arrangements for PRC (Planning Research Corporation) personnel to visit the following Naval organizations (activities).

- U.S. Naval Ships Parts Control Center
  Mechanicsburg, Pennsylvania
- U.S. Naval Supply Depot
  Newport, Rhode Island
- U.S. Naval Shipyard
  Boston, Massachusetts
- U.S. Naval Ship Research and Development Center
  Carderock, Maryland

A selected audience of function managers was determined at each activity. A presentation was given to each audience outlining the purpose, scope, and desired results of this study. Subsequent to this presentation, Navy planning personnel at each activity helped determine a list of appropriate personnel in selected functions to be interviewed. A schedule for accomplishment of these interviews was also established. At a later date, the scheduled interviews were performed, making full use of qualified personnel and the "User Interview Guide" described earlier in this study.

The data collected through these interviews indicated that the activities surveyed have a substantial involvement with technical data, especially in the areas of engineering drawings, technical and instruction manuals, and parts information. These data have been summarized into eleven major categories (see Exhibit A-1).

B. Description of Technical Data Requirements

1. Type of Engineering Data Currently Used

Engineering drawings were found in paper form at all facilities. However, at NSY Boston, a large percentage of drawings

EXHIBIT A-1 FACILITY VERSUS TECHNICAL DATA CATEGORY MATRIX

Technical Data Categories	NSY Boston	NSD Newport	NSRDC	SPCC
	Facility[1]			
1. Type of Technical Data Currently Used				
a. Engineering Drawings				
1) Aperture Cards	X			X
2) Roll Microfilm	X		X	X
3) Paper	X	X	X	X
b. List of Engineering Drawings	X		X	X
c. Instruction/Technical Manuals	X	X	X	X
d. Test Reports and Related Data	X		X	
e. Parts Information				
1) In-house 3- by 5-inch card files	X	X		
2) APL	X	X		X
3) FOCSL (PAMD)	X	X		X
4) Industrial Catalogs	X	X	X	X
5) Federal Stock Catalog	X	X	X	X
6) POMSEE	X			
f. Ordnance Data/Pamphlets	X	X		
g. Photographs	X			

Note: (1) X = Indicates user involved with category.
No X = Indicates user noninvolvement with category, or indicates that no determination was made.

EXHIBIT A-1 (Continued)

Technical Data Categories	Facility[1] NSY Boston	NSD Newport	NSRDC	SPCC
2. Present System for Handling Technical Data				
a. VSMF			X	
b. Central Technical Library	X	X		X
c. CRT (Cathode Ray Tube)				
d. Remote Printing Inquiry Device		X		X
e. AUTODIN	X	X		X
f. Paper Tape	X			
g. Microfilm with Hard Copy Capability	X			X
3. Create Technical Data When Performing the Following Functions				
a. Designing or Fabricating Components	X		X	
b. Preparing Parts Catalogs				X
c. Designing Methods and Standards	X			
4. Transfer of Technical Data When:				
a. Producing Purchase Packages	X	X	X	X
b. Reporting Results of R&D			X	
c. Answering Request of Another Facility for Technical Data	X			X
d. Issuing Parts Information				X
5. Involved with the Following Technical Data Related System Programs				
a. CASD			X	
b. 3M	X			X
c. NARDIS			X	

EXHIBIT A-1 (Continued)

Technical Data Categories	Facility[1] NSY Boston	NSD Newport	NSRDC	SPCC
6. In the Use of Technical Data, Expressed Problems in the Following Areas:				
a. Volume	X	X		X
b. Variety	X	X	X	
c. Response Time	X	X	X	X
d. Updating	X	X	X	X
7. Expressed A Need For Standardization in the Following Areas:				
a. Parts Use		X		X
b. Parts Descriptions and Specifications	X	X	X	X
c. Freight Classification Codes		X		X
8. Expressed a Concern for Time Spent Referencing Technical Data of the Catalog and Parts Lists Types	X	X	X	X
9. Expressed a Need for Up-to-Date Technical Data to Perform the Following Functions:				
a. Procurement	X	X	X	X
b. Component Design and Fabrication	X		X	
c. Testing	X		X	
d. Parts Cross Referencing	X	X	X	X
e. Material Disposal		X		X
f. Maintenance or Alteration Performance	X			
g. Maintenance Procedures Design				X

EXHIBIT A-1 (Continued)

Technical Data Categories	Facility[1] NSY Boston	NSD Newport	NSRDC	SPCC
h. Methods and Standards Determination	X			
i. Scheduling	X			
j. Training	X			
10. Expressed a Desire to Have Access to Data In the Following System Programs				
a. DLSC-DIDS	X	X		X
b. MILSCAP		X		
11. Expressed A Need for a More Up-to-Date System of Technical Data Storage and Retrieval Including:				
a. Centralized Data Base	X	X	X	X
b. Remotes	X	X		X
c. Capability to Challenge Consistency of Centralized Data Base		X		X
d. Graphic Capabilities		X	X	
e. VSMF			X	
f. Microforms	X	X	X	X

were handled by a 35mm aperture card system with manual retrieval by drawing number and a hard-copy generating capability. This system has been in existence since 1962, and at present there are 10^5 files. The shop groups (approximately 4,800 people) make extensive use of the aperture card system. They have four viewers and reproducers in each main shop with one person assigned to handle each station. Plans are being made to add more viewers (at least five).

Some problems concerning technical data noted in the survey include the following:

- Not all vendors supply aperture cards.
- Drawings are not kept up to date.
- Rights to proprietary data have to be bought often at unreasonable sums.
- Some shipyards are not complying to the NAVSHIPS microfilm program.
- Not all drawings are on microfilm.
- A composite list of all drawings on aperture cards is not available.

NSY Boston noted that there was a complete file of engineering drawings at NAVSHIPS. However, they found it difficult to obtain drawings from this file.

The component Instrumentation Division (approximately 60 people) at NSRDC deals with engineering drawings as part of the VSMF (Visual Search Microfilm File), which will be described in the following subsection. NSRDC also has drawings in paper form.

Instruction and technical manuals are found at all facilities. At NSY Boston, manuals are required mostly by the shop groups who perform the actual ship alterations, as well as for training of new shop personnel. This amounts to maintaining large cabinets of instruction manuals. Several problems were mentioned in relation to this file of instruction books:

- Matching of instruction books and jobs is sometimes difficult.

- Instruction books are difficult to maintain in up-to-date form.
- Some instruction books are not available in the yard.

Test reports and the related data needed to perform tests were evident at NSY Boston and NSRDC. At NSY Boston, the Combat Systems Division of the Planning Department performs field engineering and testing on equipment installed on ships assigned to the shipyard. This involves testing all electronic gear, weapons, and communications. Thus, they require copies of test memos, performance standards, and ordnance pamphlets.

The Component Instrumentation Division at NSRDC designs and builds test equipment for the research labs at NSRDC. They have a requirement for any type of data related to the design and development of ships. Since they are involved in the research and development phase of a weapons system, their source data must be current.

Parts information files and catalogs were found at every facility and at most departments interviewed. The mention of this one type of technical data could elicit remarks from anyone interviewed.

In the Technical Departments at both NSY Boston and NSD Newport, in-house files are maintained for the purpose of parts identification and specification. At NSY Boston such records amount to 250,000 3- by 5-inch cards filed in FIIN sequence.

Most of the departments in all of the surveyed facilities are using industrial and Federal Stock catalogs. Facilities like NSY Boston and NSD Newport, which provide parts for ships, are continually using APL's (Allowance Parts Lists) and the PAMD (Price and Management Data) catalogue. The PAMD has recently replaced the FOCSL (Fleet Operational Consolidated Allowance List). NSY Boston has consolidated APL's by combining identical items.

Ordnance data and pamphlets are used by the testing facility at NSY Boston while pursuing their testing function. This division also has a need for the POMSEE (Performance Operational Maintenance Standard Electronic Equipment). Ordnance information is also needed by the Technical Department at NSD Newport; however, it is felt that it is not supplied on an up-to-date basis by SPCC.

Photographs are sometimes used by the shops at NSY Boston to record an equipment's configuration before repair. Thus, when equipment is disassembled, it can be restored to its original configuration by use of the photographs.

By far the most extensive and well organized technical files of any of the facilities surveyed are located at SPCC. These files are discussed under the next topic.

2. <u>Present Systems for Handling Technical Data</u>

All of the facilities visited have some system for handling technical data. In some cases, it may be just a manual reference to a catalog stored in a desk drawer. In other cases, it may be a relatively advanced system containing microfilmed drawings or aperture cards with viewing and hard copy capabilities.

The VSMF (Visual Search Microfilm File) is used by the Component Instrumentation Division at NSRDC. Also the Supply Department at the same facility expresses a desire to have VSMF available for their use. VSMF is a commercial package marketed by Information Handling Services, Inc., that contains over 250,000 pages of information on microfilm. The information consists of all types of technical data, but is limited to data collected from those companies who contribute to the system. To use the system, a hard copy index is referenced, a cartridge is inserted into a microfilm viewer, a manual search is conducted, and finally a hard copy is made. The company that manufactures VSMF claims that it can reduce reference time per search from the 47 minutes required for paper files to 5.3 minutes.

Central Technical Libraries were found at NSY Boston, NSC Newport, and SPCC. These libraries contain all types and vintages of technical data. There appears to be a reluctance to purge these libraries, because requests for identification or specifications for old equipment, although infrequent, do occur. The actual size and contents of these libraries have not been well documented except in the case of SPCC (see Exhibit A-6, page A-26).

Two facilities, NSD Newport and SPCC, have remote inquiry stations. There are 4 at NSD Newport and 16 at SPCC. These stations are used by each facility to update and access information from their centralized data bases.

NSY Boston, NSD Newport, and SPCC have access to the AUTODIN (Automatic Digital Network). This is a Western Union-provided, computer-controlled communications system designed and built for the Department of Defense. It provides narrative and data transmission services throughout CONUS and Hawaii in a secure and high-speed manner. Subscribers are provided with the capability to communicate with other subscribers having either like or unlike terminals, operating in various media, using various codes, and transmitting at speeds ranging from 75 through 4,800 baud.

In the Planning Department at NSY Boston, instructions relating to previous ship alterations and repairs, along with a list of the material requirements, are maintained on paper tape. Thus, when a previously accomplished alteration or repair must be performed, the tape can be used to produce a copy of the required work statement.

An aperture card system containing engineering drawings with viewing and hard copy capabilities is found throughout NSY Boston. It is used extensively by the Production Shops and the Design Division of the Planning Department.

3. Creation of Technical Data

At each facility some amount of technical data is created. For instance, the Design Division of the Planning Department at NSY

Boston is responsible for producing drawings on specific ship conversions and alterations which the production shops then use to perform the actual work. Also at the shipyard, the Methods and Standards Branch of the Production Department prepares the "Standard Man-Hour Allowance Data" document, which standardizes the amount of man-hours allotted to specific shipyard tasks. Engineering drawings are also produced by the Purchase Department at NSD Newport to describe the equipment or work required to suppliers.

The types of technical data created at NSRDC are drawings and reports relating to ship design. As shown in the facility organization chart (see Exhibit A-2), there are five labs devoted entirely to research and development in the ship design area.

At SPCC, technical data involving parts information is created. Some of SPCC's products are the CCR (Component Characteristic Record), the CPR (Component-To-Part Record), and APL's (Allowance Parts Lists).

4. Transfer of Technical Data

SPCC prepares several listings and catalogs required by those activities associated with the operation and maintenance of ships. This information is sent to many activities, and NSY Boston and NSD Newport receive such documents as APL's, CPR's, and CCR's.

NSY Boston sends approximately 100 EAM cards to DLSC, Battle Creek, weekly for assistance in identification of parts. The communications medium is airmail in both directions, and for this reason the response time is relatively slow.

Exhibit A-3 illustrates some of the senders, receivers, and types of technical data being transferred between the facilities surveyed.

Most of the data transfer shown in the exhibit is in hard copy form with the U. S. Mail as the communications medium. Updating of this information is also mostly carried on with hard copy through the mail; this means a relatively slow updating procedure.

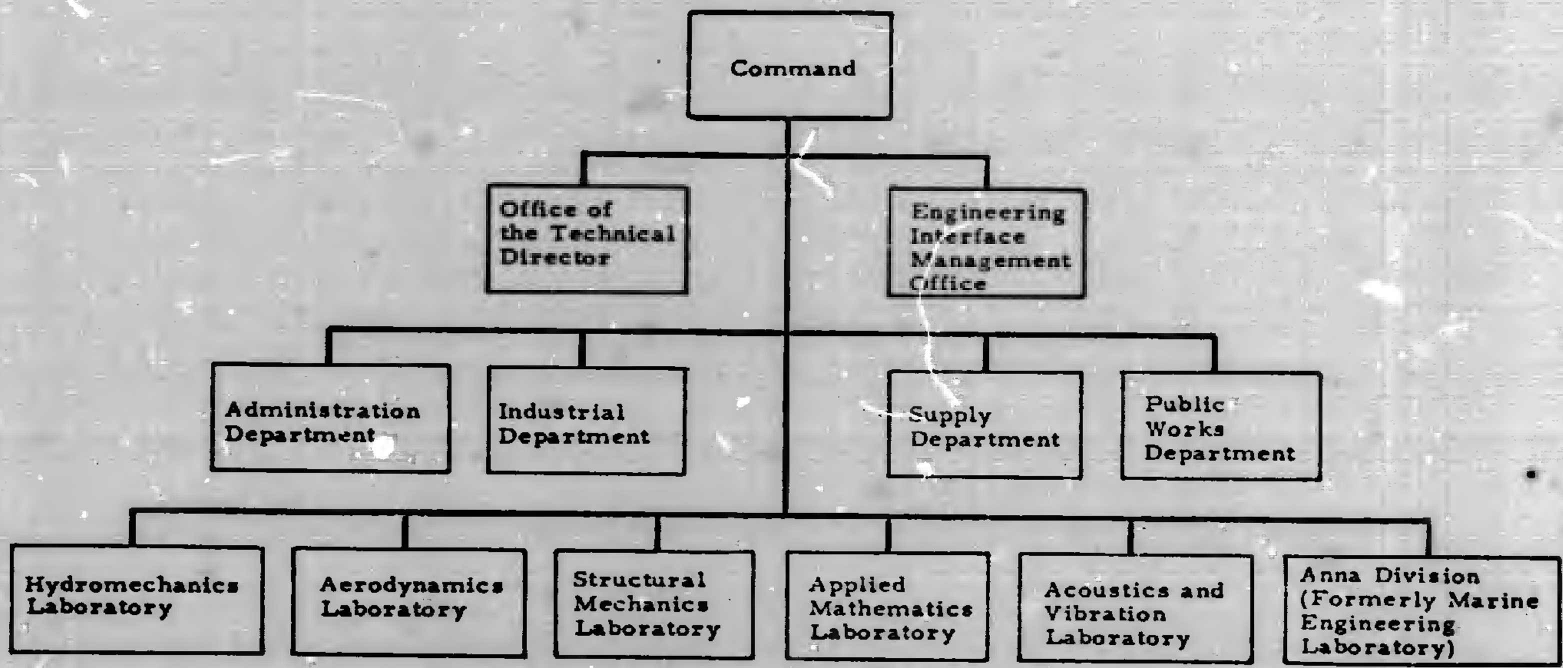
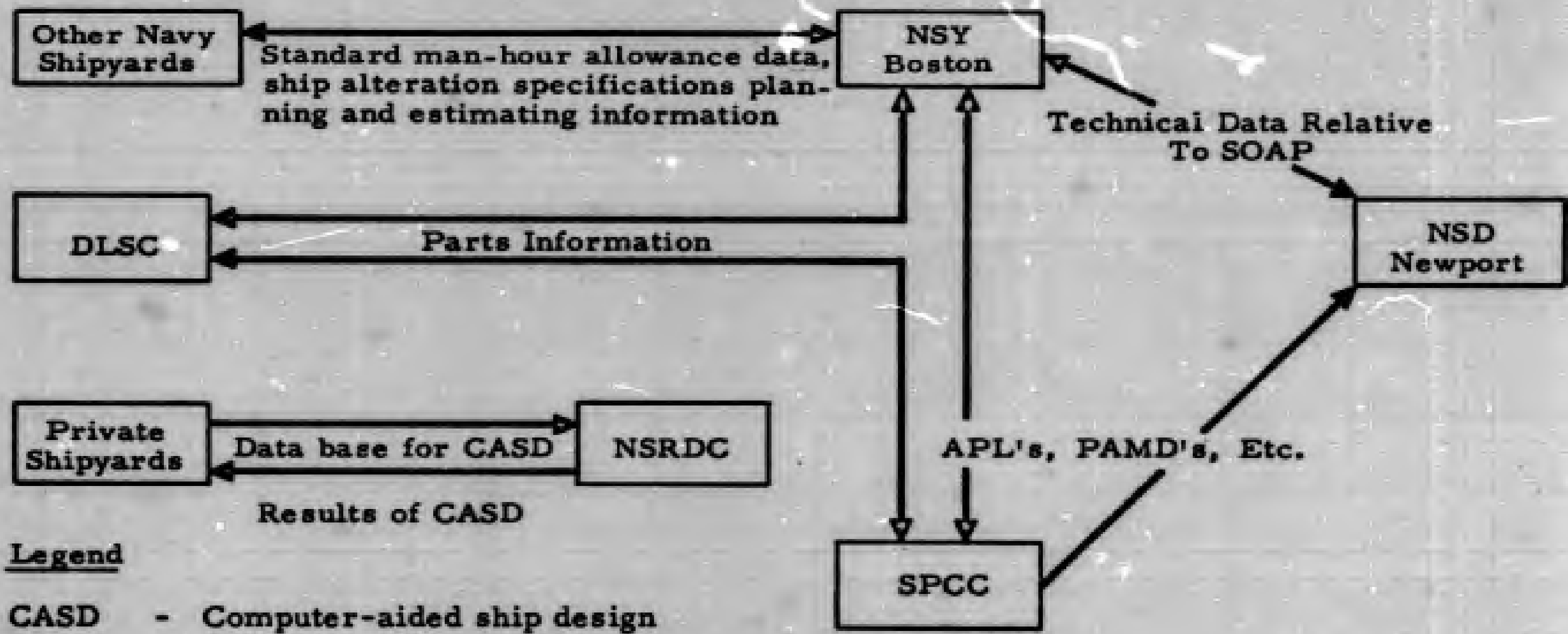


EXHIBIT A-2 NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER ORGANIZATION CHART



Legend

CASD - Computer-aided ship design
SOAP - Supply overhaul assistance program
PAMD - Price and management data
APL - Allowance parts list
DLSC - Defense Logistics Services Center (DSA)

EXHIBIT A-3 TRANSFER OF ENGINEERING DATA

5. Involvement With Technical-Data-Related System Programs

Certain system programs interface with some of the technical-data-related tasks of the facilities interviewed. Three of the more prominent programs noted are CASDC (Computer Aided Ship Design and Construction), 3M Navy Material, Management and Maintenance Program, and NARDIS (Navy Automated Research and Development Information System). NARDIS has been described in the body of this report.

CASDC is a 20-year planned program with an expected direct cost in excess of $140 million. This program will apply the advances in computer technology to ship design and construction. A description of this program can be obtained in "Computer Aided Ship Design Program Plan," PRC R-884, 1 January 1967. Exhibit A-4 is the CASDC management organization; it indicates the expected large Navy involvement in the program.

Only one facility (NSRDC) visited was deeply involved in CASDC. NSRDC is helping to build the project data base and is testing computer programs. Slight involvement was noted at NSY Boston where personnel in the Design Division express interest in CASDC. However, there was no official relation with this program.

The 3M program is sponsored and directed by CNO (Chief of Naval Operations). It embraces two broad areas: (1) a Planned Maintenance System, and (2) a Maintenance Data Collection System. This program is applicable to both ships and aircraft weapon systems. The Maintenance Data Collection System is actually more than the name conveys; it might be called a Maintenance and Material Management Control and Information System. A description of this program, as related to ships weapon systems, can be found in "Maintenance and Material Management (3M) Manual," March 1965 (including changes 1 and 2).

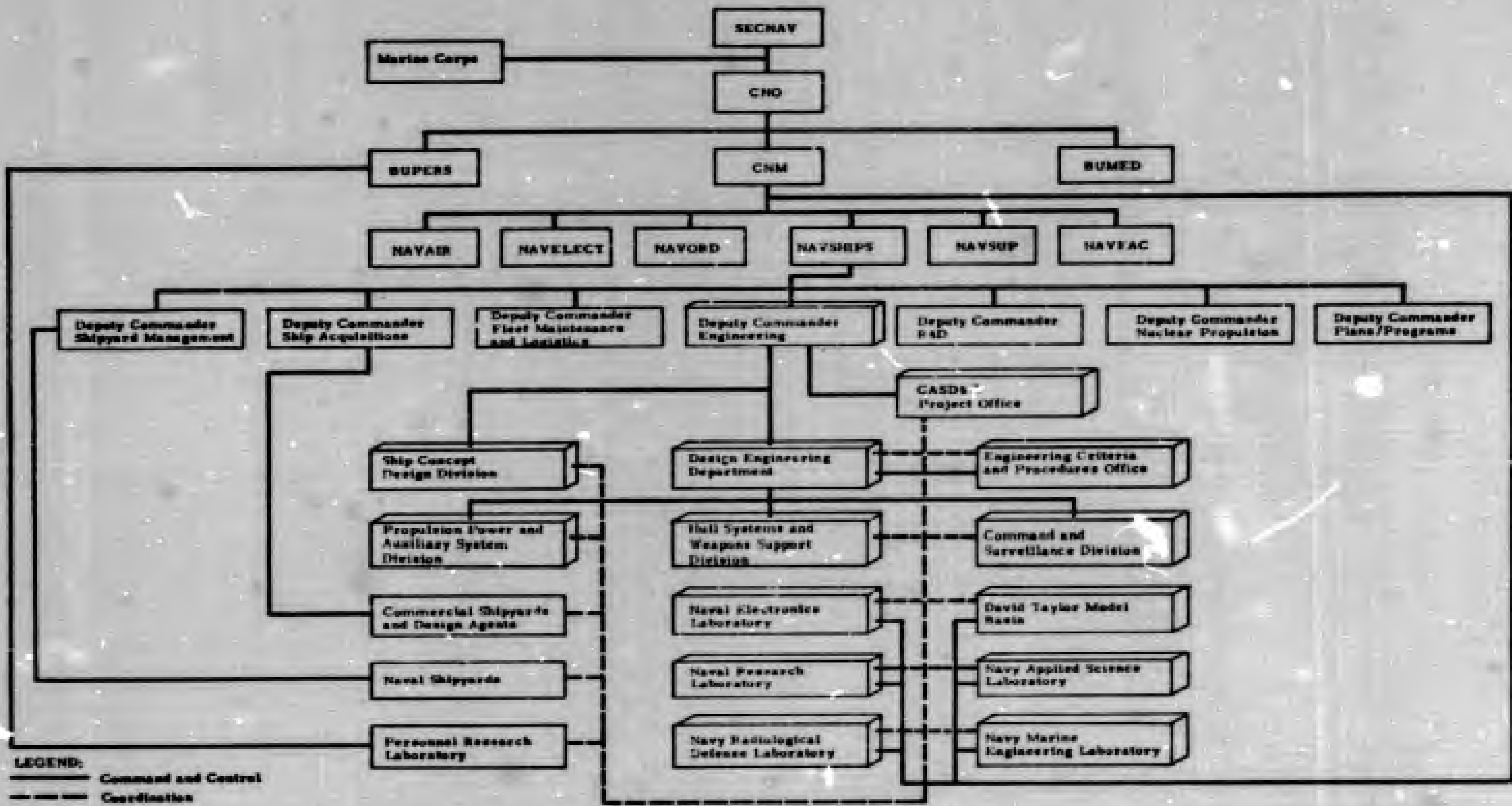


EXHIBIT A-4 CASDC PROJECT MANAGEMENT ORGANIZATION CHART

Personnel at each facility mentioned problems associated with the storage, retrieval, or use of technical data. The problem areas can be categorized by volume, variety, response time, and updating. (Problems do overlap areas.)

a. Volume

(1) Many of the commercial catalogs are obsolete but must be retained (particularly in the Technical Libraries) in case they should be needed for nonroutine identification or specification of parts.

(2) A good indication of the volume of technical data is the number of large technical libraries at all of the surveyed facilities that contain parts catalogs, technical manuals, drawings, specifications, etc.

b. Variety

(1) The unit of issue is not universal. For example, a "1" in the unit of issue descriptor may mean "1 box" or "1 item."

(2) There is difficulty matching Federal Stock Numbers with manufacturers' stock numbers.

(3) There is a problem matching instruction manuals with appropriate equipments.

(4) Identifying old parts is difficult.

(5) In all purchase departments, there is a need to know the commercial sources of material in an efficient manner.

c. Response Time

(1) Necessary instruction or technical manuals may not be available at the field activities (for instance, at the

production shops of NSY Boston) when it is time to perform a task. At times, the problem stems from the manufacturers' failure to complete their instruction manuals on time.

(2) When the production shops at NSY Boston request a drawing not in the aperture card file or the Planning Department, response time for such drawings is extremely long, often causing work rescheduling.

(3) Field activities claim that updated information on the Federal Stock Catalog should be made available in closer response to the actual change.

d. Updating

(1) According to NSY Boston there are no up-to-date APL lists. APL's generally are not considered by the surveyed facilities to be updated in an efficient, timely manner.

(2) NSY Boston also claims that there is a 3- to 6-month lag in item updating information from the ICP's.

(3) Updating of technical manuals is not timely.

(4) The Design Department at NSY Boston needs the Ship Plan Index updated more frequently.

7. Areas of Standardization Needed

At each facility, suggestions were offered by the interviewees as to what standardization procedures would be of assistance in the conduct of their functions.

a. In dealing with part descriptions and specifications, computer facilities desire format standardization. That is, freight class codes, descriptions, cube, weight, minimum order quantity, unit price, and unit of issue should each be standardized.

b. Many common parts (e.g., nuts and bolts) are not standard, necessitating the maintenance of stock information on a variety of line items, many of which fulfill the same requirements.

c. Descriptive parts information such as APL's should be standardized.

d. Navy and vendor part descriptions should be standardized.

e. Part numbers on engineering drawings and parts catalogs should be coordinated.

f. The same class of vessels should have commonality of design.

It should be noted that personnel at NSRDC were not overly concerned in the area of standardization, because they are basically a research and development activity and treat most problems as unique. However, there is no doubt that any standardization that makes the performance of their function easier would be welcomed.

8. <u>Time Spent Referencing Source Material</u>

The amount of time spent referencing catalogs, parts lists, and other technically oriented data is a matter of concern to personnel at all of the surveyed facilities. Some departments were able to estimate the percentage of their time spent in this activity:

Facility/Department	Estimated Percent of Time Spent Referencing Source Material
NSRDC	
Supply Department	30
Component Instrumentation Division	30
NSD Newport	
Technical Division of Inventory Control Department	Approaches 100
Purchase Division of Inventory Control Department	10

Facility/Department	Estimated Percent of Time Spent Referencing Source Material
Screening Branch of Material Department	Approaches 100
NSY Boston	
Supply Department (Clerical Group)	Approaches 100
Job Planning Branch of Planning Department	25
SPCC	
Financial Control Division	Approaches 50
Purchase Division	5
Cataloging Division	Approaches 100
Technical Division	80
Stock Control Division	20
Technical Records Division	Approaches 100

9. Functions Requiring Up-to-Date Technical Data

This subsection discusses the functions that are considered to be hindered by lack of up-to-date technical data. An attempt will also be made to explain why more timely information is considered to be required.

a. Procurement Each of the facilities surveyed procures parts to support its functions. Lack of complete information on parts prevents procurement personnel from buying (where advantageous) sole source, thus increasing the lead time of the procurement cycle. Conversely, incomplete information may increase costs because the best buy source may go undetected due to lack of current data.

b. Component Design Both NSRDC and NSY Boston design equipment and components. Availability of more up-to-date technical data would provide a better view of alternative designs and may alleviate the necessity of redoing designs that already exist.

c. Testing Testing of equipment is performed at NSY Boston and NSRDC. Up-to-date technical data, such as equip ment characteristics, part descriptions and test reports, facilitate the development of test procedures. NSRDC not only tests equipment (requiring knowledge of equipment characteristics) but also builds the test equipment (requiring knowledge of what parts are available and their properties).

d. Cross Referencing Parts All of the surveyed facilities must cross reference parts from vendor's catalogs and drawings to Navy catalogs and drawings. The more up-to-date the cross reference lists available, the more efficient the job.

e. Disposal All of the surveyed facilities are involved in the disposal of excess or out-of-date material. However, up-to-date technical data is not required by all of the interviewed facilities because some of them turn the material over to other facilities, which then perform the actual disposal. At NSD Newport the Disposal Branch of the Material Department desires the ability to retrieve up-to-date technical data, such as specifications and drawings, to facilitate efficient performance of their functions. For instance, a part might be marked for disposal yet actually be required by ships in the fleet for repair purposes.

f. Maintenance or Alterations At NSY Boston, up-to-date technical data is needed to perform the major task of repairing and altering ships. All departments are directly related to the task, and personnel from each department interviewed expressed an imperative need for such data.

g. Design Maintenance Procedures SPCC has as one of its tasks the designing of maintenance procedures. The performance of this task would benefit significantly from an up-to-date and more easily accessible set of technical data files.

h. Design Methods and Standards The Methods and Standards Branch of the Production Department at NSY Boston designs the "Standard Man-Hour Allowance Data" for use at this and other shipyards. Members of this department expressed the need for up-to-date technical data such as instruction manuals, technical manuals, material lists, etc.

i. Scheduling At NSY Boston, there is a scheduling department that must schedule work for all the shops at the shipyard. Up-to-date technical data on ship alterations performed at NSY Boston and other shipyards make this task easier and more accurate.

j. Training Because of the scarcity of experienced and trained workers, NSY Boston undertakes in-house training programs. Up-to-date technical data in the form of instruction and technical manuals are required to perform this task.

10. Type of Technical Data Storage and Retrieval System Required

At some facilities, personnel gave their opinions of the type of technical data handling system they envision would meet their present and future requirements (see Exhibit A-5). Of course, it is recognized that speculation in this area is limited by the interviewees' knowledge of available, or potentially available, equipment and techniques.

11. System Programs With Valuable Data

The Purchase Department at NSD Newport mentioned that source data on prior procurements of similar items would be helpful, provided that the data were in an easily retrievable form. Thus, MILSCAP, if it provided information in a readily accessible form, would satisfy the majority of purchasing retrieval requirements.

EXHIBIT A-5 TECHNICAL DATA STORAGE AND RETRIEVAL SYSTEM ENVISIONED VERSUS FACILITY AND DEPARTMENT

Facility and Department	Storage and Retrieval System Envisioned
NSY Boston	
Production Department, Shops	More extensive use of aperture cards. In particular, would like to have instruction books microfilmed and placed on aperture cards.
Planning Department, Design	More sophisticated microfilm system for handling engineering drawings
NSD Newport	
Data Processing Department	Centrally maintained data base with near real-time response to changes.
Inventory Control Department	Centralized data bank that could be interrogated and updated by remote terminals. Also, would like high-speed communications with the appropriate facilities; graphic capabilities
Technical Division	Centralized data bank with rapid access for parts information.
Disposal Division	Some system to automatically retrieve technological information such as specifications, drawings, etc.
NSRDC	
Supply Department	VSMF
Component Instrumentation Division	Have VSMF, but would like it improved by having more detailed part and material descriptions.

EXHIBIT A-5 (Continued)

Facility and Department	Storage and Retrieval System Envisioned
Applied Mathematics Laboratory	CRT (Cathode Ray Tube) for display of parts information.
SPCC	
Data Processing Division	An increase in the amount of high-speed auxilliary storage is required for faster up-dating of technical data.
Financial Control Division	Since the work is accounting oriented, it is cyclic and well suited for present tape-oriented systems.
Purchase Division	Remotes for accessing contract status information. The technical data should be provided to Technical Division personnel in an up-to-date and complete form for their evaluation.
Cataloging Division	Require faster reaction time from DLSC. Would be facilitated by DLSC's having a properly indexed, current, and complete file of technical data related to all DOD items. The transmittal of this information could thus be expedited, resulting in the DLSC Total File and SPCC's Master Item File being up-to-date. A current Master Item File would substantially reduce item identification problems and their costly ramifications.
Technical Division	An integrated application of off-line microform and on-line terminals are required to solve the problem.

EXHIBIT A-5 (Continued)

Facility and Department	Storage and Retrieval System Envisioned
Technical Records Division	The technical files, standards, and specifications should be converted from hard copy to an indexed microform for ease of access and update. Technical personnel might then view such technical data via remote CRT's selectively making hard copy where required.

MILSCAP is a follow-on to other Military Standards such as MILSTRIP and MILSTRAP. Its particular purpose is to acquire more control over material under contract, but not yet received, by providing rapid transmittal of contract status and related information. The initial input into this data system is called a Contract Abstract, which contains administrative data (Contractor, Award date, etc.), item data (item identification, FSN, quantity, etc.), delivery data (ship to, mark for, etc.), and alert data (delegations, advance payments, etc.). The outputs could be numerous and useful, such as an up-to-date file of status requests and cross reference files.

Personnel in the Technical Division of the Supply Department at NSY Boston communicate with DLSC (Defense Logistics Services Center) for the purpose of part identification. Personnel in the Disposal Division of the Material Department at NSD Newport also expressed an awareness of DLSC's activities. DLSC's primary purpose is to provide logistic information to elements of DOD. As part of this purpose, DLSC has concentrated on the process of item identification, the assignment of Federal Stock Numbers, the preparation and distribution of specifications and standards, and supplementary programs such as the Freight Classification Program. DLSC recognizes that their present data system is limited in its capacity to absorb new assignments. This limitation is due to the non-integration of proliferated logistics information programs. In order to overcome this limitation and establish an integrated system that can exploit advances in the communication area, DLSC has formulated a long-range system requirement called DLSC-DIDS (Defense Information Data System). The purpose of this long-range program is to establish and maintain a system for the generation, receipt, validation, storage, control, processing, dissemination and disposition of selected types and kinds of DOD/Federal logistics management information. Certainly, access to this information would be helpful to many of the technical-data-related tasks of the Navy.

C. Possible Growth in Amount/Kind of Technical Data

It is quite difficult to obtain quantitative predictions of requirements for technical data over the next 5 years. However, the following discussion describes what information was obtained when the surveyed facilities were visited.

SPCC is very specific about the present state and future growth of their technical library. Exhibit A-6 indicates the present status of SPCC's technical library and the yearly growth rate anticipated.

At NSRDC, there is an expected expansion in current functions. However, the extent and time aspects of this expansion are unknown. In fact, they expressed the belief that their technical data growth pattern is unpredictable.

NSD Newport expects to have an expanded volume of technical data to deal with as a result of their taking over most of the activities of Naval Supply Center, Bayonne, and their handling SOAP activities for NSY Boston.

Possible changes in the function of NSY Boston, from being principally a repair facility for destroyers and auxiliaries to specializing in ASW (Anti-Submarine Warfare), obviously could change the kind and volume of technical data requirements of this facility. Even if ASW does not become the yard's speciality, it is quite possible that specialization will take place in some other area. There also is evidence of other technical data requirement changes at the shipyard. Specifically, in the last 1-1/2 years, emphasis has shifted from structural to electronic repairs and alterations. At present, 55 percent of their work is in the electronics field, and it seems reasonable for this percentage to increase.

EXHIBIT A-6 SPCC-TECHNICAL LIBRARY STATUS, GROWTH RATE

Type of Technical Data	Volume	Yearly Growth Rate
Engineering Drawings on Microfilm	7.0×10^6	105 reels
Paper Drawings	1.2×10^6	1.45×10^5
Instruction Manuals	1.9×10^5	6.2×10^3
Ship Allowance Lists	1.1×10^4	----
Specifications (Volumes)	4.6×10^4	----
Indices for Identification and Location of Library Material	4.0×10^6	----

D. Description of User's Computer Installations

Exhibit A-7 is a tabulation of the EDP equipment presently in use at the four user locations surveyed. Planned changes and comments on present display and remote capabilities are included.

EXHIBIT A-7 DESCRIPTION OF USER'S COMPUTER INSTALLATIONS

	Computers-Mainframe	Comments
NSRDC	IBM-7090 (1), 1401 (1) UNIVAC-LARC (1) STROMBERG-CARLSON-SC4020 (1) SDS-910 (1) GE 225	In 12 months expect to have an improved third-generation computer to replace the 7090. New system will have time sharing, remote, and graphic capabilities. There will be 24 remote consoles.
NSD Newport	IBM-1401 (1) IBM-1410 (1)	Presently have four remote typewriters (in use since 1962). No other display equipment or remote capabilities.
NSY Boston	UNIVAC-3 (1) UNIVAC-1050 (1) IBM-360-20 (1) IBM-1401 (1)	Waiting for bids on replacing all computers. Presented their proposal in form of a problem and are letting vendors suggest the system to meet the problem. At present, no display equipment or remote capabilities.
SPCC	UNIVAC-U490 (2) UNIVAC-1004 (2) BURROUGHS-B-283 (1) BURROUGHS-ANALEX (1) IBM-7080 (1) IBM-360-30 (1) IBM-360-65 (1) IBM-1401 (1)	Plan to increase the number of UNIVAC computers. Presently have 16 remote Teletype Model 33 automatic send receive sets.

E. User Glossary

APL (Allowance Parts List): Document prepared for each component to describe its operational characteristics; lists all the repair parts that are applicable to the component.

Back Order: The holding in suspense of a material request until available for issue.

Cannibalize: The removal of serviceable parts from one item of equipment for stock or for installation on another item of equipment to restore the latter to a serviceable condition.

Component: An assembly or combination of parts into a unit which is normally capable of independent operation in a variety of situations.

CASDC (Computer Aided Ship Design and Construction): A 20-year planned program under the direction of NAVSHIPS, which has an expected direct cost in excess of $140 million. This program will apply the advances in computer technology to ship design and construction.

COSAL (Consolidated Shipboard Allowance List): Document that is a consolidated assembly of the SAL's (Shipboard Allowance Lists) of each major ICP.

DLSC-DIDS (Defense Logistics Services Center Integrated Data System): A system to provide for the capability to establish and maintain an information system for the generation, receipt, transmission, validation, storage, control, processing, dissemination, and disposition of management information of an integrated basis to responsively support the DOD, Federal Civil Agencies, and FFG (Friendly Foreign Governments) engage in the performance of logistics management functions under established programs.

Disposal: The act of discarding surplus, scrap, or salvage property under proper authority. Disposal may be accomplished by, but not limited to, transfer, donation, sale, declaration, abandonment, or destruction.

Equipment Allowance Lists: Publications, or sections thereof, in the military services that prescribe the equipment and weapons authorized for military organizations, air units, aboard ships, individual military personnel, and administrative equipment at posts or bases.

Engineering Drawing: A document that discloses by means of pictorial or textual presentations, or combinations thereof, the physical and/or functional engineering and product requirements of an item.

Federal Catalog System: A DOD program established pursuant to law to provide common identification language, eliminate different identifications of like items, reveal interchangeability among items, aid in standardization, facilitate inter- and intradepartmental logistical support, assist industrial mobilization, and strengthen government-industry relationships to improve supply management and military effectiveness and promote efficiency and economy in logistics operations.

FSN (Federal Stock Number): An eleven-character number that identifies an item of supply including Federal Group and Class and FIIN (Federal Item Identification Number).

FOCSL (Fleet Oriented Consolidated Stock List): A cross-index file of FSN's and part numbers used for item identification.

Freight Classification Code: Symbol to designate freight classification used to determine freight description of material.

Information Retrieval: The recovery of data from a collection for the purpose of obtaining information. Retrieval includes all the procedures used to identify, search, find, and remove specific information or data stored. It excludes both the creation and use of the data.

Inventory: (1) The amount of property on hand at any given time.
(2) Any itemized list of such property.
(3) A physical count of property on hand.
(4) The act of compiling such a list.
(5) The act of inspection to determine the physical existence of propery.

Inventory Control: That functional phase of supply operations that is concerned with applying managerial supervision to integrate the actions of requirements computed in, production procurement, distribution maintenance, and disposal of material within a supply system.

ICP (Inventory Control Point): An organizational unit within the supply system of a military source which is assigned the primary responsibility for the management of a group of items, either for a particular source or for the DOD as a whole, including computation of quantitative requirements, the authority to require procurement or initial disposal, development of worldwide quantitative and monetary inventory data, and sometimes the positioning and repositioning of material.

Job Order: Provides the basis for preparation of job order reports as well as budget function expenditure account and object class reports. Standing job orders contain monthly and accumulative totals; in addition, specific job orders contain man-hour and cost estimates.

Management Information System: A data-processing system designed to supply management and supervisory personnel with information consisting of data that are accurate, timely, and new.

MILSCAP (Military Standard Contract Administration Program): A military standard program that is a follow-on to other MILS such as MILSTRIP, MILSTRAP, etc. Its purpose is to acquire more control over material under contract, but not yet received, by providing rapid transmittal of contract status information and related reports.

Part: An item of supply which, when joined together with another item, is not normally subject to disassembly without destruction or impairment of design use.

PAMD (Price and Management Data): Supersedes the FOCSL.

Procurement Data: Data contained in source documentation prepared expressly for the identification and description of items, materials, supplies, and services to be purchased, inspected, packaged, packed, and supplied to the military services. The principal types of source documentation are specifications, purchase descriptions, item requirement sheets, item identifications, qualified products list, approved vendor lists, exceptions to specifications, etc.

Procurement Lead Time: The time interval between the initiation of procurement action and the receipt into the supply system of material purchased as a result of such action.

Scrap: Personal property discarded for use and which appears to have no value except for its basic material content.

Ship Alt (Ship Alteration): Any change in the hull, machinery, equipment, or fittings that involves a change in design, materials, number, location, or relationship of the component parts of an assembly.

Ship Life Cycle Management: The Navy's program to manage the course of events pertaining to a particular ship or class of ships, commencing with the earliest identifiable statement of requirements, evolving through a family of legitimate acquisition procedures and support functions, and ending with either the termination of the ship project or the disposal of the ship.

SAL (Shipboard Allowance List): The publication prepared for each ship consisting of:

Part I	Index of Components or equipage groups for which SPCC (Ships Parts Control Center) is responsible.
Part II	APL for each component or equipage groups for which SPCC is responsible.
Part III	Stock Number sequence listing of each repair part item in Part II that is coded on-board.

Specifications: Documents that are clear and accurate descriptions of the technical requirements for a material, a product or a service, including the procedure by which it can be determined that the requirements have been met. Specifications are documents intended to serve as instruments of design and procurement and to transmit whenever applicable, design, fabrication, testing and other technical requirements and data from buyers to sellers. The scope of this definition embraces documents used in invitations for bids, proposals, and contracts, and includes (1) federal and military specifications, (2) military purchase orders and purchase descriptions, (3) military requirements, bulletins, exhibits, and similar documents, (4) industry specifications, and (5) company specifications.

Standard Item: An item of supply identified or described in military or adopted federal and industry standards and approved for procurement, storage, and issue.

SNMMMS (Standard Navy Maintenance and Material Management System): A program sponsored and directed by the Chief of Naval Operations embracing the two broad areas of a Planned Maintenance System and a Maintenance Data Collection System.

Standardization: The adoption and use, by consensus or decision, of engineering criteria applied, as appropriate in design, development, procurement, production, inspection, supply, maintenance, and disposal of equipments and supplies. Such agreements or decisions are normally recorded in authorizations for new developments; in standards, specifications, and drawings for design, development, procurement, production, and identification; and for military supply standards for logistics management.

Stock or Part Number: A 15-digit code utilized to identify a specific item of material. See FSN (Federal Stock Number).

Supply Depot: A facility for the receipt, classification, storage, issue, maintenance, manufacture, assembly, classification, or salvage of material.

SOAP (Supply Overhaul Assistance Program): A stock purification program that removes nonapplicable or unused material from shipboard stocks. It is carried out at predetermined intervals, usually during overhaul.

Supply System: The organizations, offices, facilities, methods, and techniques utilized to provide supplies and equipment to authorized users including requirements, computation, procurement, distribution, maintenance in storage, issue, and salvage of material.

Technical Data: Data contained in original source document prepared by a design activity for the disclosure and description of configuration, design form and fit, performance, operation, reliability, maintainability, quality control, or other engineering features of items, materials, methods, practices, procedures, processes, and services. The principal types of technical data are standards, specifications, engineering drawings, associated lists (list of material, parts list, data list and index list), item data sheets, performance procedures, test procedures or reports, and other documents providing data or design disclosure.

TPCR (Technical Parts Change Record): A cross-reference item record on EAM cards (located at Ship Parts Control Center).

Its primary purpose is to lead the searcher from a reference number to a stock number.

Turnaround Time (Material): The interval between the time and end item, weapon, or a repairable item of supply is removed from use and the time it is available for reissue in a serviceable condition.

Unit of Issue: A term used to indicate the stock unit consisting of the smallest quantity used in supply operations, i.e., number, gallon, pound, foot, ream, etc.

User: A person or an organization requiring technical information; e.g., (1) decision makers in the Executive Branch, (2) members of Congress; (3) scientists and engineers in Federal Agencies, (4) those in organizations working under Federal contracts or grants, and (5) those in the technological community.

VSMF (Visual Search Microfilm File): Microfilm file containing information on parts, components, vendor capabilities, federal and military standards and specifications, etc.; it is manually accessed using index and cartridge scan. The equipment produces an instant copy of the needed data.

APPENDIX B

A. Description

This appendix contains a compilation of characteristics and comparisons of hardware and software currently available from the information processing industry. Personal interviews, product manuals, and reference manuals from in excess of 80 companies were reviewed by the project staff in the preparation of this appendix. This data base was utilized for extracting specific hardware and software characteristics considered to be of interest to technical data systems designers.

Appendix B is organized, along product lines, into six major sections:

1. Digital Central Processors
2. Communications and Related Equipment
3. External Digital Bulk Storage
4. Peripherals
5. Microforms
6. Software

Each section consists of extracted data and specifications on applicable hardware or software items, organized by vendor. These comments represent a selected sample of vendors and models designed to highlight the latest innovations available, as well as the general status of the information processing art. Following each vendor review are equipment characteristic tables providing comparisons of the product lines discussed.

B. Current Equipments

1. Digital Central Processors

a. Selected Vendors

(1) Collins Radio

The Collins C-8560 is a high-speed, general-purpose digital computer combining multispeed communication, business/scientific computation, and on-line, real-time control. The C-8560 combines, as hardware features, integrated circuits and ATR box packaging with software concepts based on functional program modules. Specific features include:

- Overlapped memory modules offering a cycle time of 2.0 microseconds for a 32-bit word plus parity. The basic memory module is 65,536 bytes with 1 to 4 modules per system. Each module is equipped with individual address and data registers.
- A low cost option of a single 16,384-byte module with a 3.0-microsecond cycle time. All memory is directly addressable.
- A comprehensive instruction repertoire consisting of 93 instructions, including hardware multiply, divide, and short and long form floating-point capability. Fixed-point addition requires only 4.5 microseconds.
- An input/output system that operates directly into core memory from the multiplex communication loop at speeds up to 1,228,800 bits per second or via high-speed record channels at rates up to 640,000 bytes per second.
- Application requirements can be met with standard off-the-shelf units that provide both maximum adaptability and minimum implementation time.

- Core storage that may be expanded, or record channels that can be added without modifying the basic functional program concept.
- ATR box packaging that provides mechanical rigidity, close environmental control, and a totally enclosed, prewired, printed circuit backplate, together with either air or water cooling.

(2) CDC (Control Data Corporation)

The Control Data 1700 uses a basic 18-bit word (16 data or instruction bits, 1 program-protect bit, and 1 parity bit) and features all-silicon, solid-state circuitry operable in various temperatures and environments. The basic computer cabinet is small: 72 inches long by 26 inches wide by 41 inches high, readily allowing either vertical or horizontal system expansion. The basic core memory features a 1.1-microsecond cycle time and is directly addressable in 4,096-word increments up to 32,768 words. The mainframe is prewired for ease of plug-in expansion up to the system's maximum. The core volumes and associated circuitry are temperature controlled and horizontally mounted (rather than in the conventional vertical stack) near the air intake to minimize temperature rises or temperature differences from volume to volume. Complement, signed, fixed-point arithmetic is employed in the Control Data 1700 with hardware multiply and divide, additive indexing in a single instruction word, an adaptive interrupt structure, extensive interregister logical and arithmetic capabilities, and a program protect system. Both programmed and buffered, direct access channels are available for input/output transfer rates up to 910 KC per word.

The Control Data 5400 is a microminiaturized, single-address digital computer with the weight, size, power, speed, and operating characteristics required in a data transmission application for data recording, system checkout, data transmission, message switching, and video processing. It uses integrated circuits, high-speed, thin-film memory and compact multilayer etched wiring. Its dependability is based on a simplified and efficient circuit design and logic organization. This system is characterized by the following:

- Binary, parallel, general-purpose operation
- Integrated circuit logic
- Random access NDRO and DRO memories
- Scientific-type repertoire

The speed of the Control Data 6400/6600 is derived from silicon transistor circuitry, the concurrent operation of peripheral tasks and high-speed computation, and special characteristics of computer and software which provide for doubling up on jobs, such as multiprogramming and multiprocessing. Its size is efficiently utilized through the use of a large central memory; high-capacity auxiliary storage devices; and multiple, high-speed data channels to accommodate a variety of peripheral devices.

The system's versatility and ease of use, for the most part, is the result of a combination of two factors. The first is a software package designed to complement unique hardware characteristics, and yet programmable in a traditional manner for a variety of jobs. The second is the availability of a wide variety of peripheral and input/output devices, facilitating the design of total systems tailored to individual user requirements, including real-time, on-line, and hybrid equipment.

Of all these characteristics, the concurrency, or simultaneous operation, of the central processor and peripheral processors is primarily responsible for the approach to computing offered by the 6400/6600 Systems. This is especially true for large scientific/mathematical assignments. The computer is a combination of 12 data channels, 10 peripheral/control processors, a large central memory, and an ultra-high-speed processor.

(3) DEC (Digital Equipment Corporation)

The PDP-9 general-purpose computer has 8,192 18-bit words, 1-microsecond core memory (expandable to 32K), 200 nanosecond adder, high-speed control memory, real-time clock, optional parity bit, and power failure protection. The instruction repertoire includes 16 familes of instruction. Memory reference instructions use either direct or indirect addressing. Input/output instructions handle 256 devices with up to three pulses per device. The software package includes FORTRAN IV, monitor, macro-assembler, peripheral interchange programs, and on-line debugging programs.

The PDP-IO is a general-purpose, stored program, binary digital computer. It operates with parallel processing, asynchronous operation, 36-bit work, and 16 general-purpose registers. It has high-speed multiplexor channels, a flexible I/O bus structure, and reliability flip-chip logic.

(4) EMR (Electro-Mechanical Research, Inc.)

The EMR 6000 series computers are all 24-bit data word machines, which offer memories with a cycle time of 1.9 microseconds.

The 6130 has memory options that vary in speed, size, and multiple access capability. A basic 4,096-word memory (16 bits, plus parity and memory protect bits) is available at a 900-nanosecond total cycle time. A 600-nanosecond cycle time memory is optionally available. Basic memory size is expandable to 32,768 directly addressable words. Peripheral device communication is performed via programmed input/output, buffered sequential word, or multiplexed buffered channels. Other features include three hardware index registers, hardware multiple-precision arithmetic, and a large, powerful instruction repertoire for data computation and manipulation with 32 programmed instructions.

The 6020 includes 4,096-word (24-bit plus parity bit) core memory, 1.9-microsecond memory cycle time, buffered input/output character communication channel, and other channel options. Its basic core memory of 4,096 words is expandable to 32,768 words that are all directly addressable. Additional features include double-precision hardware, 16 programmed input/output channels, and a repertoire exceeding 90 instructions.

The 6040 includes 4,096-word (24-bit plus parity bit) core memory, high-speed, double-precision hardware, 1.9-microsecond memory cycle time, buffered input/output character communication channel, and other channel options. Its basic core memory of 4,096 words is expandable to 32,768 words that are all directly addressable. Additional features include integrated circuitry, 3 hardware index registers, 16 programmed instructions, programmed input/output channel, and a repertoire exceeding 95 instructions.

The 6050 includes 4,096-word (24-bit plus parity bit) core memory, high-speed arithmetic, double-precision and floating-point hardware, 1.9-microsecond memory cycle time, buffered input/output character communication channel, and other channel options. Its basic core memory of 4,096 words is expandable to 32,768 words that are all directly addressable. It has 11 definable programmed instructions, more than 110 24-bit single address instructions, monolithic integrated circuitry, and 3 hardware index registers.

The 6070 includes 4,096-word (24-bit plus parity bit) core memory; high-speed arithmetic, floating-point, double-precision hardware. It has an accelerated processing unit, 1.9-microsecond memory cycle time, variable format buffered input/output channel, buffered input/output character communications channel, and other channel options. Its basic 4,096-word core memory is expandable to 32,768 words that are all directly addressable, with such additional features as monolithic integrated circuitry, 11 definable programmed instructions, more than 110 24-bit single-address instructions, and 3 hardware index registers.

(4) General Electric Company

The 600 Series processor module has a hardware feature that provides two modes of operation: master and slave. In the master mode, all system features are accessible, i.e., no restrictions are imposed on memory access or communication with peripherals. In the slave mode, certain machine instructions are not available; thus, specific registers may not be changed, and memory may not be accessed in certain specified areas. Control programs operate in the master mode. In the slave mode the processor module performs the data movement, arithmetic, logic comparison, and control operations for carrying out job program tasks.

Core memory speed is 1 microsecond total cycle time for the GE-635; 2 microseconds total time for the GE-625. Two words (74 bits) are accessed in each memory cycle. The core storage unit consists of banks of core modules, each containing 32,768 (36-bit) words. Four banks of core modules can be connected to a system controller. The GE-625 or GE-635 systems can have 1 to 4 system controllers, for a total of 262,144 directly addressable words.

Any word in memory may be used as an accumulator. The contents of the A-register, as well as other registers, can be added to a memory word using a single instruction without disturbing the contents of the processor registers. Core memory units are logically assigned, and hence, are readdressable. For example, if a memory unit is disabled, the address ranges of the remaining units can be manually switched to maintain consecutive addressing.

The extended memory subsystem is an extension to magnetic core storage and can have a capacity of up to 16 million words.

The extended memory can connect directly to as many as eight memory modules.

The GE-400 series computers (415/425/435/455/465) have strong family similarities that facilitate business data processing and data communication systems growth. All five use a 4-character word with 24 bits plus parity; use one- or two-address instructions; accept alphanumeric data; and perform decimal arithmetic. Each model operates with the same peripherals. Special I/O channels provide access to a communication network for remote stations, while user-oriented features operate together to provide the systems with batch, random, and real-time capabilities.

System characteristics include the following:

- Core memory of up to 131,072 characters.
- Cycle time equivalent to 2.3 msecs per character.
- Over 200 instructions.
- Four 6-bit characters per word.
- Alphanumeric I/O and data manipulation.
- Decimal arithmetic.
- Binary instruction and addressing.

The accumulator, located anywhere in memory, may be 4, 8, 12, or 16 characters long, and is changeable by program. Any word in memory may be an index word. Also, six fixed-index words are available for conventional indexing; eight buffered I/O channels for peripherals; a special controller for data communication lines; complete error checking circuits; while scatter-read and gather-write capabilities increase processor efficiency.

The most popular GE computer time sharing system consists of two central processors (a DATANET-30 and a GE-235); a DS-20 (disc storage unit); a master control console and multiple remote consoles; and a variety of peripherals. The distance between the remote consoles and the central processors is only limited by the telephone lines and teletype lines available.

The DATANET-30 is a stored program data communications processor. It is used to control the remote consoles, contain the master executive program, and control the GE-235. The GE-235 has a 6-msec memory cycle and a 16K word storage capacity. It is the fastest and largest member of the GE-200 line. In this system its function is to compile programs and perform floating-point arithmetic.

(5) EDP Division of Honeywell

Series 200 represents an "off the shelf" processing capability consisting of processing, input/output, and software modules that can be brought together in any combination to form systems tailored to solve business or business-related data processing problems. It includes six compatible processors that offer the user flexibility in choice of speed, simultaneity, and memory capacity.

Memory speeds range from 3 microseconds to 188 nanoseconds per character, and memory capacities range from 2,048 to 524,288 characters, in modular increments. They are available with up to 30 index registers and flexible nanosecond control memories. A universal set of powerful instructions affords program compatibility between the processors. The instruction repertoire is compatible with IBM 1401, 1410, 1460, and 7010 systems. Advanced programming and memory addressing methods, plus editing and multiply/divide operations are offered as a powerful floating-point capability.

(6) Computer Control Division of Honeywell

The Honeywell DDP-224 is a binary core memory digital computer having single address with indexing and indirect addressing. The system has a memory of 4,096 words, expandable to 32,768 words. All words are addressable, have a coincident current ferrite core, and nonvolatile storage. A special option memory expansion to 65,536 words is possible as well as 1.9-microsecond cycle time and 0.8-millisecond access time.

A large number and variety of I/O channels can be added. The system has program controlled input-output, or automatic interrupt for any I/O channel up to a 325 KC, 24-bit word rate for input-output operations. Up to 4,096 control pulses to peripheral equipment are available, and up to 8,192 sense inputs from external sources exist.

The Honeywell 3C DDP-416 has fully parallel machine organization with 960-nanosecond memory cycle, and 1.92 msec add. It has a 4096-word memory, expandable to 16,384 words. Other features include 16-bit word, two's complement arithmetic, multi-level indirect addressing, large sector size for maximum memory efficiency, standard priority interrupt, standard power failure interrupt, movable control console, and front access for ease of maintenance. Most instructions are executed in 1.92 msecs or less and memory reference instructions include: load, store, add, subtract, logical or exclusive increment memory, skip, jump, and jump-store.

DDP-416 is useful in real-time on-line systems applications. Several aspects of this system are quick response to external conditions, ability to process several inputs and outputs simultaneously, and service I/O requests in order of priority without hold conditions.

(7) IBM (International Business Machines)

System/360 is IBM's entry into the third generation of central processors. In most versions of System/360, actual computation is accomplished through the combined use of memory and special, high-speed registers. The performance of these elements enables System/360 to attain nanosecond range processing speeds. System/360 offers high-speed memory in a broad range of capacities. The main memory in System/360 can range from 8,000 up to more than 500,000 characters. Memory can be added, as needed.

To meet specific user requirements, core storage can be added to supplement main memory-in increments of 1 or 2 million characters, for a total of over 8.5 million characters. Every character of this additional storage is directly addressable and up to eight characters can be accessed in 8 microseconds.

For each version of System/360, an instruction control element provides a way to have the same instruction repertoire that is found on the largest System/360 configuration. The instruction set includes channel commands, "translate and test" commands for code conversion, instructions for program switching, masks, and Boolean calculation. Because the instruction set is the same for every System/360 processor, it is possible to write a program for one System/360 that can run on any other having equivalent memory and input/output equipment.

Instead of the usual 6-bit character, System/360 employs 8 bits to represent an alphabetic character. This 8-bit segment (or byte) permits two numeric characters to be "packed" in one 8-bit byte. This "packed decimal" capability conserves storage space in memory, tape, and disk storage units. It also increases the effective data transfer rate from storage.

The system offers facilities for full binary arithmetic, both fixed-point and floating-point. A set of 15 registers can be used as index registers, relocation registers, and accumulators for fixed-point arithmetic. An optional set of four floating-point registers can be used to extend general arithmetic capability as well as to handle floating-point calculations. Memory protection is accomplished without reduction in computer speed or efficiency.

(8) MTI (Memory Technology, Inc.)

Memory Technology, Inc., has molded the attractive characteristics of braided transformer memories into a practical technology. The company has developed and constructed machines specifically designed to braid such memories. Controlled by an electronic processor, these "logic looms" braid the information word lines into the desired binary patterns. Short of physical destruction, the memory is permanently fixed.

The features of read-only memories are available as plug-in modules complete with line-selection semiconductors and output sense gates. MTI has a complete line of compatible modules that assemble into memory systems. Thus, their modules now provide the means for block-diagram design of read-only memory systems to customer specifications. For applications where fixed memories are suited, the braided transformer technique offers concept simplicity, reliability, and applications flexibility.

The heart of a system employing MTI modules is the Memory Pac. It consists of a braid, line selection devices, transformer cores, and sense gates. The braid, which is woven to the customer's desired information content, is mounted on a mother board, which also contains the matrixed semiconductors. This mother board is sandwiched together with transformer cores and a sense-gate board that contains the output windings and the DTL (diode-transistor logic) sense gates.

In addition to the Memory Pac, which contains the user's particular braid, MTI supplies other standardized modules: current source and control, flip-flop, and selector gating. These and the Memory Pac form a complete system. The modules have been designed to interface directly with standard positive DTL logic. However, if required, MTI can also supply, in modular form, circuits to meet interface requirements.

Read-only memories have the potential for a broad spectrum of uses. A few possible applications are the following:

- Function generators in a general-purpose computer
- Microprogram control
- Look-up tables
- Information storage for optical devices
- Hyphenation memory for computerized typesetting
- Computer program storage
- Numerical control of machinery

Memory Technology, Inc., produces braided woven ROM (read-only memory) modules in varying sizes from 5K to 500K bits. The largest component board produced by them at this point is 65K bits. Thus, the module package can be described as being 5 by 12 inches in size and made up of 64K words by 8K bits. The total module may be described as a 16 by 16 by 32 by 8 matrix of bits of information. There is essentially no constraint to the number of modules that may be connected in a system other than the linkage capacity of the computer involved. The present cycle time quoted is 250 nanoseconds. However, if speed requirements were lowered to 1 msec, each module could be made to store 1 million bits; i.e., 32 by 16 by 32 by 8.

Standard read-only memory storage in quantities of one at the 500K level are quoted at 3.8 cents per bit; at the 16 K level at 10 cents per bit. These costs include the required electronics. Storage is also sold at 1 cent per bit, with bit flux of 512 million bits per second. These prices are being substantially reduced because of

- Increased production's yielding lower unit cost.
- Automatic insertion of components.
- Automatic wire termination.

These cost-reducing factors have been brought about by the introduction of an automatic weaving machine developed by MTI.

The Memory Technology ROM System features the following:

- Very fast cycle and access times.
- Extremely low cost per bit.
- Very flexible application.
- Extremely large storage capacity, if required.
- Economical low capacity storage.
- High packing density.
- Small size.
- Radiation hardness.
- No moving parts.
- Plugable information portion for rapid information changes.
- Mechanical ruggedness.
- Silicon semiconductors.
- Temperature range: 0 to +70° C (commerical SPEC); -65° to +150° C storage (MIL SPEC).
- Easy adaptation to military applications.
- Reasonable input and output word lengths.
- Standard module for required access and output signals.

(9) Raytheon Company

Raytheon Company has expanded its data systems product line of IC (Integrated Circuitry) modules, multiplexers, and conversion equipment with a new low-cost 16-bit IC digital computer, the 703. It was designed as the control element in data acquisition, processing, and control systems. It's characteristics include the following:

- 16-bit word length
- Two's complement arithmetic
- 71 hardware instructions
- Direct and indexed addressing
- 4K to 32K Memory

- Byte and word addressing
- Byte manipulation
- Register entry and display control panel
- Programmed word transfer via 16-bit I/O bus
- 2-microsecond cycle time
- Interrupt system
- Software package which includes diagnostics, assembler, and an executive routine.

Options provided include the following:

- Direct memory access channels, buffered/unbuffered
- High-speed hardware multiply/divide
- Real-time clock
- Peripherals, including the ASR 33 or ASR 35 with paper tape reader and punch, magnetic tape, line printer, disk, and Raytheon's line of data systems equipment.

In the Raytheon 703 computer's set of 71 hardware instructions there are 16 skip instructions providing it with the power and speed for data acquisition applications. A parallel arithmetic unit provides the power and speed for scientific applications. Byte manipulation, word manipulation, byte compare and word compare plus register transfers between the four hardware registers gives the 703 additional power and versatility.

(10) <u>RCA (Radio Corporation of America)</u>

RCA Spectra System 70/15 may be utilized as a low-cost, high-speed computer for large volume input/output operations. It can function as either a remote communications terminal or an off-line satellite. It may also be used to integrate a unit record installation into a total management system, while gaining data processing capabilities. Memory cycle time is 2 microseconds per 8-bit character. Capacity is 4,096 or 8,192 bytes.

System 70/25 is well suited to users requiring a fast and versatile computer, to replace an overtaxed magnetic tape/punched card data processing system. Memory cycle time is 1.5 microseconds per 8-bit word. Capacities are 16,384, 32,768, or 65,536 bytes. Four-character moves within memory accelerate throughput. Four types of interrupts facilitate flexibility of operations and error recovery. Up to 123 communication, terminal, peripheral I/O, and storage operations can be on-line.

System 70/45 is designed with monolithic integrated electronic circuitry. It has the capabilities required for a medium-scale integrated management system. Memory speed is 1.44 microseconds for two bytes (16-bits); storage capacities, 16,384, 32,768, 65,536, 131,072, or 262,144 8-bit bytes. Fast data transmission and computation rates are provided along with a complement of up to 144 instructions, including optional floating point. Up to 11-way simultaneity of I/O operations is available, depending on permissible data rate.

System 70/55 is identical in instruction complement with System 70/45, but has larger and much faster memory, more powerful 4-bytes-at-a-time data handling, and standard double-precision, floating-point arithmetic. Parallel logic is "wired in" and implemented by solid-state integrated electronic circuitry. Memory cycle time is 840 nanoseconds for 4 bytes (32 bits). Capacities are 65,536, 131,072, 262,144, or 524,288 bytes. Up to 14-way simultaneity of I/O operations is available, depending on permissible data rate.

(11) SDS (Scientific Data Systems)

The SDS 930 is a general-purpose digital computer suited for a broad range of scientific and engineering applications. Memory cycle time is 1.75 microseconds. Built-in multiply/divide capabilities provide fast arithmetic, with fixed-point multiplication requiring 7.0 microseconds. The basic 4,096-word core memory can be expanded to 32,768 words, all directly addressable. Versatile input/output is simultaneous with computation, and a maximum I/O throughput rate of 572,000 words per second can be obtained.

The SDS 940 is an extension of the SDS 930 computer, with hardware modifications that permit multiple users to engage simultaneously in on-line program preparation and debugging. The SDS 940 system can be viewed as if it were a 16,348-word, 1.75 msec memory-cycle computer at the sole disposal of each user. User programs are not limited to 16,384 words, however, because system software services permit the user's program to grow to an arbitrary and unbounded size. SDS provides the 940 user with a comprehensive and fully integrated set of software.

The SDS 9300 is a general-purpose digital computer comparable in speed and performance with large-scale computers; yet its price is in the medium-scale computer range. Features of the SDS 9300 include a basic core memory of 4,096 words, expandable to 32,768 words, all directly addressable. It also includes one standard and virtually any number of optional buffered I/O channels with rates up to 572,000 words per second; up to 1,024 levels of priority interrupt; 1.75-msec memory cycle time; overlapping memories reducing effective cycle time to less than 0.9 msec; optional floating-point hardware; and word length of 24 bits plus parity.

In its Sigma Series, SDS currently offers two digital computers that are designed specifically for real-time assignments in a broad range of data processing applications.

Sigma 2's design permits the user to operate one or more real-time programs in the foreground, while concurrently operating a general-purpose program in the background. This system provides up to 132 distinct levels of interrupt, each with its own hardware identification and priority. Each level can be individually disarmed (to discontinue response) and/or disabled (to defer response), which permits reassignment of prioritites. Sigma 2's rapid context switching permits interrupt processing to begin promptly. It features standard input/output rates of over 5 million bits per second, internal memory speeds of 900 nsec, and re-entrant software.

Design of the Sigma 7 permits multiple time sharing of the system's capability by users. Several data processing tasks can be performed simultaneously, while real-time assignments are granted priority. The real-time functions can be processed concurrently, either seperately or as several foreground tasks that are time-multiplexed with any mix of background jobs.

A Sigma 7 system consists of a central processing unit; one or more core memories; and one or more input/output processors, each of which has one or more subchannels, device controllers, and input/output devices. All input/output operations are executed by the input/output processor under control of its own stored program, thereby making the CPU totally available for major processing tasks.

Major Sigma 7 characteristics include the following:

- Up to 224 external interrupt levels.
- Input/output rates up to 160 million bits per second.
- Memory cycle time of 1.2 msec.
- Registers that can be added in blocks of 16 to a total of 512.
- Directly addressable memory that can be expanded from 4,096 to 131,072 words.
- Memory mapping for automatic memory fragmentation and dynamic relocation of programs.
- More than 100 major instructions including optional hardware floating-point and decimal arithmetic.
- Selectively alterable memory in terms of doublewords, words, half-words, and 8-bit bytes.
- Two-way or four-way interleaved addressing of memory modules and overlapping memory organization.

(12) UNIVAC

The UNIVAC 9200 is one of the latest of the UNIVAC computers. This system has multiply, divide, and edit hardware. Its instruction set operates at speeds several times faster than those of more expensive computers. This option will also free a portion of the basic memory so that larger object programs can be run.

Plated-wire memory provides this system with a 1.2-microsecond cycle time. The central processor can perform over 10,000 additions or subtractions per second. It can handle complex computing problems at very high speeds with a capability sufficient even for scientific computations.

The 9200 processor has 8,192 storage locations, or bytes of memory, which are field expandable to 12,288 or 16,384 bytes. Each byte contains 8 bits plus a parity bit, and can store one character or two numerical digits of information. The size of field is limited only by the number of storage positions reserved in the program. Stored information is completely addressable by bytes, and any part of storage may be accessed for processing at any time.

UNIVAC's monolithic integrated circuits are built on very small silicon chips. A single chip may contain the equivalent of 21 transistors, 27 resistors, and 3 diodes. A very high reliability factor is engineered into these advanced assemblies, requiring no interconnections, as do hybrid integrated cirucits. Thus, a more compact processor is produced by shortening electronic paths.

The 9300 central processor provides sixteen registers, in addition to a powerful, standard instruction repertoire. Eight are general purpose, available for indexing, arithmetic, and central processor functions; the other eight are used for input/output control. Processing is overlapped with card input/output, printing, and tape reading or writing.

The 9300 systems operate at 600-nanosecond memory cycle time. As a result, the central processor can perform over 20,000 additions per second, because the plated-wire memory is faster than available core memory. The computer starts at 8,192 storage locations and is field expandable to 32,768 bytes.

b. <u>Equipment Characteristic Tables</u>

(See following pages.)

Equipment Characteristic Tables

	Add Time	Storage Cycle Time	Input-Output Rates (in thousands)	Internal Storage Capacity (in thousands)	Major Instruction	Other Factors					Software Compilers	
						Program Interrupt	Index Registers	Indirect Addressing	Floating-Point Arithmetic	Memory Protection	FORTRAN	COBOL
Collins Radio												
C-8560	4.5 µsec	2.0 µsec	640 bytes/sec	65.5 bytes	93		X		X	X	X	X
Control Data												
3200	2.5 µsec	1.25 µsec	500 samples/sec	32,768 words	164	X	X	X	X	X	X	X
3300	2.75 µsec	1.25 µsec		262 words		X	X	X	X	X	X	X
3800	.8 µsec	.8 µsec		262 words		X	X	X	X	X	X	X
5360	12 µsec	6 µsec		32,768 words	24		X					
5400	3.1 µsec	2.5 µsec	8kc	12 words		X	X					
5500	5 µsec	2.5 µsec		8,192 words	64	X	X					
160	12.8 µsec	6.4 µsec		4 words	64						X	
160A	12.8 µsec	6.4 µsec		32 words		X	X				X	X
160G	3 µsec	1.35 µsec		131 words	189	X					X	X
924A	9.3 µsec	6.4 µsec		32 words	66	X	X	X			X	
1640A	4.8 µsec	6.4 µsec		32 words	62	X	X	X	X		X	X
1700	2.2 µsec	1.1 µsec		32 words	72	X	X	X		X	X	
3100	3.5 µsec	1.75 µsec		32 words	164	X	X	X	X	X	X	X
no longer marketed 3400	2.6 µsec	1.5 µsec		32 words	75	X	X	X	X	X	X	X
3500	1.3 µsec	.8 µsec		262 words		X	X	X	X	X	X	X
3600	2.07 µsec	1.4 µsec		262 words	98	X	X	X	X	X	X	X
6400	1.1 µsec	1.0 µsec		131 words	73	X	X		X	X	X	X
6600	.3 µsec	1.0 µsec		131 words	73		X		X		X	X
6800	.1 µsec	.25 µsec		131 words		X	X	X		X	X	X
8090	12.8 µsec	6.4 µsec		32 words	130	X		X				X
8092	12 µsec	4 µsec		4 words	42	X	X	X				

Equipment Characteristic Tables (Continued)

							Other Factors					Software Compilers	
	Add Time	Storage Cycle Time	Input-Output Rates (in thousands)	Internal Storage Capacity (in thousands)	Major Instructions		Program Interrupt	Index Registers	Indirect Addressing	Floating-Point Arithmetic	Memory Protection	FORTRAN	COBOL
Digital Equipment Corporation													
PDP-8	3.2 µsec	1.6 µsec	625 words		49		X	X	X	-	-	X	-
PDP-10		1.0 µsec	(262)	8K	365		X	X	X	X	X	X	
PDP-9	2.0 µsec	1.0 µsec	18×10^3 bits/sec	32,763 words	16		X	X	X			X	
PDP-7	3.5 µsec	1.75 µsec		32 words	16		X	-	X	-	X	X	
PDP-6	4.4 µsec	1.75 µsec		262 words	263		X	X	X	X	X	X	X
PDP-5	18 µsec	6 µsec		32 words	8		X	-	X	-	-	X	-
PDP-4 and 1	(no longer marketed (1, 4, 5, 6, and 7)												
Electro-Mechanical Research, Inc. (ASI)													
6130	1.8 µsec	900 ηsec		32,768 words	32			X				X	
6020	3.8 µsec	1.9 µsec		32,768 words	90			X				X	
6040	3.8 µsec	1.9 µsec		32,768 words	95			X				X	
6050	3.8 µsec	1.9 µsec		32,768 words	110			X		X		X	
6070	3.8 µsec	1.9 µsec		32,768 words	110			X		X		X	
210	6 µsec	2 µsec		8 words	48		X	X	X	-	-	X	-
2100	4 µsec	2 µsec		32 words	70		X	X	X	-	-	X	X
General Electric													
115	148 µsec	6.5 µsec		16 words	38		-	-	-	-	-	-	X
635,645	1.8 µsec	1.0 µsec		1,018 words	175		X	X	X	X	X	X	
Datanet 30	14 µsec	7 µsec		16 words	78		X	-	X	-	-	-	-
GE/PAC 4020	3.2 µsec	1.6 µsec		32 words	28		X	X	-	-	X	X	-
GE/PAC 4040	15 µsec	5 µsec		16 words	22		X	X	-	-	X	X	-
GE/PAC 4050-I	10.2 µsec	5.1 µsec		64 words	36		X	X	-	X	X	X	-
4050-II	6.8 µsec	3.4 µsec		64 words	36		X	X	-	X	X	X	-
4060	3.4 µsec	1.7 µsec		64 words	36		X	X	-	X	X	X	-

Equipment Characteristic Tables (Continued)

	Add Time	Storage Cycle Time	Input-Output Rates (in thousands)	Internal Storage Capacity (in thousands)	Major Instruction	Other Factors: Program Interrupt	Index Registers	Indirect Addressing	Floating-Point Arithmetic	Memory Protection	Software Compilers: FORTRAN	COBOL
Honeywell EDP												
800	24 μsec	60 μsec		16	60	–	X	X	X	–	X	X
200/120	69 μsec	3 μsec		32 words	37	X	X	X	–	–	X	X
200/200	48 μsec	2 μsec		65 words	39	X	X	X	–	–	X	X
200/1200	35 μsec	1.5 μsec		131 words	57	X	X	X	X	X	X	X
200/2200	25 μsec	1 μsec		262 words	57	X	X	X	X	X	X	X
200/C/200	12 μsec	.75 μsec		524 words	57	X	X	X	X	X	X	X
200/8200	1.75 μsec	.75 μsec		1,048 words	126	X	X	X	X	X	X	X
1400	78 μsec	6.5 μsec		32 words	71	X	X	X	X	–	X	X
1800	8 μsec	2 μsec		65 words	71		X	X	X		X	X
Honeywell 3C												
DDP-124	3.5 μsec	1.75 μsec	285 computations/sec	32,768 words		X	X					
DDP-516	1.92 μsec	0.96 μsec		32,768 words	88	X	X	X	X	X	X	
DDP-416	1.92 μsec	960 nsec		16,384 words	30	X		X		X		
DDP-224	3.8 μsec	1.9 μsec	275 words/sec	32,768 words	64	X	X	X	X		X	
IBM												
360/20	206 μsec	7.2 μsec		16 words	36	X	–	–	–	–		X
360/30	39 μsec	1.5 μsec		65 words	139	X	–	–	X	X	X	X
360/40	11.88 μsec	2.5 μsec		262 words	139	X	–	–	X	X	X	X
360/44	1.75 μsec	1.75 μsec		262 words	109	X	–	–	X	X	X	X
360/50	4 μsec	2 μsec		262 words	139	X	–	–	X	X	X	X
360/65, 67	1.3 μsec	.75 μsec		1,048 words	139	X	–	–	X	X	X	X

Equipment Characteristic Tables (Continued)

	Add Time	Storage Cycle Time	Input-Output Rates (in thousands)	Internal Storage Capacity (in thousands)	Major Instructions	Other Factors: Program Interrupt	Index Registers	Indirect Addressing	Floating-Point Arithmetic	Memory Protection	Software Compilers: FORTRAN	COBOL
IBM												
360/75	.8 μsec	.75 μsec	1.048 words	139		X	–	–	X	X	X	X
360/90	.18 μsec	.75 μsec	1.024 words	139		X	–	–	X	X	X	X
1130	.8 μsec	3.6 μsec	8 words	31		X	X	X	–	–	X	–
1710	560 μsec	20 μsec	60 words	[illegible]		X	X	X	X	–	–	–
1800	6 μsec	2 μsec	32 words	26		X	X	X	–	–		–
7700	6 μsec	2 μsec	49 words	34		X	X	X	–	–	?	–
Raytheon												
703	4 μsec	2 μsec	16.384 words			X	X	X			X	X
250	24 μsec	3070 μsec	16 words	51		–	X	–	–	–	X	X
440	1 μsec	2 μsec	32 words	60		X	X	–	–	–	X	–
RCA												
Spectra 70:												
70/15	56[1] μsec	2.0 μsec	8 bytes	25		X	–	–	–	–	–	X
70/25	33 μsec	1.5 μsec	65.5 bytes	32		X	X	–	–	–	–	X
70/35	23.08 μsec	1.44 μsec	65.5 bytes	144		X	X	–	X	X	X	X
70/45	9.6 μsec	1.44 μsec	262 bytes	144		X	X	–	X	X	X	X
70/55	2.58 μsec	.84 μsec	524 bytes	144		X	X	–	X	X	X	X
301	98 μsec	7 μsec	40 words	46		–	X	X	X	–	X	X
3301	27.5 μsec	1.5 μsec	320 words	62		X	X	X	X	–	X	X
SDS												
Sigma 2	2.25 μsec	900 μsec	5×10^3 bits/sec	65 words (max)	25	X	X	X	–	X	X	–
Sigma 7	2.0 μsec	1.2 μsec	160×10^3 bits/sec	131.072 words (max)	106	X	X	X	X	X	X	X

Note: (1) For RCA Spectra 70, 5-character add decimal.

Equipment Characteristic Tables (Continued)

	Add Time	Storage Cycle Time	Input-Output Rates (in thousands)	Internal Storage Capacity (in thousands)	Major Instruction	Other Factors: Program Interrupt	Index Registers	Indirect Addressing	Floating-Point Arithmetic	Memory Protection	Software Compilers: FORTRAN	COBOL
SDS												
SDS 930	3.5 μsec	1.75 μsec	572 words/sec	30,758 words	60	X	X	X	–	–	X	X
SDS 940	3.5 μsec	1.75 μsec		16,384 words	60	X	X	X	–	X	X	X
SDS 9300	1.75 μsec	1.75 μsec	472 word/sec	32,768	60	X	X	X	X	X	X	X
Sigma 5	2.06 μsec	850 μsec	500 bytes/sec	131,072 words	89	X	X	X	X	X	X	X
UNIVAC												
9200	104[1] μsec	1.2 μsec		16,383 bytes	32	X	X				X	X
9300	52 μsec	0.6 μsec		32,767 bytes	35	X	X				X	X
1005 II, III	208 μsec	6.5 μsec		4 bytes	39	X		X		X		
1108	375 μsec	375 μsec		262 words	77	X	X	X	X	X	X	X
CP-788	16 μsec	8 μsec		512 words	621	X	X					
1218	8 μsec	4 μsec		32 words	98	X	X		X		X	
1219	4 μsec	2 μsec	500 words/sec	65 words	102	X	X		X		X	
1230	2 μsec	2 μsec		115 words	98	X	X		X		X	
CP-642B	8 μsec	2 μsec		32 words	62	X	X		X		X	
1830	8 μsec	4 μsec		32 words	62	X	X		X			
CP-667	2 μsec	2 μsec		32 words	89	X	X		X	X		
1824	8 μsec	4 μsec		1,024 words	41	X	X		X	X		
1818		2 μsec		32,768 words	28	X	X					
1830 A	2 μsec	2 μsec		131,072 words	62	X	X				X	
418 II	4 μsec	2 μsec		65,500 words	94	X	X	X		X	X	X
1904 I	112 μsec	8 μsec		,961 words	36	X	–	–	–	–	–	–

Note: (1) For UNIVAC, Two 5-digit fields.

2. Communications and Related Equipments

a. Remote Terminals

(1) Selected Vendors

(a) Bunker-Ramo Corporation

The Bunker-Ramo Corporation has distinguished itself as a leader in the use of state-of-the-art components to implement novel design concepts. Using orthodox hardware and new ideas, they have developed a wide range of versatile and reliable equipment. Although the corporation is best known in the information processing area--for their computers, the AN/UYK-1 and AN/UYK-3--their control-and-display equipment has received attention and has been considered an important addition to the field.

The Bunker-Ramo 85 Control/Display Console will operate with almost any general-purpose computer. A group of them can communicate with a computer over the same input/output lines, and the user needs no computer training. The keys on the program keyboard are labeled in English and have interchangeable keyboard overlays that allow the system to be used for many applications.

Text, symbols, point plots, and line drawings may be produced on the 12- by 16-inch display area of the 23-inch TV-type screen. Symbols generated at the rate of 100,000 per second may be produced in two sizes, and may be made to blink on the screen. Cursor control and a light pen are provided for accessing the computer.

The BR90 is the latest development of the corporation. Called a "Visual Analysis Console," the 90 features combined electronic and photographic displays using a rear-ported CRT and stored program control. It can interface with most computers and digital communication systems, and provides all the necessary tools for graphical data analysis, data generation, and computer control.

(b) IDI (Information Displays Incorporated

Information Displays Incorporated offers a variety of displays, expandable from one level capability to another and configured in a variety of packages. Most IDI graphic consoles use 21-inch rectangular CRT's, and the user can adjust for either a 12-inch or 16-inch rectangle, a 13- by 13-inch square, or a 15-inch diameter circle.

One of the displays is called the Series M10000 High-Speed DUALFLEC. Random settling time on the display is 14 microseconds and small angle positioning time is 3 microseconds. Another display is the less expensive Series M10000 Standard Speed DUALFLEC with settling time of 50 microseconds and small angle positioning time of 10 microseconds. Settling times are defined as the time required to settle to one spot size. This means that character, spot, or line writing can start at the end of the specified settling time without affecting the resolution of the graphic element.

IDI utilizes their CURVILINE (Registered Trademark) for character generation. The CURVILINE writes alphanumerics and mathematical symbols with combinations of continuous straight and curved lines. The characters can be made any size between 3/32 inch and 1/2 inch and do not break up into illegible groups of dots or scanning lines. CURVILINE is available on the DUALFLEC consoles and may be either low speed (67 microseconds per character) or high speed (10 microseconds per character). Sixty-four different symbols are available. Exhibit B-1 represents the number of characters that can be displayed at 30 frames per second.

A vector generator draws a line between any two points, given the origin (X_1, Y_1) and termination (X_2, Y_2).

Recently, IDI has announced a new, fully buffered graphic CRT console called the IDIIOM (IDI Input/Output Machine). The new IDIIOM is free standing and self contained, needing no external

EXHIBIT B-1 NUMBER OF CHARACTERS DISPLAYED AT 30 FRAMES PER SECOND, CURVILINE

	CURVILINE Low Speed		CURVILINE High Speed	
	Random	Formatted	Random	Formatted
Standard DUALFLEC	280	420	550	1600
High-Speed DUALFLEC	400	470	1300	2600

computer for message composing and editing, for light pen tracking, or display refresh.

IDIIOM characteristics are summarized below:

- A high speed DUALFLEC display with a 21-inch rectangular CRT featuring bonded, etched faceplate to reduce reflections and neutral density filter to enhance contrast; 13- by 13-inch, 12- by 16-inch, or 15-inch diameter display area; 14-msec random positioning time.
- A light pen which is a light weight, easy-to-use, sensitive fibre optics unit. An aiming circle shows exactly where the pen is pointed, featuring self-contained light pen tracking.
- Alphanumeric keyboard ASR33, includes paper tape punch and reader.
- Three programmable function keys that can be used to convert A/N keyboard into function keyboard.
- A high-speed CURVILINE character generator with a 64-symbol vocabulary (ASCII, Standard). Each character is written in 10 msec. Characters are formed from continuous straight and curved lines, featuring an expandable character set.
- Four character sizes range from 3/32 inch to 1/2 inch in height, spaced from 32 characters per line to 128 characters per line.
- Under program control, characters can be rotated 90 degrees CCW, and plotted vertically instead of horizontally.
- A vector generator is typically factory set so that continuous lines up to 3 inches long can be drawn in 20 msec.
- Four line structures (solid, dash, dash-dot, dot) are under program control.

- True, continuous-line circles can be drawn up to full screen diameter, in 100 msec.
- Points, characters, lines, and circles may be drawn bright, dim, or bright flashing.
- Point, character, line, and circle modes plus memory saving subroutining UNICOM are featured with a powerful instruction set.
- A buffer provides a programmable 4K- by 16-bit; 1.8-msec memory; register lights; expandable to 32K; and optional high-speed multiply and divide; an extensive list of peripherals can be added.
- Can be used to drive slaved direct view display, hard copy device or wall size display up to 1,000 feet from IDIIOM.

(c) <u>IBM (International Business Machines</u>

The 1015 Inquiry Display Terminal is used to interrogate and receive visually displayed replies from System/360, Models 30, 40, or 50. A message of 1,160 characters may be displayed on a self-storing dark-trace CRT. The tube displays up to 40 characters horizontally and 30 characters vertically. Characters are generated at a rate of 650 per second. The character set consists of 26 letters, 10 digits, and 23 special characters. Up to ten 1015 models can be attached to the 1016 control unit.

Modular features of the IBM2250 display console provide equipment that will permit real-time and/or near real-time man-machine communications. The basic console contains a direct-view 21-inch cathode ray tube and associated power supply, and digital and analog circuitry. Alphameric information is drawn on the face of the tube by positioning the CRT electron beam under program control. The images are constructed by displaying a series of dots in the desired pattern. Simultaneously, 3,848 characters can be displayed in 52 lines with 74 characters per line. To relieve the computer that feeds the display of plotting characters, a character generator is available to perform this function. Using this generator, two sizes may be specified for each character.

All information displayed on a cathode ray tube normally fades within a fraction of a second. Regeneration is the process of continuously rewriting the display to provide a steady, stationary image. To relieve the computer of this task, an optional buffer can be supplied. This is a separate block of core storage, integrated into the display console and used for regeneration as well as for storage of messages going to and from the computer. The arrival of new data into the buffer does not interfere with regeneration. The new data simply replace the old on the screen. Either a 4K or an 8K buffer can be selected.

For manual input, a choice of three units is available. The alphameric keyboard is a standard typewriter keyboard for applications where any considerable amount of alphameric data is to be entered into the system. The program function keyboard contains 32 keys and is designed to allow the operator to indicate program-interpretive functions to the system by means of a single key depression. The keys themselves are unidentified, but a coded removable overlay inscribed with any desired labeling is used to identify the temporary key function to the program and the operator.

The light pen is a hand-held penlike device that can pinpoint the location of a line, spot, or character on the face of the cathode ray tube and can communicate this information to the computer program. It can be used as (1) a tracing or sketching instrument that can be programmed to permit drawing of lines, curves, sketches, etc., or (2) an electronic pointer that can be programmed to allow detection of desired lines of data, selected characters, etc.

Model 1 of the 2250 is for single display and control. Model 2 is for multiple display units. Multiplexing logic provides the ability to share time of a number of consoles on one computer without operator delay.

Both models have the same choice of manual inputs. With a 2840 Display Control, an 8K buffer, and a display multiplexor, up to six additional Model 2's can be attached to a system. Manual input units may be placed remotely up to 2,000 feet from the computer.

Single or multiple display units can be attached to either a multiplexor or selectro channel on a System/360, Model 30, [illegible] 50. Display units may also be attached to a selector channel on a System/360, Model 60, 62, or 70.

(d) Philco/Ford

Philco/Ford has designed and constructed an entire line of digital displays. Being wholly digital, they are light in weight and occupy less space than the usual CRT terminals. Comparable to commercial television, they provide ten times the picture quality of the best television and ten times the registration accuracy of analog CRT displays.

By digitally counting a given scan line and a given precision time interval on each line, relative registration of picture elements is perfect and independent of small distortions and nonlinearities present in all CRT displays. The only connection between the console display and the central processor is one coaxial wire, which can be 1,000 feet long. Exhibit B-2 describes Philco display system specifications. Note that all have a seven-color capability.

(e) Raytheon Company

The Raytheon Company has long been associated with the development of cathode ray tube terminals. The DIDS-400 Display Terminal incorporates a cathode ray tube and associated circuitry, with character generator, display refresh

EXHIBIT B-2 PHILCO DISPLAY SYSTEM SPECIFICATIONS

MODEL NUMBER	525/256 -R	525/512 -I	525/1024 -I	729/860 -I	875/512 -R	875/1024 -I	945/512 -R	945/1024 -I	1029/512 -R	1029/1024 -I	1125/512 -R	1125/1024 -I
LINE STANDARDS	525	525	525	729	875	875	945	945	1029	1029	1125	1125
Horizontal Resolution-Elements	256	512	1024	860	512	1024	512	1024	512	1024	512	1024
Vertical Resolution-Elements	245	490	490	640	410	820	440	880	478	956	512	1024
Refresh Rate-Fields/Frames Per Second	60/30	60/30	60/30	60/30	60/30	60/30	60/30	60/30	60/30	60/30	60/30	60/30
SYSTEM DISPLAY DEVICES												
• Black and White Consoles—Type							CRT					
CRT--Size							ANY					
Brightness--Ft-Lamberts	75	75	75	75	75	75	75	75	75	75	75	75
Black-White Reversal							YES					
• Black and White Group Displays												
Can Be Driven in Parallel							YES					
Black-White Reversal							YES					
Large Display-Type							EIDOPHOR					
Max. Square Feet of Screen (20 Ft-Candles Incident)	200	200	200	200	200	200	200	200	200	200	200	200
Medium Display Type							SCHMITT					
Max. Square Feet of Screen (20 Ft-Candles Incident)	10	10	10	10*	10	10	10	10	10	10	10	10
• Color Consoles--Type							PROJ. CRT					
Max. Square In. of Screen (20 Ft-Lamberts Brightness)	112	112	112	112	112	112	112	112	112	112	112	112
• Color Group Displays												
Can Be Driven in Parallel							YES					
Large Display--Type							EIDOPHOR					
Max. Square Feet of Screen (20 Ft.-Candles Incident)	150	150	150	150	150	150	150	150	150	150	150	150

EXHIBIT B-2 (Continued)

SYMBOL GENERATION CAPABILITY												
• Symbol Storage Technique	MAGNETIC CORE											
• Generation Technique	TABLE LOOK-UP											
• Number of Types--(Typical)	128	128	256	256	128	256	128	256	128	256	128	256
• Number of Sizes	6	6	6	6	6	6	6	6	6	6	6	6
• Symbols Per Row (Max.)	32	64	128	107	64	128	64	128	64	128	64	128
• Number of Rows (Max.)	24	48	48	64	40	81	43	87	47	94	50	100
• Symbol Positioning Error (Max.) (Percent)	0.2	0.1	0.1	0.1	0.1	0.06	0.1	0.06	0.1	0.05	0.1	0.05
• Symbol Update Rate--Symbols/Sec	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000
VECTOR GENERATION CAPABILITY												
• Vector Generation Technique	DIGITAL											
• Max. Length--Percent of Display	100	100	100	100	100	100	100	100	100	100	100	100
• Registration Error--Max.	0.2	0.1	0.1	0.1	0.1	0.06	0.1	0.06	0.1	0.05	0.1	0.05
• Vectors Per Display (Max.)	7,000	30,000	60,000	60,000	30,000	120,000	30,000	120,000	40,000	140,000	75,000	150,000
• Vector Update Rate--Vectors/Sec	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
PHYSICAL												
• Simultaneous Independent Displays Per Central	64	64	64	64	64	64	64	64	64	64	64	64
• Maximum Separation Central-to-Display (Feet)	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
• Type of Logic	MICROLOGIC											
• Equipment Racks Per Central (Basic)	1	1	2	2	1	2	1	2	1	2	1	2
• Equipment Racks Per Central (Per Independent Display)	0.25	0.5	1.0	1.0	0.5	1.0	0.5	1.0	0.5	1.0	0.5	1.0
• Weight Per Console CRT Display (Pounds)	50	50	50	50	50	50	50	50	50	50	50	50
FEATURES AVAILABLE												
• Hard Copy	YES											
• Automatic Backgrounds	YES											
• Automatic Symbol Spacing	YES											
• Keyboard, Track Ball, Cursor, Light Pen	YES											

memory, keyboard and function controls, edit and character entry logic, and all necessary power supplies. Since each operating position is provided with a self-contained unit incorporating all of the above elements, the resulting system has a high degree of reliability, reducing the probability of multiple display breakdown.

A wide range of display formats is available within the DIDS-400 family, including the total number of characters that can be displayed on the screen and the number of characters available on each line. Full screen capacities of 520 and 1,040 characters are available. The 520-character format consists of 13 lines of 40 characters and the 1,040-character format consists of 13 lines of 80 characters.

The character viewing area is approximately 8.5 inches wide by 6.5 inches high and is presented on a 12-inch rectangular cathode ray tube. This display area allows character sizes that are easily viewed at normal operating distances. The display presentation is refreshed at 67 cps, which is well above the threshold of visual flicker and permits specification of a most efficient phosphor for maximum light output and display viewing contrast. An antiglare safety glass is used to further enhance the display presentation.

The combined ON-OFF/BRIGHTNESS control, located on the right side of the display terminal, permits operator adjustment of brightness to adapt to ambient lighting conditions and operator comfort.

The Raytheon display employs a solid-state electronic keyboard that provides reliable operation, low noise level, and flexibility in key arrangement. Special keyboard configurations can be designed to incorporate special function keys and the edit and control keys required. The standard layout is similar to that of a typewriter with edit and control keys organized for ease of operation.

Associated with a group of displays is a control unit that performs the following functions:

- Interfaces up to 64 individual displays, supervisor's consoles, or hard copy printers with the computer or communication modem.
- Centralizes common on-line system components that are not used frequently enough to warrant their inclusion in each display unit.
- Permits optimum usage of the communication lines between the display terminals and the computer, and consequently minimizes both the number of lines required and the number of input/output channels required from the computer.

Each control unit contains circuits for display address and interface, timing generation, modem synchronization and interface logic, parity generation and detection, message heading, and line driving. Several alternate models are available to meet particular site requirements, either individually or in combination.

Two series of control units are available: the Series 420 units, which interface groups of displays directly to the high-speed input/output channel of a computer, and the Series 425 units, which interface groups of displays to communication modems, and efficiently use the maximum capacity of a 1,200- or 2,400-baud line. Both types of control units are available in models to economically handle up to 64 display terminals each. Higher speed communications interfaces are available in models to economically handle up to 64 display terminals each. Higher speed communications interfaces are available on special order.

A teletype printer adapter can be connected to any control unit in place of a display terminal. Each such unit incorporates a local store that allows a receipt of message transfer rate equivalent to all other message transfers. Since the operating rate of the printer is relatively slow, the accumulated messages are accessed from the local store by the printer at its normal printout rate without further commitment of either the control unit or the communication system.

The standard printer is a Teletype Model 33 or 35. Logic circuitry is included for control unit interface and access control, and a display refresh memory is used as the high-speed data acceptor and access store for printout. Included is the capability to generate and send to the computer via the control unit, a status message indicating one of the following conditions: power off, low paper supply, and busy printing.

(f) Sanders Associates, Inc.

The Sanders 720 Communicator display is designed for use in business data processing, communications, and information retrieval operations. It can communicate with any computer, either directly or via DATA-PHONE equipment.

Operators can correct, delete, add, and move data at will. There is a minimum interruption of computer operations, because display memories buffer data from the computer at all times except during transmission and reception of complete messages.

The 720 has been designed with inherent flexibility. It is completely modular and only necessary capabilities are provided; e.g., the 720 may be used as a retrieval-only system or as a full editing retrieval, edit, and data entry system. Exhibit B-3 represents a systems configuration for a typical application.

(g) Tasker Industries

The Tasker 9000 offers a wide choice of optional control and display devices, memories, and computer interfaces. The console can be custom-outfitted to interface with all standard computers and systems. The data display on the 9000 can be analog, digital, or hybrid.

Particular attention has been paid to human factors in the design and construction of Tasker consoles. Proportions, control

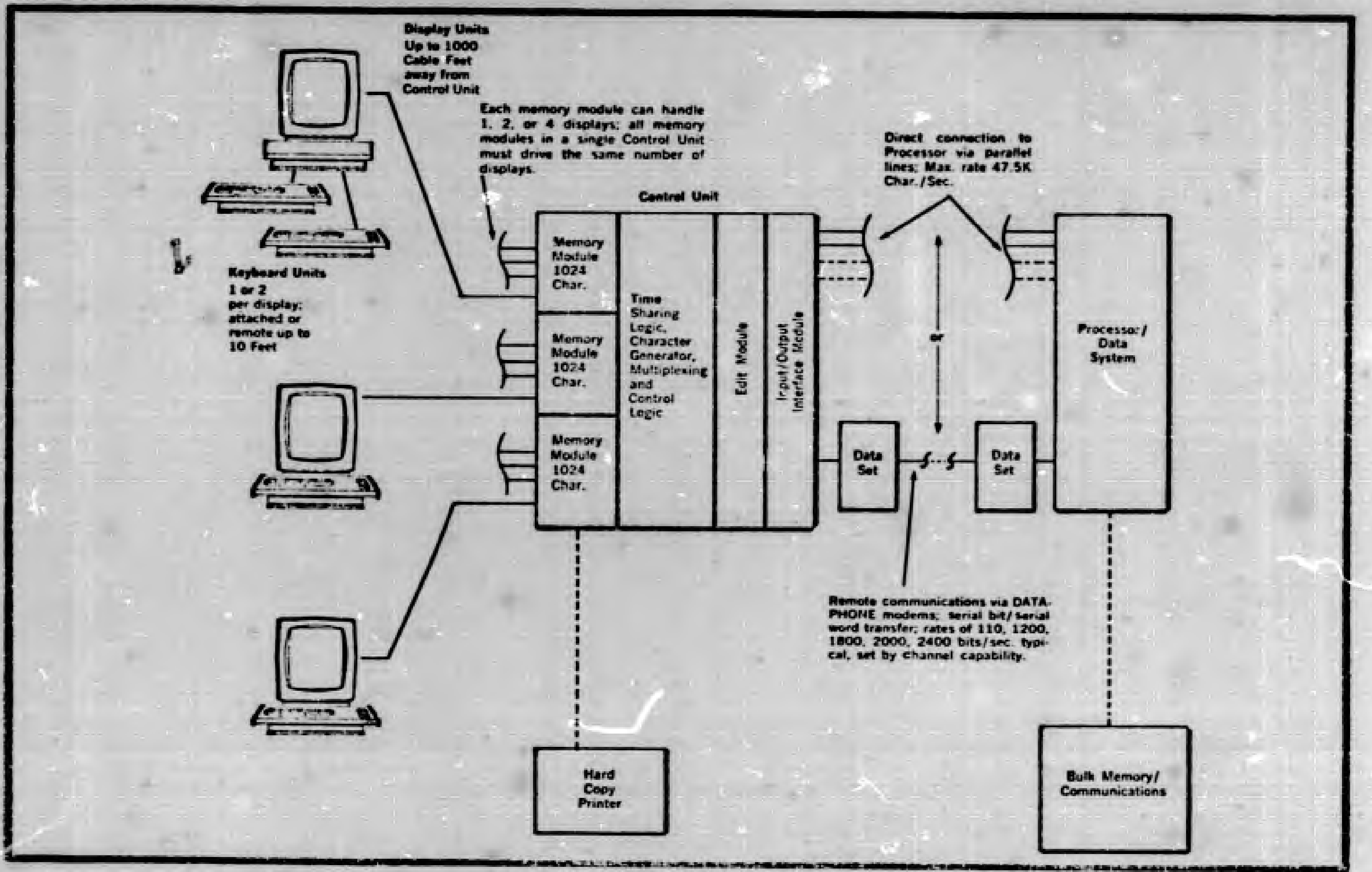


EXHIBIT B-3 A TYPICAL 720 COMMUNICATOR SYSTEM CONFIGURATION positions, and cabinetry have been carefully engineered for fatigue-free operation. An interesting feature is the associated keyboard. When first developed it was completely silent, efficient, and correct in every detail. Through human-factors studies it was determined that the silence of the keys was considerably annoying to the operator, even leading to fatigue. To remedy this, a plastic sheet was placed under the keys with no other purpose except to produce a clicking sound when the keys were depressed.

The light pen is used for adding, erasing, correcting, copying, and transferring information directly upon the CRT face. Also, with appropriate circuitry, it can be used to control the generation and positioning of vectors. A "joy-stick" is optional for use as a cursor or to position the end points of vectors in selected locations. A "bouting bowl" is also an optional feature, performing identical functions as the joy stick.

A Tasker development, TAG (Transparent Address Grid) is incorporated into the 9000 series. TAG is a fine wire grid that is imbedded in pliable plastic and positioned over the face of the CRT. When a particular X-Y coordinate square of the grid is depressed with the finger tip or a pencil, the corresponding X-Y coordinates in the computer will be addressed and a new display called out.

Slide formats can be projected through an optical port at the rear of the CRT when called up through the computer or keyboard selection switches. The operator can then superimpose alphanumerics and special symbols onto the film display. A similar function is performed by an optional format generator, which is custom designed to the needs of the user and which presents formats such as order blanks as screen displays. The Tasker 9000 can be interfaced to any hard-copy printer commercially available.

(2) Equipment Characteristic Tables

(See following pages.)

CRT Remote Terminals

Manufacturer	Bunker-Ramo	Bunker-Ramo	Raytheon	Sanders Assoc.
Model	200 Series	400 Series	DIDS 400	720
Display Storage (No. of Characters)	32 to 768 (delay line)	384	520/1040 characters	256/512/1024 (delay time)
Screen Size	4-1/2 inch by 3-1/2 inches 7 inch by 5 inches	7-3/4 inch by 5-5/8 inches	6-1/2 inch by 8 inches	7-1/2 inch by 9-1/2 inches
Transmission				
Speed	240 char/sec	-	120 char/sec	110/1200/1800 (asynchronous) 2000/2400 (synchronous) bit/sec
Simultaneity	Half-duplex	Half-duplex	Half-duplex	
Synchronization	Asynchronous	-	Asynchronous	Synchronous or Asynchronous
Error Detection	Yes	-	-	Parity
Codes	ASCII	-	ASCII	ASCII
Editing	Full cursor	Full cursor	Sufficient cursor	Partial or full cursor
Direct Computer Trans. Rate	-	-	100,000 char/sec	47,500 char/sec. (parallel)
Character Screen Formats	2 lines of 16 to 12 lines of 64 characters	12 lines of 32 char.	13 lines of 80 characters or 13 x 40	40 lines of 52 or 32 lines of 64 char.
Regeneration	42 times/sec	-	4[illegible]7 frames/sec	46.5 times per sec.
Controls	Brightness Focus Character Height	Brightness, Focus Character Height	Brightness	Brightness, Focus Character Size Page Size
Alternate Output	Yes	No	-	Teleprinter
Special Features	-	Alternate input (paper tape)	-	Character tilt

CRT Consoles

Manufacturer and Model Number	Bunker-Ramo TRW 85	Bunker-Ramo BR-90	IBM 2250	IDI M11000	IDI M11000	IDI M10000	IDI M10000	Stromberg-Carlson SC1090	Tasker 9003
Product Description	-	-	-	Standard Monoflec	High Speed Monoflec	Standard Dualflec	High Speed Dualflec	-	-
CRT Characteristics									
Accuracy	-	-	-	±3% of full scale	±1% of full scale	±3% of full scale	±3% of full scale	-	0.5%
Brightness	-	20 ft. lamberts	-	20 ft. lamberts	20 ft. lamberts	20 ft. lamberts	20 ft. lamberts	20 ft. lamberts	100 ft. lamberts
Phosphor	-	P-4	P-7	P-31	P-31	P-31	P-31	-	-
Spot Size	-	.02 inch	0.018 inch	0.01 inch	0.01 inch	0.01 inch	0.01 inch	-	0.015 inch
Stability	0.5% in 8 hours	1% of full scale	-	0.5% in 8 hours	0.5% in 8 hours	0.5% in 8 hours	0.5% in 8 hours	0.015-inch spot movement	-
Tube Size	23 inches	-	21 inches	21 inches	21 inches	21 inches	21 inches	19 inches charactron	23 inches
Deflection System	magnetic & electrostatic	magnetic	-	magnetic	magnetic	magnetic & electrostatic	magnetic & electrostatic	-	Electromagnetic high-speed
Graphic Characteristics									
Display Area	12 by 16 inches	13.2 by 13.2 inches	12 by 12 inches	12 by 16 inches	12 by 16 inches	12 by 16 inches	12 by 16 inches	-	13 by 18 inches
				15 inch dia.	15 inch dia.	15 inch dia.	15 inch dia.		
				13 by 13 inches	13 by 13 inches	13 by 13 inches	13 by 13 inches		
Grid Size	512 x 384	512 x 512	1024 x 1024	1024 x 1024	1024 x 1024	1024 x 1024	1024 x 1024	-	-
Image Regeneration Rate	30 to 60 times/sec	60 times/sec	30 to 40 times/sec	30/sec	30/sec	30/sec	30/sec	30/sec	60 times/sec
Point Plotting Speed	-	-	-	50 µsec/point	14 µsec/point	90 µsec/point	14 µsec/point	-	random position (4 µsec)
Vector Plotting Speed	3 inch length in 50 µsec	-	16 µsec	150 µsec full screen	50 µsec full screen	150 µsec	50 µsec	2 inch in 80 µsec	1 µsec for 3/4 inch vector
Character Generation									
No. Characters	64	63	64	N/A	N/A	71	71	64	64
Rate of Generation	100,000 char/sec	200,000 char/sec	66,000 char/sec	N/A	N/A	14,000/sec	100,000/sec	30,000 char/sec	250,000 char/sec
Type of Generation	-	stroke	stroke	N/A	N/A	stroke	stroke	shaped beam	stroke
Size of Character	-	0.13 by 0.10 inch/0.26 by 0.20 inch	-	-	-	-	-	-	0.1 by 0.1 inch/1.5 by 1.5 inches
Control Functions									
Auxiliary Outputs	-	-	-	Yes	Yes	Yes	Yes	Film projector	-
Buffering	4096 words	Yes	Yes	Yes	Yes	Yes	Yes	Optional	-
Keyboard/Status Display	Yes	Yes	Keyboard and Status	Yes	Yes	Yes	Yes	-	Yes
Light Pen	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Comments	-	circle generator; slide capacity is 5 magazines of 70mm slide.	-	-	-	-	-	-	Displays 4000 char.

b. Facsimile Equipment

(1) Selected Vendors

(a) AM (Addressograph Multigraph Corporation

The Electronic Image Systems Corporation (EIS) is a wholly owned subsidiary of AM Corporation, and since 1961 it has developed systems and equipments for long-distance transmission of graphic information. Addressograph Multigraph developed a prototype commercial system for scanning and transmitting graphics on business documents at the same time EIS was performing its research. The system developed by AM and EIS is called Telikon II. It is a facsimile system that uses telephone lines as a communications link.

Until now, all conventional facsimile equipment have employed transmission techniques whereby the entire document is scanned at a fixed rate of speed and all areas of the document, whether containing intelligence or not, are represented by pulses that enter the communication channel. The "white space," i.e., the areas with no useful information such as margins, etc., costs the same to transmit as pertinent information. Clearly, since the cost of the line presents the largest individual cost element in the system, attempts had to be made to eliminate unnecessary transmission. The major advance made in the Telikon II system is the addition of a workable and efficient automatic method of information encoding. In scanning each line of typewritten data, Telikon II selects the code that will transmit the minimum amount of information required. If a blank line is encountered, the code selected transmits a small amount of digital information telling the receiver that the particular line is blank, rather than transmitting the entire blank space.

While conventional voice grade line facsimile systems take 4 to 6 minutes of line time to send and receive an 8-1/2- by 11-inch document, Telikon II transmits the same document in less than 1 minute, utilizing the same facilities. In the transmission of graphics, even more time is saved, principally because graphics contain a great deal of white space.

(b) Alden Electronic and Impulse Recording Equipment Co., Inc.

The Alden Company has been a leader in the design and manufacture of facsimile systems and devices. Their devices are capable of using almost any communication medium, such as radio, dataphone, private voice grade lines, broadband lines from 2KC to 48KC, Telpak, and communications satellites.

A typical Alden system would consist of a scanner, a communications link, and a recorder. The scanner is flat copy loading and does not have the limitations of drum or slot loading transmitters. This type of loading also permits continuous operation and selectivity; i. e., it is not necessary to transmit an entire document but only that portion selected. The recorders operate as unattended slaves to the scanners, starting, synchronizing, printing, and stopping on command from transmitting scanner.

With the Alden process, it is possible to transmit from paper to paper, microfilm (16mm or 35mm) to paper, or to viewgraph plastic or magnetic tape. Cryptographic devices may be interfaced with the system for secure transmission.

It is possible to have several Alden devices performing separate missions, e. g., as communication devices, sonar devices, and graphic devices, and yet be similar in configuration. Maintenance and repair can be completed by means of cannibalization if necessary. The similarity of the equipments allows for an easier learning process for the operator.

The following is a listing of some current Alden equipments:

- Alden 2: Prints out copy 2 inches wide by any length at a rate of 36 inches per minute using a 10KC FM broadcast line.

- Alden 4: Transmitter and receiver with in-house telephones and intercom system. Prints out copy 3.5 inches wide by any length at the rate of 3.5 inches per minute.
- Alden 5: Prints out copy 5 inches wide by any length used over a standard telephone network with an output of 6.25 inches per minute. Over a 10KC FM broadcast line, the Alden 5 can print out at a rate of 18.75 inches per minute.
- 11 Alspeed: Offers four separate speeds (120, 240, 480, and 960 RPM) matching the message load to the line available (3KC, 10KC, 15KC). This system offers dual resolution (96 and 166 LPI) and will print out 1.25, 2.5, 5, and 10 inches per minute on an 11-inch-wide format.
- 18 Alpurfax: Operates over voice grade telephone lines producing copy 18 inches wide by any length at an output rate of 1.25 inches per minute.

A recently developed system has incorporated both the Alden facsimile equipment and Eastman Kodak's Miracode indexing of microfilm (ED50009 and ED50016). Currently being used by the Army Materiel Command on their helicopter repair ships, the system utilizes microfilm storage and facsimile transmission. Literature stored in microfilm cartridges in a centralized file is retrieved by telephone dialing and relayed to the user. When the document is dialed, it appears on a viewer screen, which is scanned, and the facsimile is placed on magnetic tape. The facsimile tape is then used to transmit the picture over the telephone circuits.

(c) Xerox Corporation

LDX (Long Distance Xerography) is a system devised by the Xerox Corporation that provides transmission of written and graphic material. The system marries the xerographic process to broadband transmission and essentially consists of three parts: a scanner, a transmission link, and a printer.

The system is restricted to usage of 48KC and 240KC channels, capable of transmitting hard copy 8-1/2 inches wide by any length. Scan rates are either 135 or 190 lines per inch and the corresponding transmission rates for both grades of resolution are noted in Exhibit B-4.

Items of interest concerning the LDX System include:

- An 8-1/2- by 11-inch copy costs 4 cents. Copies can be sent over ordinary channels, satellite, microwave, etc., with the exception of voice grade lines.
- Six-point type is the smallest that can be transmitted and received with good resolution.
- The Xerox Corporation is presently experimenting with an LDX computer adaptor that allows remote input/output scanning of graphics. The adaptor is compatible with most System 360 CPU's.
- There are 1,024 bits per 8-1/2-inch scan line, with approximately 131 scan lines per inch. An ordinary 8-1/2- by 11-inch sheet of paper has 131 x 11 x 1,024 bits or 1.5 bits x 10^6 bits of data to be transmitted.
- The computer is dedicated while the graphic is being transmitted.
- LDX can be adapted to provide secure communications techniques.
- Front-access equipments are utilized.

Xerox markets Magnavox's Telecopier, which is based on a stylus impact principle, scanning 96 lines per inch, transmitting the data over ordinary voice grade lines. It delivers an 8-1/2- by 11-inch copy in various shades of gray in 6 minutes.

(2) Equipment Characteristics Table

(See following pages.)

Scan Rate (Lines Per Inch)	Number of Documents Per Minute (With Transmission Rate of)	
	48KC	240KC
135	1.7	8.7
190	0.9	4.3

Addressograph Multigraph	Electrostatic	Voice	1 Minute
Alden Electronics	Electrolytic Paper	Voice	6 Minutes
		Conditioned 3KC	4 Minutes
		Telpak	30 Seconds
		Conditioned 3KC	4 Minutes
		Telpak	1 Minute or 30 Seconds
A. B. Dick	Electrostatic	Telpak or Microwave	6 Seconds
Dictaphone	Electrolytic Paper	Voice	6 Minutes
		Conditioned 3KC	3 Minutes
		Telpak	1 Minute
Litton Industries (Westrex Division)	Photographic Pressure Sensitive or Electrolytic Paper	Voice	6 Minutes
		Telpak	2 Minutes
Stewart-Warner	Electrolytic Paper	Voice	6 Minutes
		Conditioned 3KC	2 Minutes
		Telpak	1 Minute
Telautograph (Hogan Laboratories)	Electrolytic Paper	Voice	6 Minutes
		Telpak	2 Minutes or 1 Minute
Western Union	"Teledeltos" Electrosensitive Paper	Voice	6 Minutes
Xerox	Xerography	Telpak	6 Seconds
	Pressure Sensitive	Voice	6 Minutes

(1) Selected Vendors

(a) Bryant Computer Products

Bryant Computer Products is the largest independent supplier of magnetic drums and disk files. They specialize in the design and production of random access memory systems for general or auxiliary storage.

The Auto-Lift Drum line consists of four series, the 185000, the 75000, the 10000, and the 5000. The smallest drum, the series 5000, is 12 inches high, and has a rotor of 5 inches in diameter with standard rotational speeds from 3,600 or 12,000 rpm. It has a data storage capacity on its largest model of 4.3×10^6 bits and an average access time as low as 8.35 milliseconds.

Each drum is a head-per-track, i.e., the read/write heads are fixed in position and are capable of recording or retrieving a single track of digital data from the rotating drum surface. The "flying" head principle is used and the heads never come in contact with the drum or disk surface in Bryant products. All Bryant products feature the noncontact start-stop principle for maximum life and reliability.

The "PhD" drum line provides random access storage with simultaneous read/write access through four independently positionable channels. The PhD 340 currently has the largest storage capacity with 340×10^6 bits, and its recording surface is 20 inches with a maximum access time of 50 milliseconds.

The Series 4000 disk files have disk diameter of 39 inches, and are available with data storage capacity of a maximum 3.8×10^9 bits with 50 data storage disk surfaces and 300 general data storage heads and an average access time of 90 milliseconds.

Bryant believes that shipboard systems utilizing currently available disk files are not yet practical. The problems of this environment can be solved but will require special designs or modification. Large drums are inherently more stable, and there would be less difficulty in making them shipboard operational. Bryant's small drums are currently used in the Polaris submarines and in the Navy E2A (Hawkeye) Program with very good operating results, even though they were not necessarily designed for such rugged service.

(b) Burroughs Corporation

Burroughs has a line of high performance disk files that has been expanded to 15 models. Each subsystem is available in economical increments. They range from systems memory files with an average access time of 17 milliseconds with capacities of 1 to 4 million bytes to massive bulk storage devices with capacities ranging in billions of characters. Combinations of two or more different disk file subsystems are available with almost all Burroughs computers. The slowest average access time of any of these 15 disk file models is 60 milliseconds, significantly faster than the fastest moving arm files.

System memory units are small, fast storage units designed as an extension of main memory. Control programs, operating software and program libraries are stored in systems memory and may be accessed when needed. Additional systems memory capacity may be used for records and data. Average access time is 17 milliseconds.

Modular random storage units are high-speed subsystems designed to handle medium-size, high-activity files. In addition, a modular random storage subsystem may perform all of the functions of the systems memory disks. Average access times are 20 and 23 milliseconds.

Data memory bank subsystems are characterized by low cost, high performance, and large capacity, and they are designed to handle high volumes of information storage. Data memory banks, which feature large initial increments, may be expanded in smaller increments at a continued low cost. Average access times are 20, 23, 40, and 60 milliseconds.

(c) CDC (Control Data Corporation)

Control Data bulk storage equipment is disk storage, such as the 853 and 854 disk files used with their 3,000 series computers and the 6638 disk files used for their 6,000 series equipments.

Control Data 852, 853, and 854 Disk Storage Drives combine the features of magnetic tape and magnetic disk recording: unlimited shelf storage and fast random access. This is made possible by CDC Model 850 disk packs, which are fully enclosed for protection against dust and damage during both storage and recording. The selected pack is inserted on-line in an 852, 853, or 854 drive. Data are recorded or updated on it, and then are stored indefinitely like a magnetic tape reel. The data recorded on any 852, 853, or 854 are readily available for reading on any drive unit with the same model number. The 852 also provides compatibility with any IBM Model 1311 disk storage drive.

The 852, 853, and 854 all have direct seek capabilities; the last address used is retained by the disk storage drive and made available to the controller to determine the distance and direction of the next head movement. Then the speed with which the heads are moved is made proportional to the number of tracks that must be traversed to reach the new location. All this provides considerably faster access times than the older return-to-home method.

In addition, seek-overlap, a standard feature on all these models, permits any or all idle drive units in a computer system to seek new addresses while one unit is reading or writing. The 853 and 854 models also provide latency-overlap, which enables the controller to select the first drive unit on which a desired sector address will be available.

(d) Data Disc, Inc.

Data Disc, Inc. specializes in the production of random-access disk memory systems using in-contact read/write heads. The disk uses a head/track to reduce the access time and the in-contact recording to give higher packing. Currently, Data Disc is developing a smaller head size to permit still higher packing density. It is their belief that by using in-contact recording, up to 1 billion bits of data can be placed on a 24-inch disk.

As well as reducing the size of the heads, Data Disc is finding that less expensive metals can be used in the disks to reduce the cost and thus allow more heads per disk and faster access at a reduced cost. Since in-contact recording is used, Data Disc believes that their disk system can be packaged small enough and stable enough to be used aboard ship.

Another product is the M Video Disc Recorder, which stores one video frame on each of 262 frames per disk. The movable magnetic head can be positioned to display or change any frame in an average time of one-third second. The technique of making contact without causing significant wear is a proprietary development of Data Disc, Inc. The Model M-4 Movable Head Interchangeable Disc Memory System features the following:

- Single movable head
- Low cost per on-line bit
- High single disk capacity--4 million bits per surface
- Broad flexibility--interfaces with any digital computer synchronous or asynchronous I/O; any fixed or variable record length

- High reliability--10,000 hours of operation guaranteed
- No routine maintenance
- No elaborate disk handling procedures

The Model F-6 Fixed Head Disk Memory System features:

- One head per track, 32 heads per surface, 64 heads per disk
- Low cost per on-line bit
- High single disk capacity--6,000 bits
- Broad flexibility--straightforward interface with any computer; synchronous or asynchronous I/O; any fixed or variable record length
- High reliability--10,000 hours of operation guaranteed
- No routine maintenance
- Compact and lightweight

The Model M-6 Interchangeable Disk Memory System features:

- Higher density through in-contact recording
- 13 million bits per disk storage capacity
- Interchangeable disks in protective cartridges
- Cartridge write-lockout safety feature
- Variable format under computer control
- High reliability--1-year guarantee

(e) General Electric

In the GE DSU 150 Removable Disk Storage Unit, each disk stores 7,864,320 6-bit characters, transferring data at 281,000 characters per second. The average positioning time is 70 milliseconds, with an average latency time of 25 milliseconds. A single controller controls up to 8 disk drives. Data is recorded on 16-inch metallic disks enclosed in an easy-to-handle carrying case. Disks are mounted vertically, and thus are easily changeable.

Model DSU 204 Disk Storage Unit permits the expansion of storage capacity as needed; one may start with as few as 4 disks and expand to 16. Four disks may have read/write heads fixed over the disk to provide a 26 millisecond access to high priority data. The 1,024-character buffer is addressable on a character basis.

The disk storage unit contains 23.5 million 6-bit characters. Up to four files may be connected to one controller, storing 94 million characters. There can be up to 16 disks and 16 positioning arms per file unit, and up to 32 240-character records may be read or written with one command from the central processor. Each character transferred from the buffer to the disk is checked for parity. Average transfer rate to the central processor is 62,500 characters per second. Arms can move from one read/write position to another in an average of 199 milliseconds.

The DSU 250 provides simultaneous access with limited interference to a data storage in excess of 800 million characters. Modularity permits adding storage in increments of 50 million characters. There are 32 disks per unit, with 16 independent positioning arms. Four 32-disk units may be connected to one controller. The processor communicates with the controller through one to four processor I/O channels. Four channels may be used for four processor I/O channels. Four channels also may be used for four simultaneous read/write operations, attaining an effective character transfer rate of 980 KC. The single channel transfer rate is 300 KC. In a random positioning environment, the arms attain position in an average of 90 milliseconds.

The MDS 200 Magnetic Drum Storage is a large magnetic drum available for program and data storage. The drum stores 4.7 million characters for the GE-400 and GE-600 Systems. Transfer rate is 370,000 6-bit characters per second, with dual channels available for access by two processors. Average access time to any data is 17 milliseconds.

The MDS 300 drum provides a large capacity, and high throughput auxiliary storage for programs and data. Single drum capacity is 6 million characters, with expansion to an additional 6-million character drum as an option. Transfer rate is 370,000 6-bit characters per second, with dual channels available for access by two processors. Average access time to any data is 8. 5 milliseconds.

(f) EDP Division of Honeywell

Honeywell's Mass Memory File is a random access, mass storage facility consisting of three transports and a general-purpose control unit. The three transport types constitute a broad range of capacities, and include the most up-to-date design features.

Mass Memory File transports write data onto, and read data from, tape strips. Each tape strip contains a series of recording tracks in which data are organized, or formatted, according to parameters established by the user. A pack of 512 uniquely notched strips is used during transport operation. When stored off-line, a pack is locked in a lightweight, dust-proof cartridge.

A single program command controls the selection of a strip containing a specified data location. Once a strip has been selected, an accelerator bar moves it down a raceway and onto a read/write drum. Data transfer to or from a specified location is directed by a search and data transfer command. When data transfer has been completed, the strip is released from the drum, passed on to a decelerating capstan, and returned to the pack. Strips travel from station to station under their own momentum on a smooth, aircushioned raceway.

On-line data storage capacities for the three transports are (Type 251) 15 million characters; (Type 252) 63 million characters, and (Type 253) 317 million characters. Up to eight transports in any combination can be connected to a single control unit (Type 250), and thus a single control unit's on-line storage may amount to over 2 billion characters. On-line storage can be changed simply by exchanging tape packs on the transport with those kept off-line.

The Type 251 transport accesses any on-line data record in an average time of 95 milliseconds, Type 252 in 150 milliseconds, and Type 253 in 225 milliseconds. These access times, plus a high data transfer rate, provide rapid transaction handling. Type 251, for example, can access, read, and write a 900-character record in 115.7 milliseconds, or 132.4 milliseconds if a write check is included.

Air pressure is used to control and lubricate all tape strip manipulations. Pinch rollers, often the cause of data destruction and surface wear, are not used; the data side of tape strips comes in direct contact only with the read/write heads. Moreover, the notches on Honeywell tape strips do not touch the read/write drum or decelerating capstan; thus, notch wear and damage, and the resulting costs and errors, are virtually eliminated. Tape strip data are also protected from unintentional alteration by program through the use of three of programmer-designated file safeguards.

The Honeywell Type 270 Random Access Drum Storage and Control provides an efficient, random access data storage medium. The drum subsystem achieves a fine combination of high-speed access to large quantities of stored data and low storage cost per unit of information.

One to eight drum files can be connected to a control unit to operate on-line in a Honeywell Series 200 system. The storage capacity of each drum is 20,480 records of 128 6-bit characters each, or 2,621,440 characters. Thus, a single control/drum subsystem can have a total capacity of over 20 million characters.

Program control of drum operations is maintained by use of two instructions: search-and-write and search-and-read. Both instructions can handle variable as well as fixed-length records.

A drum rotation speed of 1,200 rpm, coupled with the use of 512 read/write heads, provides access to a specified drum record in an average of 27.5 milliseconds. Data transfer to and from the drum takes place at an average rate of 102,000 characters per second.

One memory cycle of central processor time is required for data transfer between the drum control and main memory. Therefore, the proportion of a data transfer interval available for other central processor operations varies from 69.6 percent for a Model 120 processor to 92.4 percent for a Model 4200.

The drum control automatically generates a parity bit for each character to be written. The parity bits accompany the record onto the drum. An automatic character-parity check is performed while reading; any discrepancy results in the setting of a program-accessible indicator. A file protection feature prevents the accidental programmed alteration of data encoded on any programmer-assigned group of 64 data tracks. As many as eight groups of tracks may be individually protected.

(g) IBM (International Business Machines)

The 2311 Disk Storage Drive can store up to 7,250,000 bytes or 14,500,000 packed digits on 1316 Disk Packs. The interchangeable 1316's provide large off-line data storage capabilities as follows:

- Average access time is 75 msec; maximum is 135 msec
- The comb-type access mechanism, with 10 vertically aligned heads (one for each disk surface), minimizes

access time and increases throughput. Up to 36,250 bytes (72,500 packed digits) are available at one setting of the mechanism.

- The instruction format allows transfers of multiple records to or from disk storage with one instruction. The reading/writing rate of up to 156,000 bytes per second (312,000 packed decimal digits) permits efficient sequential and random access processing.
- Up to eight 2311 Disk Storage Drives can be attached to the 2841 Storage Control unit for a total of 58,000,000 bytes or 116,000,000 packed digits of on-line direct access storage.

Each 2314 Direct Access Storage Facility can store up to 207,014,400 bytes or 414,028,800 packed digits on eight removable 2316 Disk Packs. A single unit, the 2314, provides its own controls and has eight independent storage drives. Nearly 10 billion bytes can be on-line at one time. Eight 2314's can be attached to each of six selector channels on the System/360 Models 65 and 75. The 2314 is also utilized with System/360 Models 30, 40, and 50. Specific features include:

- Average access time is 75ms; maximum is 135ms.
- Each drive operates mechanically and electronically independent of the others.
- The cylinder concept, retained by the 2314, permits multiple records to be read and written by a sequence of channel commands without any rotational delay between records.
- Data is recorded on 20 disk surfaces on each of the eight 2316 Disk Packs.
- 2314's may be attached directly to any selector channel on System/360 Models 50, 65, and 75; to channel 1 only on Models 30 and 40.

- A ninth drive within the 2314 provides a backup capability to be used during preventive or emergency maintenance.

The 2321 Data Cell Drive, Model I, provides an economic solution to the storage of extremely large sequentially organized data files requiring random reference. Specific features include:

- A capacity of 400 million bytes or 800 million packed digits. Ten data cells, each with a capacity of 40 million bytes, are housed in each data cell drive. A data cell has 20 subcells, each with 10 magnetic tape strips. During data record reading and writing operations, a magnetic tape strip is selected, controlled through the reference cycle, and returned to its subcell.
- Up to eight 2321's may be attached to a single 2841 Storage Control unit for a total direct access capability of over 3 billion bytes. Each of the 10 data cells is removable and interchangeable so that off-line storage capacity is virtually unlimited.
- Sequential reading/writing rate is 55,000 bytes or 110,000 packed digits per second with an access time from 175 to 600ms.

Model 2301 Drum provides high-speed-response intermediate data storage. Specific features include:

- Average drum latency to any record is 8.6msecs.
- Storage capacity is 4,090,000 bytes or 8,180,000 packed digits.
- Attaches to the IBM 2820 Storage Control. Functional operation of the 2820 is similar to that of the 2841 Storage Control unit, except that the 2820 enables the 2301 Drum Storage to transfer data in parallel, 4 bits

at a time. The 2820 then transfers the data to the channel at the rate of 1.2 million bytes per second.

- Each 2820 handles up to four 2301 Drum Storage units.

The 2303 Drum is similar to the 2301 in rotational speed and capacity, with data read serially from a single track instead of four tracks in parallel. Its features include:

- Data storage on the surface of the drum in 800 tracks that are accessed in an average of 8.6ms.
- Each track records 4,892 bytes, providing a drum capacity of 2.91M bytes.

(h) Librascope Group of General Precision, Inc.

LIBRAFILE 3800 mass memories are large-capacity, high-speed, random-access information storage systems that can be used with any data processing system, whether already in use or scheduled to be installed in the near future. The LIBRAFILE 3800 mass memory features a "flying-head per track." The read/write heads are mounted on plates interleaved between the discs. They ride on a 0.0001-inch cushion of air when the discs rotate. The number of heads used depends on the total bit-storage requirements of the particular application.

The LIBRAFILE 4800 mass memories are large-capacity, high-speed, random-access information storage systems. A LIBRAFILE 4800 mass memory consists of two principal elements: (1) a mass-memory unit to provide data storage, and (2) a controller unit that provides necessary interface, control, and read/write electronics.

The technique of information retrieval is either fixed-address search or search-by-record content, depending on the master-control electronics used. Average access time is 35 milliseconds. Search-by-record content is an exclusive General

Precision/Librascope technique that permits any desired field to be used as the access key. Thus, it is not necessary to know where the data is stored, but only what is desired. This obviates the need for a costly flagging and table-look-up program, conserves space in the central processing unit's mainframe memory, and permits simultaneous off-line search.

Librascope Disc-Memory Systems are a family of high-speed, random-access, magnetic disc memories, available in military and industrial versions. They include small-capacity and medium-capacity models:

- Series L100, inexpensive memories with capacities to 300,000 bits.
- Series L200, low-cost, high-performance memories with capacities to 2 million bits.
- Series L400, versatile, high-performance memories with capacities to 50 million bits.

(i) Magne-Head

All Magne-Head drums in the small- to medium-size D50 Series share basic design criteria and provide fine performance in terms of bits per square inch of recording surface, higher output signal levels, and long-term, maintenance-free operation. To the systems designer, this means fewer interface restrictions when integrating the memory subsystem into his total system.

The D5000 Bulk Storage Magnetic Memory Drum employs a new technique of modular section construction that permits the stacking of sections to expand bulk storage capacity. Each modular section has a total memory capacity of 20,000,000 bits, and four sections can be stacked to expand total bulk storage memory to as many as 80,000,000 bits. Each individual section incorporates all of the design features of Magne-Head's D50 and D500 Series of Magnetic Memory Drums.

The modular section drum is well designed for computers built for bulk storage memory and for computers whose total memory varies as a function of application, e. g., process control and inventory control. In applications of this nature, where total bulk storage capacity is an unknown or varying factor, the modular section technique of stacking eliminates the necessity of specifying a special drum for each size of memory and the need for anticipating the optimum memory requirement of the application.

(j) NCR (National Cash Register)

CRAM (Card Random Access Memory) is a relatively new random access device. It is a substantial breakthrough in the external storage of data for high-speed electronic processing. It opens up some new processing techniques pointed toward economy and efficiency in magnetic file operations. CRAM retains certain features of the standard external memory devices that have proven to be successful. Since the introduction of electronics to business recordkeeping, magnetic tapes, disks, and drums have been the most widely used forms of external memory. CRAM has been designed to incorporate the advantages of these other types of memory, and at the same time, it attempts to eliminate many of their disadvantages.

Some of its specifications include:

- Its recording media are Mylar magnetic cards, 14 inches long and 3-1/4 inches wide.
- The recording capacity per magnetic card is 21,700 alphanumeric characters.
- There are seven recording tracks per card.
- The recording capacity per track is 3,100 alphanumeric characters.
- A deck of 256 cards is on-line in a single unit.

- The recording capacity of 256 magnetic cards is 5,555,200 alphanumeric characters.
- The time required to change decks of magnetic cards is approximately 30 seconds.
- The number of off-line decks per CRAM is unlimited.
- Up to 16 CRAM units may be attached on-line in a single system.
- The data transfer rate is 100,000 alphanumeric characters per second.

(k) RCA (Radio Corporation of America)

One of the most promising techniques in storing large quantities of information, both digital and graphic, seems to be the utilization of hologram memories. The holograms are prepared via use of laser beams, and by recording these images on film. RCA is currently utilizing RACE (Random Access Card Equipment) to test this technique, and has been able to achieve 160:1 reduction of standard 8-1/2- by 11-inch paper. This amounts to storing 256 documents on one RACE card. One of the advantages of using the holographic process is that wear and poor quality do not destroy the image. This may be demonstrated by passing the RACE card consisting of the holograms through the RACE machine; this results in scratching the surface of the film, but not destroying the holograms.

The Model 70/564 Disk Storage Unit provides random-access storage for 7.25 million bytes of information on an interchangeable disk pack. The operation of this device is controlled by the Model 70/551 Random Access Controller, and up to 16 units may be attached to one controller.

The disk storage unit consists of 203 tracks per read/write head and has 10 heads providing a total disk-pack capacity of 2,030 tracks. With a packing density of 1,100 bits per inch, each track contains 3,660 bytes producing a total information capacity of 7.25 million bytes per disk pack.

The disk pack is removable and interchangeable. Interchangeability denotes the capability of any disk-storage unit to read disk-pack information previously written by any other disk storage unit. The disk pack weighs about 10 pounds and can be changed in less than one minute.

Data is transferred between the central processor and the disk pack at the rate of 156,000 bytes per second. The track-to-track access is 30 milliseconds. The average seek time is 85 milliseconds with a maximum of 145 milliseconds. Since the disks rotate at 2,400 rpm, there is an average latency of 12. 5 milliseconds. All accuracy control and data validity checking for the disk storage unit are performed in conjunction with the Model 70/551 Random Access Controller.

The drum memory unit consists of a magnetic data drum and associated control electronics. Two models of the drum are available. The 70/565-12 holds 800,000 bytes and consists of 256 tracks on eight cylinders (each cylinder contains 32 tracks). A packing density of 570 bits per inch provides a track-storage capacity of 3,098 bytes per track. The drum has individual read/write heads, making each track individually addressable. A drum speed of 3,600 rpm produces an average access time of 8.6 milliseconds. Data is transferred at approximately 210,000 bytes per second. Operation of the device is controlled by the Model 70/551 Random Access Controller. All accuracy-control and data-validity checking for this device is performed in conjunction with the Model 70/551 Random Access Controller.

The Model 70/568 Mass Storage Unit consists of a mass storage, retrieval unit, and associated control electronics. The operation of this device is controlled by the Model 70/551 Random Access Controller. The Model 70/568-1 consists of from one to eight removable magazines. The Model 70/568-2 Expansion Assembly can be added to the mass storage unit to increase the magazine capacity to 16. The mass-storage unit and the expansion assembly are serviced by one read/write station. Up to 8 read/write stations may be attached to a Model 70/551 Random Access Controller, providing multibillion byte-storage capacity in the millisecond access range.

The basic storage element of this mass memory unit is a 16- by 4-1/2-inch magnetic card. Data are recorded on one side of the card only. Each Model 70/568 card contains 128 separately addressable tracks of 1,090 bytes each. There are 256 cards housed in each magazine.

A card is removed from a magazine and enters a raceway over which it is transported to a read/write station (revolving capstan). At the read/write station the card passes beneath a set of eight read/write heads where data are either read or recorded. The read/write station includes a gate that controls the recirculation or return of the card to its associated magazine. All accuracy control and data validity checking for this unit is performed in conjunction with the Model 70/551 Random Access Controller.

(l) VRC (Vermont Research Corporation)

The design goal leading to the development of VRC high density drums was a medium-to-large random access memory device with inherent reliability, economy, and fast access time. Since VRC felt that reliability in magnetic storage begins with noncontract recording, the large drum with its advantage of design simplicity, was their logical choice. Magnetic heads are also inherently simple devices that lend themselves to production techniques giving uniform performance and cost economy. Hydrodynamic bearings, using the boundary layer of air on the drum, are applied to space the heads uniformly close to the recording medium. The resulting combination provides only one moving part, the drum itself.

Vermont Research Corporation has applied these principles in development work in which "flying heads" were used to record at frequencies of over 7 megacycles at recording densities of more than 1,000 pulses per inch.

Attention was directed to eliminating head/surface contact at speeds below that required to provide hydrodynamic support. This was accomplished with a spring steel flexure-pivot for head/bearing mounting, and a mechanical actuator to move the head to and from the recording position.

Well engineered, simply designed components, combined with a means of eliminating contact at low speeds, have yielded a fast, reliable, economical memory. The magnetic head supporting method facilitates use of high density recording techniques, providing both a large store per tract and efficient use of the total recording area.

(m) UNIVAC

The Flying Head-880 Magnetic Drum Subsystem is a large-capacity, high-speed random access storage device used for program storage, temporary data storage, or file storage. The magnetic drum units used in the Flying Head-880 Magnetic Drum Subsystem differ from conventional drum units in that the read/write heads float on a boundary layer of air created by the drum's rotation. Since the boundary is extremely thin (less than 0.0005 inch), the head-to-surface distance is reduced and the read/write heads follow the contours of the drum in precise manner. This feature permits a greater recording density, since it eliminates the disadvantages of the wider head-to-surface distance required in conventional drum units to compensate for surface irregularities. All read operations are parity checked. All search operations may be conducted off line; that is, once the search instruction is received by the drum synchronizer control unit, the central processor is free for other functions until the search is completed.

The FASTRAND Mass Storage subsystem is a very large capacity, random access mass storage device. As many as eight FASTRAND Mass Storage Units may be connected to any available input/output channel. Each FASTRAND Mass Storage Unit in the subsystem contains two magnetic drums. These drums are similar to those used in the Flying-Head-880 Magnetic Drum Subsystem in that they employ flying read/write heads; however, these drums have an additional feature, the ability to laterally position the read/write heads.

On each drum there are 3,072 recording tracks, each of which can store 2,112 30-bit computer words; that is, 6,488,054 computer words can be stored on one drum. Since there are two drums in a FASTRAND Mass Storage Unit, the total storage capacity is 12,976,128 computer words per unit, or approximately 65 million characters. The total words of storage per available channel is approximately 104 million; the total characters, 520 million.

Among the valuable features of the FASTRAND system is a unique search function. The search may be initiated to search on the first word of each sector, or it may be initiated to search all words of the sectors involved. When a find is made, the search function automatically converts into a read operation as specified by instruction. In the process of searching, the operation may be limited to search through as few as 64 sectors, or to search through as many as 4,096 sectors. This variable search length feature is under program control.

All functions of the FASTRAND are buffered from the central processor so that the computer may continue processing while records are being accessed on the FASTRAND unit. All read operations are parity checked.

(2) Equipment Characteristics Tables

(See following pages.)

External Storage Systems: Positionable-Head Devices

Manufacturer	Model	Capacity (Millionbits)	Arc Positioning Time (Millisecs)	Half-Latency Time (Millisecs)	Storage Element	Number of Cylinders	Tracks Per Cylinder	Density (Bits/Inch)
Applied Magnetics	MCM-2	90.0	90	30	64 Cards	64	128	800
Bryant	PhD 170	170	38	17	Drum	64	43	1,000
Bryant	4000	3,800	92	25	26 Disks	256	300	800
Control Data	852	14.0	70	20	5 Disks	100	10	988
Control Data	853	24.6	70	13	5 Disks	100	[illegible]	1,105
Control Data	854	49.2	70	13	5 Disks	200	10	1,105
Data Disc	M6	6.5	315	25	Disk	130	1	3,000
Data Products	5022/5/6	225	205	25	16 Disks	64	128	600
Data Products	5045	765	115	25	32 Disks	64	256	1,000
General Electric	DSU150	7.8	70	25	16 Disks	--	--	--
General Electric	DSU204	141	199	--	Disks	--	--	--
General Electric	DSU250	800	90	--	32 Disks	--	--	--
Honeywell EDP	258	27.5	85	13	5 Disks	100	10	1,105
Honeywell EDP	256/259/A	55.0	85	13	5 Disks	203	10	1,105
Honeywell EDP	261	900	70	26	36 Disks	256	64	--
Honeywell EDP	262	1,800	70	26	72 Disks	256	128	--
IBM	1311	12.0	150	21	Disks	100	10	--
IBM	2311	60.0	75	13	6 Disks	200	10	--
IBM	1301	168	165	17	Disks	250	40	--
IBM	2316	200	75	13	11 Disks	200	18	--
IBM	1302	702	165	17	Disks	500	40	--
IBM	2302	896	165	17	25 Disks	500	45	--
IBM	2321	3,200	450	25	2000 Strips	2,000	100	--

External Storage Systems: Positionable-Head Devices (Continued)

Manufacturer	Model	Capacity (Millionbits)	Arc Positioning Time (Millisecs)	Half-Latency Time (Millisecs)	Storage Element	Number of Cylinders	Tracks Per Cylinder	Density (Bits/Inch)
NCR (CRAM)	EM-H1	33.6	235	--	256 Cards	256	55	260
NCR (CRAM)	EM-H2	48.0	235	--	128 Cards	128	56	700
NCR (CRAM)	EM-H3	96.0	--	--	256 Cards	256	56	700
NCR (CRAM)	353-5	496	166	--	384 Cards	384	--	--
Optimized Devices	MD-9	0.036	25	25	Disk	9	1	200
Potter Instrument (RAM)	TLM-4550	50.2	71	25	16 Loops	28	64	1,020
RCA	70/564	60.0	85	13	5 Disks	200	10	1,100
RCA	70/568	4,300	447	30	2048 Cards	2,048	128	1,400
UNIVAC	Fastrand 1	3,892	92	17	Drum	96	64	1,000
UNIVAC	Fastrand 2	7,784	92	17	Drum	192	64	1,000

External Storage Systems: Head-Per-Tract Devices, Disk

Manufacturer	Model	Capacity (Millionbits)	Access Time (Millisecs)	Number of Tracks	Density (Bits/Inch)	Storage Element
Applied Magnetics	MDM-12-1	4.2	17.0	128	1,000	Disk
Applied Magnetics	MDM-12-4	16.9	17.0	512	1,000	4 Disks
Applied Magnetics	MDM-12-2	8.5	17.0	256	1,000	2 Disks
Burroughs	BC475	60.0	20.0	1,200	1,100	4 Disks
Burroughs	BC475-1A	102.0	40.0	1,200	1,550	4 Disks
Burroughs	BC475-1B	120.0	40.0	1,200	2,275	4 Disks
Burroughs	BC475-1C	200.0	40.0	1,200	3,500	4 Disks
Data Disc	F.75	0.80	16.7	8	3,330	Disk
Data Disc	F1.5	1.6	16.7	16	3,330	Disk
Data Disc	F3	3.2	16.9	32	3,330	Disk
Data Disc	F6	6.4	16.7	64	3,330	Disk
Librascope	L321-8	0.34	8.3	45	500	Disk
Librascope	L322-8	0.67	8.3	90	500	Disk
Librascope	L110-8	1.2	8.3	72	1,000	Disk
Librascope	L207-4	1.3	3.3	132	1,000	Disk
Librascope	L210-8	2.4	8.3	144	1,000	Disk
Librascope	L116	6.0	8.3	128	1,500	Disk
Librascope	L216	12.0	8.3	256	1,500	Disk
Librascope	L124	16.4	16.7	256	1,500	Disk
Librascope	L316	18.0	8.3	384	1,500	Disk
Librascope	L416	24.1	8.3	512	1,500	Disk

External Storage Systems: Head-Per-Tract Devices, Disk (Continued)

Manufacturer	Model	Capacity (Millionbits)	Access Time (Millisecs)	Number of Tracks	Density (Bits/Inch)	Storage Element
Librascope	L224	32.7	16.7	512	1,500	Disk
Librascope	L324	49.2	16.7	768	1,500	Disk
Librascope	L424	65.5	16.7	1,024	1,500	Disk
Librascope	L238	100.4	33.3	1,024	1,300	Disk
Librascope	L438	200.7	33.3	2,048	1,300	Disk
Magnehead	71.64	0.50	8.5	64	532	Disk
Magnehead	71-128	0.70	8.5	128	500	Disk
Magnehead	91-64	0.70	8.5	64	533	Disk
Magnehead	111-64	1.0	8.5	64	533	Disk
Magnehead	91-128	1.1	8.5	128	533	Disk
Magnehead	131-64	1.2	8.5	64	533	Disk
Magnehead	72-256	1.3	8.5	256	500	2 Disks
Magnehead	111-128	1.6	8.5	128	533	Disk
Magnehead	131-128	2.0	8.5	128	548	Disk
Magnehead	92-256	2.3	8.5	256	533	2 Disks
Magnehead	112-256	3.1	8.5	256	533	2 Disks
Magnehead	132-256	4.1	8.5	256	548	2 Disks
Magnehead	134-512	8.2	8.5	512	548	4 Disks
SDS	9366/67	3.1	17.5	--	--	Disk
SDS	RAD7202	6.0	17.0	128	--	Disk

External Storage Systems: Head-Per-Tract Devices, Disk (Continued)

Manufacturer	Model	Capacity (Millionbits)	Access Time (Millisecs)	Number of Tracks	Density (Bits/Inch)	Storage Element
SDS	RAD7203	12.0	17.0	256	--	Disk
SDS	9366/67	12.6	17.5	--	--	Disk
SDS	RAD7204	24.0	17.0	512	--	Disk
SDS	RAD7212	33.6	17.5	512	--	Disk

External Storage Systems: Head-Per-Track Devices, Drum

Manufacturer	Model	Capacity (Millionbits)	Access Time (Millisecs)	Number of Tracks	Density (Bits/Inch)
Bryant	5064	1.1	2.5	90	800
Bryant	75064	1.7	5.0	90	800
Bryant	5128	2.0	2.5	156	800
Bryant	75128	2.9	6.7	156	800
Bryant	5256	3.6	3.8	288	800
Bryant	10128	3.9	6.7	156	800
Bryant	75256	5.4	6.7	288	800
Bryant	10256	7.2	8.4	288	800
Bryant	10384	11.0	8.4	440	800
Bryant	185256	13.4	16.7	288	800
Bryant	10512	14.5	8.4	576	800
Bryant	185384	20.4	16.7	440	800
Bryant	185512	26.8	16.7	576	800
Bryant	1851021	47.6	16.7	1,024	800
Bryant	185128	7.2	8.35	156	800
General Electric	MDS200	4.7	17.0	--	--
General Electric	MDS300	6.0	8.5	--	--
Honeywell EDP	270 A1	15.7	26.5	512	560

External Storage Systems: Head-Per-Track Devices, Drum
(Continued)

Manufacturer	Model	Capacity (Millionbits)	Access Time (Millisecs)	Number of Tracks	Density (Bits/Inch)
Honeywell EDP	270 A2	31.5	26.5	512	560
Honeywell EDP	270 A3	47.2	26.5	512	560
IBM	7320	6.6	8.6	400	--
IBM	2303	31.3	8.6	800	--
IBM	2301	32.7	8.6	800	--
IBM	2314	160.0	8.6	200	--
Magnehead	S20M512	20.0	8.5	512	1,200
Magnehead	D 5000	20.0	8.5	--	1,200
Magnehead	560M1024	60.0	17.0	1,024	1,200
RCA	70/565-12	6.3	8.6	256	800
RCA	70/565-13	12.5	8.6	512	800
UNIVAC	FH330	4.7	8.5	256	--
UNIVAC	FH432	7.9	4.3	432	--
UNIVAC	FH880	28.3	8.5	768	--
Vermont Research	52	0.20	8.3	--	--
Vermont Research	104-S	2.6	3.7	128	--
Vermont Research	154	3.8	8.3	128	--

External Storage Systems: Head-Per-Track Devices, Drum
(Continued)

Manufacturer	Model	Capacity (Millionbits)	Access Time (Millisecs)	Number of Tracks	Density (Bits/Inch)
Vermont Research	108	5.1	8.3	256	--
Vermont Research	158	7.7	8.3	256	--
Vermont Research	116	10.2	8.3	512	--
Vermont Research	1116	12.5	8.5	512	800
Vermont Research	166	15.4	8.3	512	--
Vermont Research	216A	20.0	17.0	512	700
Vermont Research	132	20.5	8.3	1,024	--
Vermont Research	182	30.7	8.3	1,024	--
Vermont Research	232	41.0	8.3	1,024	--
Vermont Research	264B	102.0	17.3	2,048	--
Vermont Research	102A	--	--	64	--
Vermont Research	152A	--	--	64	--
Vermont Research	202A	--	--	64	--
Vermont Research	204A	--	--	128	--
Vermont Research	208A	--	--	256	--

b. Digital Magnetic Tape

(1) Selected Vendors

(a) Ampex

The Ampex Single Capstan Series provides electronic data processors with a wide range of reliable tape memories, maintaining transfer rates from 1 to 120 KC.

The Ampex Single Capstan Series offers a number of advantages. All units of the series are interface interchangeable with each other. They all write and read IBM compatible 7- or 9-track formats. Service requirements are similar for all units; replacements are readily available from one source.

Ampex tape memory systems offer an impressive set of performance characteristics:

- Decreased number of components and extreme mechanical simplicity result in reliability equal to or exceeding other computer equipment.
- Dropout errors are virtually eliminated because the oxide side of the tape is in sliding contact with minimal surfaces (read/write head and tape cleaner).
- Controlled-tension tape path, plus minimal number of strategically placed tape guides, results in greatly increased tape life and maximum tape protection.
- Positive control of start/stop cycles (with no shock transients as induced by pinch rollers, clutches, and vacuum capstan tape movement devices) results in tape memory programming and operation with no restrictions whatever.
- During rewind, tape is not removed from the vacuum chambers.
- Since Ampex DE-200 Data Electronics are used in all Single Capstan Systems, all units are changeable with

each other. This permits use of a combination of drives, or replacement to upgrade a system.

(b) CDC (Control Data Corporation)

The Control Data 600 Series Magnetic Tape Transports are available for 50- or 60-cycle power sources in a variety of tape speeds up to 150 inches per second and recording density up to 800 bits per inch. These transports provide fast, reliable storage and manipulation of digital information for computing and data processing systems. Maximum reliable operating time, simplicity in programming and control, extended tape life, and ease of maintenance are basic characteristics of the 600 series.

Some of the more interesting features of the series include:

- Some models have the capability to read in the reverse direction, greatly increasing the capacity of the data processing systems. The reverse read capability is limited to tapes prepared on the same installation.

- The 600 series features complete pneumatic control of the magnetic tape. Tape movement is determined by valving either a vacuum or a pressure to the two synchronously driven fluted capstans, which rotate continuously in opposite directions. A vacuum is used to hold the tape to the driving capstan while pressure in the nondriving capstan causes the tape to float over it on a cushion of air. The use of pneumatic capstans eliminates the need for pinch rollers or mechanical clutches and results in smooth uniform tape acceleration with a minimum of tape stress and stretch. The tape is braked smoothly and precisely by a pneumatic brake pad. Vacuum columns are used rather than mechanical tape arms to provide uniformly controlled tape tension. The vacuum column loops are photoelectrically sensed and the digital signals generated are used to control the DC shunt wound reel drive motors. Integrally mounted and direct coupled brakes complete the reel servo system. All other motors are the AC inductive type conservatively rated for maximum life.

- The head assembly consists of individual read and write heads, erase head, and pressure pad. The dual gap seven-channel head construction provides "read after write" capabilities as well as format compatibility with accepted industry standards. Head and tape wear is minimize by use of jets of air to maintain precise contact pressure between the tape and head gaps. The reliability of the recording is enhanced by the broad band erase head and by electronic skew compensation. The recording reliability is further improved by vacuum operated tape cleaners, which function during all read and write operations.

- The electronics of the 600 series are composed of solid-state computer building block modules that have been tested and proven in Control Data's computer systems. Included as an integral part of the 600 series circuits are complete read-write circuits, skew control, and local motion control. All incoming and outgoing data and control information is in digital form. These are designed for full computer control and require no programmed delays. Local control of off-line operations and tape load and unload procedures is provided by a bank of operator keys and status indicators. Tape changing is simplified by straight line threading and the use of leaderless tape, which requires only a single wrap on the take-up reel. Industry and system compatibility is maintained by use of 10-1/2 inch IBM-type reels and standard End of Tape and Beginning of Tape reflective spot sensing.

- High reliability and ease of maintenance were the prime design criteria in the development of these units. Quick maintenance by the replacement of major components is facilitated by the use of pluggable modules and subassemblies. Convenient access to all components is made possible by careful attention to their placement and by the use of snap-off skins and hinged panels.

In multiple unit installations, off-line maintenance is facilitated by the single-unit design philosophy, which eliminates shared components and composite cabinets. The independent construction permits each tape transport to be removed from the line for testing and maintenance without affecting operation of other units.

(c) Datamec

Lower initial cost, reduced maintenance expense, maximum up-time, and higher reliability are the design objectives D 2020 of the series of computer magnetic tape units from Datamec. The D 2020 series offers a variety of standard options in heads, data electronics, controls, and cabinetry designed to facilitate interfacing. All standard units are IBM compatible, using the 200-, 556-, and 800-characters-per-inch tape formats at 45-inches-per-second tape speed. Units operating at lower tape speeds, as well as two-speed units, also are supplied as standard configurations. To achieve added savings, D 2020 multi-tape systems incorporate solid-state electronic switching of data and control signals to the tape unit selected by the computer.

The D 2020 user is offered high performance dependability. These tape units are designed to meet rigorous demands: continuous operation by nontechnical personnel, continuous operation under command of automatic control, and continuous operation with minimum maintenance. The D 2020 features responsible for high reliability include vacuum column tape buffering, solid-state electronics, short unsupported tape spans, and vacuum tape cleaners in the head assemblies.

The unit is designed to operate at a tape speed of 45 ips, writing and reading tapes in the 200-, 556-, and 800-cpi IBM formats. The D 2020 offers extremely low initial hardware cost, and also provides high up-time and minimum maintenance requirements.

The D 2020 is an attractively priced unit for computer and off-line applications where moderate speed performance is practical. It readily becomes an integral part of any computer system, providing a transfer rate as high as 36,000 characters per second.

The D 3030 series of computer magnetic tape units has been engineered specifically for the major computer market and its medium speed requirements. The unit offers economy and reliability for heavy-duty, on-line use with digital computers and other digital EDP systems requiring higher data transfer rates.

D 3030 offers such features as:

- Reading and writing all three density formats (800, 556, and 200 characters per inch) at 75 inches-per-second tape speed. Data transfer rates are 60,000, 41,700, and 15,000 characters per second.
- Fast threading, making this job relatively effortless and nearly automatic. No special tape leaders are required. The rotary, positive stop, self-seating reel hold down makes loading/unloading extremely simple.
- Initial cost is lowest in the medium speed class, while maintenance expense, both routine and corrective, is well beyond old accepted minimums.

(d) DEC (Digital Electronics Corp.)

The DECtape system provides a fixed-address magnetic tape facility for program and data storage and retrieval. To achieve reliability, convenience, and low cost DECtape features the following:

- Fixed-position addressing to permit the selective reading or up-dating of information without the necessity of reading or rewriting the entire block.
- Automatic word transfers, via the PDP-9 data channel facility, to allow concurrent processing and data transfer.
- Bidirectional operation to allow reading, writing, and searching in either direction.
- Redundant phase recording to ensure transfer reliability, reduce the problem of skewing, and minimize bit dropouts.
- Prerecorded timing and mark tracks to simplify programming and permit block and word addressibility.
- Three-inch diameter tape reels, each holding 3,000,000 bits of information, recorded at 375 bpi and 80 ips.

The DECtape Control, Type TC02, controls up to eight DECtape transports, Type TU55. Binary information is transferred to and from the PDP-9 at the rate of one 18-bit word every 200 microseconds, using the data channel facility. Mode of operation, function, and direction of motion are controlled by status registers that can be loaded and read by the computer. More than one DECtape control can be interfaced to any PDP-9.

The DECtape Transport, Type TU55, provides bidirectional reading and writing of 3-inch-diameter DECtape reels. Each reel can hold 3 million bits of information (over 150,000 18-bit words) recorded at 375 bits per inch. Tape moves at 80 inches per second and requires no vacuum columns or capstans.

Magnetic Tape Systems PDP-9 offers both 7- and 9-channel IBM-compatible magnetic tape systems. Transports that operate at 45 inches per second and triple density are currently available.

The Automatic Magnetic Tape Control, Type TC59, transfers data to and from IBM-compatible transports via the data channel facility. Up to eight transports can be handled by a single control, and both BCD and binary modes are available. One TC59 control can handle both 7- and 9-channel transports at both 45 and 75 ips. Read/write functions, recording density, and tape manipulation functions are controlled by status registers that can be loaded and read by the PDP-9.

The Type TU20 Magnetic Tape Transport can read and write 7-channel IBM-compatible tapes at 45 inches per second and 200, 556, or 800 bits per inch. One 18-bit PDP-9 word is written as three tape characters on the Type TU20.

Its 9-channel counterpart, the Type TU20A Magnetic Tape Transport operates at the same speed and recording densities. In two-character mode, the TU20A reads or writes two 8-bit characters per 18-bit word (ignoring two bits), while in three-character mode it reads or writes three 6-bit characters (one PDP-9 word) as three 8-bit tape characters.

(e) EDP Division of Honeywell

Two complete families of magnetic tape units are provided by Honeywell for use in Series 200 systems:

- Units that process 1/2-inch tape provide: a) the standard means for storing 6-bit data; and b) IBM compatibility, including end-of-file mark recognition and the ability to translate between card images in IBM even-parity tape code and Series 200 processor code.
- Units that process 3/4-inch tape provide data compatibility with Honeywell 400/1400/800/1800 systems and, in addition, feature Honeywell's Orthotronic control technique for data checking and regeneration.

Programmed tape operations include the following:

- The 1/2-inch tape units read forward, write forward, backspace one record, space forward one record, rewind, rewind and release (not available with 24-inch-per-second tape units), and erase; also optionally available is a read reverse feature.
- The 3/4-inch tape units read forward, write forward, backspace one record, rewind, release, and regenerate tape channel.

Data transfer speeds range from 7,200 to 96,000 characters per second for units processing 1/2-inch tape, and from 32,000 to 88,000 characters per second for 3/4-inch units. The design of all Honeywell tape units incorporates the vacuum techniques that have earned a fine reputation for error-free operation. Vacuum control is used in mounting, driving, and stopping the tape so as to avoid any danger of damage; the reading surface of the tape has physical contact with the read/write head only. A write-enable ring and a manual tape unit switch guard information on tape from accidental destruction by an unintentional write operation.

(f) Kennedy

The D5370 is an incremental magnetic tape recorder that prepares standard computer tapes from input sources operating at random or nonstandard rates. It operates with uniform character density and all gaps and marks for full IBM compatibility. A constantly rotating capstan allows high-speed gap insertion or continuous read or write if required. Stop-at-a-time operation eliminates buffering. The step motor drive with magnetic detents produces accurate steps at high rates. Typical data input sources are typewriters, keyboards, teletype lines, digital voltmeters, and counters.

Continuous reading at 30 inches per second is featured by the DS370R. Equipped with a read-write head, file protect, and read electronics in a separate 7-inch card cage, the DS370R can also be furnished for any one of the speeds of 10, 15, or 20 ips. This unit will start and stop in a standard 3/4-inch gap.

The DS370IR (Incremental Read) adds the versatility of reliable incremental reading of magnetic tape at 150 characters per second to the usual incremental write capabilities of the DS370. The 200 bpi computer tapes may be read one character at a time, eliminating buffers in such applications as printer operation, data communications, and tape-to-tape converters.

Models 1400/1500 offer economical means of recording data in IBM format. Both units contain all necessary electronics to write data and insert gaps and marks required. The small size of the Model 1400 (12-1/4- by 19-inches) makes it particularly attractive for compact systems. Standard 8-1/2-inch reels accommodate 1,200 feet of standard computer tape, enough for 2,880,000 characters at 200 bpi. Model 1500 accommodates full size 10-1/2-inch, 2,400-foot reels, but it is otherwise identical in performance to the 1400.

Models 1400/1500 are equipped to accept positive or negative data and commands making system application universal. All silicon electronics are standard equipment. Optional binary zero to BCD ten conversion is included as are complete remote control facilities. Both machines are available in continuous and incremental read versions. Write-only machines may be equipped with Flux-Check as an extra option.

Flux-Check is a new development providing instant verification of data written on tape which is applicable to any IBM compatible tape recorder. In the Flux-Check system, each character is read immediately after recording to verify that it appears on the tape in its intended form. This system overcomes the last remaining objection to the replacement of punched tape by magnetic tape, that of nonvisible data. With Flux-Check the advantages of magnetic tape may be utilized without payment of this sometimes decisive penalty. Flux-Check is not a simple echo check that merely determines that the machine electronics are operating. Data on the tape are actually read in time to effect corrective action before the succeeding character.

(g) Midwestern Instruments

Midwestern's magnetic tape equipments provide the following features:

- Tape handling with positive pressure pneumatic drive for controlled motion, positive stop, tape speed stability, and minimum dynamic tape stress under all program conditions.
- Data reliability with less than one transient data error in 10^9 data bits; factory tested under random program and data conditions.
- Full IBM compatibility with 7- or 9-channel formats, single or multiple density up to 800 bpi NRZI, and full gap control under all program conditions.
- Complete performance range from 25 to 150 ips, single or dual speed, with common interface and modular design for all tape speeds, densities, and formats.
- Field convertibility between 7- and 9-channel tape formats with simple plug-in modules, plus field modification of tape speed and data transfer rates.
- Operator convenience with straight-line threading, quick-action hubs, automatic load and unload, and IBM identical reel mounting and tape path configuration.
- System dependability by elimination of high impact mechanisms and critical adjustments, plus fully derated components and proven digital logic design.

- Simplicity of maintenance with complete plug-in designs, full front access, minimum adjustments, and simple operator access for periodic cleaning.
- Basic, master, and slave transport configurations, with options for parallel bus operation and shared data electronics on up to eight transports with select control.
- Optional control features including Address Select Switch, Two and Three Density Select, Manual Write Permit, Special Indicators, and Programmable Control Toggles.
- Basic data electronics including standard and high density write circuits and buffered, deskewed, and strobed read output in both forward and reverse motion, with switchable skew correction by density and tape speed.
- Optional data features including odd/even selectable Lateral Parity Checking, Gap Detection, LRCC Parity Checking, and End-of-File Detection.
- Special interface configurations including micrologic compatibility, inverted levels and functions, and special features adapted to user system requirements.

(2) Equipment Characteristics Tables

(See following pages.)

Digital Magnetic Tape Equipment, Low to Medium Speed

Manufacturer	Model	Maximum R/W Speed (IPS)	Maximum Packing Density (BA)	Start/Stop Times (ms)	Comments
Ampex	TM-7/7211	45	800	10/10	
	TM-9	75	800	-	
	TM-13	75	800	6/6	
Burroughs	BC-422	120	556	3/3	
	BC-425	90	800	-	
CEC	DR-3000	75	800	4/3	
Control Data	601	37.5	556	3/3	
	603	75	556	3/3	
	604	75	800	3/3	
	606	150	556	3/2	
DATAMEC	D2020	45	800	5/1.5	
	D3030	75	800	5/2	
Digital Equipment	TU55	97	350	200/150	
Honeywell EDP	204A	120	533	3.5/3.5	Complete series of models
	204B	120	556	3/3	Complete series of models
NCR	EM-F1	60	556	7.6/7	Transport only
Potter Instruments	MT-24	36	800	5/2	
	MT-36	50	800	5/2	
	MT-75	75	800	3/2	
	8C-1060	112.5	800	5/3	
S-1 Electronics	DT-03	37.5	200	5/5	

Digital Magnetic Tape Equipment, High Speed

Manufacturer	Module	Maximum R/W Speed (IPS)	Packing Density (BA)	Start/Stop Times (ms)	Comments
Ampex	TM-11/11200	120	200, 556, 800	3.8/3.8	Modular, single capstan
	TM-12/12700	150	200, 556, 800	3/3	Modular, single capstan
Control Data	607	1[illegible]0	200, 556, 800	2.75/ 1.75	
	626	150	800	2.5/ 2.25	
Honeywell EDP	204B-9	120	556, 800	-	
Midwestern Instruments	M4000-2	120	200, 556, 800	3.5/3	
	M4000-1	1[illegible]0	200, 556, 800	3.5/3	
R. M. Parsons	DR1200	120	200, 556, 800	4/4	Portable
Potter Instruments	SC1065	120	200, 556, 800	4/4	Single capstan
	SC1080	150	200, 556, 800	3/3	Single capstan
	SC1150	150	200, 556, 800	3/3	Single capstan, militarized
	MT120	120	800	3/1.5	Modular
	FT151/152	150	200, 556, 800	50/100	DC operation
	M90611-2	150	200, 556, 800	3/2	Modular

Incremental Magnetic Tape Equipment

Manufacturer	Model	Maximum R/W Speeds (char./sec) Asynchronous R/W	Synchronous R/W	Packing Density (BPI)	Storage	Comments
Cubic Corps	TH-3700	-/300	6000/-	200	-	Militarized
DARTEX	101	75/75	1200/1200	556	Reels	
Digi-Data	DSR 1420	-/200	1500/1500	200, 556	Coax Reels	
	DSR 1430	-/300	1500/1500	200, 556	Coax Reels	
	DSR 1440	-/400	1500/1500	200, 556	Coax Reels	
	DSR 1450	-/500	1500/1500	200, 556	Coax Reels	
Honeywell EDP	6200	100	200	200	Reels	Write-only
Kennedy	DS-300	500	-	200	Cartridge	Write-only; militarized
	DS-370	300	-	200, 556	Reels	
	DS-3701R	150/300	-	200	Reels	Militarized
	DSP-340	50	-	200	Cartridge	Write-only; portable
	1400	-/200	-	200, 556	Reels	DC operations; optional
	M-201	65/65	-	200	Cartridge	-
R. M. Parsons	AIR-940	400	-	200, 556	Coax Reels	Write-only; militarized
	DIR-940	600	-	556	Coax Reels	Write-only; militarized
Precision Instruments	PI-1107	300/300	600/600	200, 556	Reels	
	PI-1167	200	500	200	Reels	Write-only
	PI-1177	200	500	200	Reels	Write-only; portable
Potter Instruments	MT-5R	500/500	-	200	Reels	
	MT-5W	300	-	200, 556	Reels	Write-only
TRAK	DS-2	333/333	333/333	833	Bin	Bidirectional

4. Peripheral Equipments

a. Input Typewriter and Keyboards

(1) Selected Vendors

(a) CDC (Control Data Corporation)

Standard peripherals of the 1700 system include:

- The 1711 Teletypewriter, which is a heavy-duty, send-receive unit that operates at 100 words per minute using an 8-level code. The 4-row keyboard facilitates easy typist operation.
- The 1713 Teletypewriter, which consists of the 1711 Teletypewriter plus paper-tape input/output control and remote mode selection.

Equipment for the 3300/3500 systems include a Control Data 210 keyboard and CRT display with 20 lines of 50 characters from a 64-character repertoire on a 6- by 8-inch display screen. Controllers provide a 1K buffer and character generator. Acoustic couplers are also available to provide standard telephone communication links for special remote devices.

Teletypewriter terminal units are available for connection between communications terminal controllers and 60- to 100-word-per-minute simplex or duplex Teletype lines.

(b) DEC (Digital Equipment Company)

Standard input/output devices for the PDP-9 includes the Console Teleprinter and Control. The console teleprinter, Teletype Model KSR-33 (or equivalent), can be used to type in or print out information at rates up to 10 characters per second. The keyboard control includes an 8-bit buffer to hold the last character (ASCII code) struck on the keyboard and a flag to signal the processor of the presence of a character. The printer control contains an 8-bit buffer to hold one character while it is being printed. When the Model ASR-33 or ASR-35 Teletype is used as the console teleprinter, its paper tape reader and punch are not interfaced to the PDP-9.

(c) IBM (International Business Machines)

For manual input, a choice of 3 units is available. The alphameric keyboard is a standard typewriter keyboard for applications where any considerable amount of alphameric data is to be entered into the system. The programmed function keyboard contains 32 keys and is designed to allow the operator to indicate program-interpretive functions to the system by means of a single key depression. The keys themselves are unidentified, but a coded removable overlay inscribed with any desired labeling is used to identify the temporary key function to the programmer and the operator.

(2) Equipment Characteristic Tables

(See following page.)

Input Typewriters

Manufacturer	Model	Chassis	Technique	Code	Rate
Conn. Technical		Underwood	Electromechanical	Direct	9.3 char/sec
Friden	2303		Electromechanical	8 bits	145 words/min
Invac	TTR100	RemRand	Photoelectric	8 bits	10 char/sec
	TTR200	Selectric	Photoelectric	8 bits	15.5 char/sec
SCM	311		Photoelectric	6 bits	24-40 char/sec
Soroban	Computeriter	IBM	Electromechanical	8 bits	10 char/sec

Input Keyboards

Manufacturer	Model	Technique	Keys	Code
Burroughs	410	Electromechanical	13, 16	Direct
Conn. Technical	KB-100	Electromechanical	70	8 bits
	KB-200	Electromechanical	50	6 bits
Invac	Series 200	Photoelectric	Unlimited	Up to 14 bits
	PK-144	Photoelectric	46	8 bits
	PK-164	Photoelectric	64	8 bits
Soroban	FK	Electromechanical	Up to 64	8 bits
Teletype		Electromechanical	52	Direct
Ultronic Systems	500	Electromechanical	Unlimited	5 bits
	600	Electromechanical	Unlimited	Unlimited

b. Digital Printers

(1) Selected Vendors

(a) Burroughs Corporation

The B 321 is a printer that produces alphanumeric reports at the rate of 700 lines per minute, single spaced, or 650 lines per minute, double spaced. All formatting, spacing, and editing are performed in the central processor under program control. This feature eliminates the need for control panels.

For every line of information printed, three independent verifications of data transferred take place. A validity check occurs as data is transferred from the central processor to the print buffer. The data is parity checked when transferred from the print buffer to the print head activators. Additionally, a print drum position check is performed as data is transferred from the print hammers to the paper form.

The B 321 Printer has 120 print positions with any of 64 characters available in each printing position. The 64-character set is comprised of the numerals 0 to 9, the alphabetic characters A to Z, and 28 special characters (including 17 that conform to ALGOL or COBOL notation). Spacing specifications are 10 characters per inch horizontally and six or eight spaces to the inch vertically. Preprinted continuous form stock (original and 5 copies) and continuous form punched card stock may be prepared on the B 321 Printer.

All printing operations are completely buffered in order to optimize productivity. During the print cycle, a line of information is formatted for transfer to the print buffer. Thus, realistic timing estimates may be predicated on rated output speed.

(b) Collins Radio

The 8852A-1 line printer provides printed page output up to 1,000 lines per minute. The full character repertoire is 64 characters, 132 characters per line. Horizontal character spacing is 10 characters per inch; vertical line spacing is 6 lines per inch. The unit contains control electronics and a full line buffer.

(c) CDC (Control Data Corporation)

A full line of low-, medium-, and high-speed line printers comes from CDC. Speeds range from 150, 300, 500, 600, 1,000, and 1,100 lines per minute with 64 characters and 136 columns. Printers are available for either single or dual channel operation.

(d) Data Products Corporation

The Data Products M series off-line Line Printer Station is a self-contained system designed to provide a reliable method of listing magnetic tapes by means of an off-line magnetic tape transport coupled to a high-speed line printer. This equipment permits computer throughput to be improved by making report listing an off-line operation, or tapes prepared on remote sites to be listed locally. The magnetic tape transport, housed in its own console, reads 200-, 556-, or 800-character-per-inch IBM 729 format compatible tape and drives a 132-column (optionally 84 to 132), 64-character line printer at a nominal rate of 600 lines-per-minute (optionally 360 and 1,000 lpm).

The basic models of the series are the L/P M360 (A, B, C, D); the L/P M600 (A, B, C, D); and the L/P M1000 (A, B, C, D). The M360 models have 360-rpm print drums, the M600 models have 600-rpm print drums, and the M1000 models have 1,000-rpm print drums. All of these speed ranges are available with single line (A); 1,024 characters (B); 2,048 characters (C); 4,096 characters (D); or block buffers. A variety of options allows for a broad range of tape data formats and printer format control.

(e) DEC (Digital Equipment Corporation)

The PDP-9 system can be equipped with a line printer. The Type 647 Automatic Line Printer is available in 300- and 600-line-per-minute models. It prints text in lines up to 120 characters from a 64-character set. Models are available at 1,000 lines per minute and with up to 160 characters per line, upon special order.

(f) GE (General Electric)

The General Electric Company offers a line printer that prints 1,200 lines per minute, 136 characters per line. An operator switch permits vertical line spacing at 6 or 8 lines per inch. Paper is skipped at 27-1/2 inches per second.

Vertical format is controlled by print command: single, double, top of page, or no spacing. Paper can be skipped to one of 15 lines defined on the paper tape loop; 0 to 15 lines by count-down, or skipped to top of page. Paper can be from 3 to 19 inches wide, with 22-inch fanfolds. An original and up to 4 copies can be printed, as well as continuous tabulating single part card stock.

Automatic checking features check for following conditions: low paper, out-of-paper, incorrect parity in paper loop, hammer drive fuse failure, skip error, and buffer overflow parity error. The printer has a 136-character buffer that holds the print line data during printing.

(g) EDP Division of Honeywell

Honeywell offers printers for the Series 200 computer to meet a wide variety of requirements. Printing speeds offered range from 450 to 950 single-spaced lines per minute for alphanumeric characters and up to 1,300 for lines containing a numeric character set; 96 to 132 print positions per line are available. Up to seven carbon copies can be provided.

Printing is performed in response to peripheral data transfer instructions issued to the printer control from the central processor. The peripheral control and branch instruction is used to handle such functions as line and form spacing. An edit instruction allows the programmer to arrange output data into any desired format.

During printing, an operator-changeable type roll on which characters are embossed moves past print hammers at each print position. Actuated as the proper character moves by, these hammers print the characters indicated by the print instruction. A cycle check technique ensures the accuracy of printed information. Standard drums for Honeywell printers have 63 characters available at each print position--26 alphabetic, 10 numeric, a blank symbol, and a number of special characters (e. g., credit symbol, asterisk, dollar sign, etc.). Each print position of the drum used for high-speed numeric printing has available a special 49-character set that is the same as the standard set except it contains fewer special characters. Also available is a bar code drum that generates documents readable by the Type 289-8 Data Station Bar Code Reader. Two special symbols of the standard print drum are replaced by the left and right ortho bars in the bar code drum.

(h) <u>IBM (International Business Machines)</u>

All of the following printers are applicable to IBM's System/360 series computers:

- The 1403 Printer, Model 2 has 132 print positions, and prints at 600 lines per minute (750 lines per minute maximum with universal character set feature). It attaches to Models 30, 40, 50, 65, and 75 via a 2821 Control Unit. Optional equipment presented are auxiliary ribbon feeding, interchangeable chain cartridge adapter, selective tape listing, and universal character set features.

- The 1403 Printer, Model 7 has 120 print positions, and prints at 600 lines per minute maximum. It attaches to Models 30, 40, 50, 65 and 75 via a 2821 Control Unit. Optional features are auxiliary ribbon feeding, and interchangeable chain cartridge adapter.

- The 1403 Printer, Model N1 has 132 print positions, and prints at 1,100 lines/minute (1,400 lines per minute maximum with universal character set feature). It can be attached to Models 30, 40, 50, 65, and 75 via a 2821 Control Unit. Type 1416 interchangeable train cartridge is required. Optional features are selective tape listing, and universal character set.

- The 1404 Printer, Model 2 prints on cut cards or continuous forms. The card feed becomes operative when the printing assembly is shifted to the card side of the 1404.

Dual card feed permits printing on up to 800 cards per minute. Its features include 132 print positions, and maximum print rate of 600 lines per minute, using continuous forms. It attaches to Models 30, 40, or 50 via a 2821 Control Unit, Model 4. Optional features are interchangeable chain cartridge adapter and read-compare.

- The 1443 Printer, Model N1 has 120 print positions. The rated speed in lines/minute varies with operation and character set as follows:

Optional 13-character set, 600 lpm
Optional 39-character set, 300 lpm
Standard 52-character set, 240 lpm
Optional 63-character set, 200 lpm

The printer attaches to a selector or multiplexor channel on Models 30, 40, 50, 65, or 75. Optional features include additional print positions (24 additional), and selective character set.

- The 1445 Printer, Model N1 has conventional or MICR printed output, with 113 print positions. Characters are spaced eight to the inch. The rated speed in lines per minute varies with operation and character set as follows:

Optional 14-character set, 525 lpm

Optional 42-character set, 240 lpm

Standard 56-character set, 190 lpm

The printer can be attached to Model 30 via a selector or multiplexor channel. A selective character set is available as an optional feature.

(i) UNIVAC

The syst em 9200 printer operates at a minimum speed of 250 lines per minute, with the standard 63-character type bar. Printing speed can be greatly increased with the variable print-speed feature. A type bar with 48 characters provides printing between 250 and 500 lines per minute. Alphanumeric information (48-character font) is printed at the rate of 250 lines per minute, and lines containing numeric information (16-character font) are printed at the rate of 500 lines per minute. The standard 96 print positions can be optionally expanded to 120 or 132.

The 63-character printer of the 9300 operates at 600 lines per minute, and a 16-character type bar permits all-numeric printing at 1,200 lines per minute. The standard 120 print positions can be optionally expanded to 132. Highly versatile, interchangeable type bars, a standard feature, permit standard type bars to be replaced by specialized fonts in less than 60 seconds.

(2) Digital Printers

(See following page.)

Digital Printers

Manufacturer	Model	Major Application	Through-Put (char/sec)	Maximum Number of Columns	Speed (lines/sec)	Printing Technique	Data Entry	Buffer	Comments
Burroughs	B329	Computer	2,300	132	17	On-the-fly	Char-Serial	Line	
Franklin Electronics	120A	Communication	20	1	-	On-the-fly	Char-Serial	No	Strip Printer
	3200	Computer	640	32	20	On-the-fly	Parallel	No	
Data Products	L/P M300	Computer	792	132	6	On-the-fly	Par or Ser	Block	Computer Interfaces Available
	L/P M600	Computer	1,320	132	11	On-the-fly	Par or Ser	Block	Computer Interfaces Available
	L/P M1000	Computer	2,200	132	17	On-the-fly	Par or Ser	Block	Computer Interfaces Available
IBM	2203	Computer	1,870	144	13	On-the-fly	-	-	For System 360/20
	1403N1	Computer	2,380	132	18	On-the-fly	-	-	For All System 360 Models
	1403-2	Computer	1,320	132	10	On-the-fly	-	-	For All IBM Computers
	1403-7	Computer	1,200	120	10	On-the-fly	-	-	For All System 360
	1445N1	Computer	-	-	4	On-the-fly	-	-	For Magnetic Ink Printing
Potter Instrument	PS6020	Computer	1,240	132	14	On-the-fly	Char-Serial	Line	
	HSP3502	Computer	1,300	132	10	On-the-fly	Parallel	Line	
Teletype	32	Communication	10	80	-	Tab	Char-Serial	No	
	33	Communication	10	80	-	Tab	Char-Serial	No	
	35	Communication	10	80	-	Tab	Char-Serial	No	Heavy Duty

c. Document Readers

(1) Selected Vendors

(a) IBM (International Business Machines

The IBM 1231 Optical Mark Page Reader reads marked data from 8-1/2- by 11-inch data sheets directly into a central processor. The data sheets have up to 1K mark positions per side. Reading speed is controlled by computer program, with speed varying up to 1.6K documents per hour. However, if the mode is set to "continuous," feeding is at a constant 2K documents per hour. The unit connects directly to a multiplexor channel. IBM 1231 specific features include:

- Optical reading head that scan up to 2M mark positions per hour.
- Data transfer from sonic delay line to computer in 10 milliseconds.
- Programming procedure is simplified by loading a specially marked sheet into the reader ahead of the regular data sheets to be scanned.
- Pre-set switches test each word or segment for such conditions as no-mark, multimark.
- Mark discrimination prepares each mark against a predetermined level.
- An optional feature permits up to 10 digits of data common to a series of data sheets to be stored and read only once.

The IBM 1418 Optical Character Reader optically reads numerical data from documents prepared on special electric typewriters equipped with an appropriate type font. The unit provides direct input to a central processor through an adaptor to a multiplexor channel. The IBM 1418's optimum operating speed varies from 420 per minute for the 5-7/8-inch-wide documents to 300 per minute for 8-3/4-inch-wide documents. An optional feature enables the unit to read data on documents as printed characters are read. A list of some specific features includes:

- Models 1 and 3 have three output stackers; Model 2 has thirteen output stackers and may be used for off-line sorting of paper documents.
- Equipped with a single scanning station as standard equipment, either a second scanning station or a mark read station may be added.
- Reads characters 0 through 9, plus three special characters.
- Continuous feeding and removal of documents with the nonstop hopper and the alternate pocket stacking feature.
- Line selection device permits operator selection for reading any printed line on a document.
- Models 1 and 2 read paper documents ranging in size from 2-3/4 inches high by 5-7/8 inches wide to 3-2/3 inches high by 8-3/4 inches wide; Model 3 reads documents ranging from 2-1/3 inches high by 3 inches wide to 4-7/32 inches high to 8-3/4 inches wide.
- All functions of the 1418 are under control of the program used by the system to which it is attached.

The IBM 1428 Alphanumeric Optical Reader optically reads upper-case alphabetic, numeric, and specific special characters from documents prepared on special electric typewriters equipped with an appropriate type font. The unit provides direct input to a central processor through an adaptor to a multiplexor channel. An optional feature enables the IBM 1428 to read data marked on documents as printed characters are read. A list of some specific features includes:

- Models 1 and 3 have three output stackers; Model 2 has thirteen output stackers and may be used for off-line sorting of paper documents.
- Equipped with a single scanning station as standard equipment, either a second scanning station or a mark read station may be added.
- Reads 42 characters, including the upper case letters A through Z, the numeric digits 0 through 9, and the more commonly used special characters.
- All models read up to 400 documents a minute, depending upon the size of the document.
- Continuous feeding and removal of documents with the nonstop hopper and the alternate pocket stacking ing feature.
- A line selection device permits operator selection for reading any printed line on a document.
- Documents to be read by the 1428 can be originated by a printer or by an electric typewriter equipped with a special type font.
- Models 1 and 2 read paper documents ranging in size from 2-3/4 inches high by 5-7/8 inches wide to 3-2/3 inches high by 8-3/4 inches wide; Model 3 reads documents ranging from 2-1/3 inches high by 3 inches wide to 4-7/32 inches high to 8-3/4 inches wide.
- All functions of the 1428 are under control of the program used by the system to which it is attached.

The IBM 1282 Optical Card Punch Reader optically reads printed, imprinted, or hand-marked data from a card. It also punches the same card, thus eliminating manual key punching. This machine operates off-line preparing data for entry into a data processing system. Specific model characteristics include:

- Reads and punches 51- or 80-column cards at a maximum rate of 200 per minute.
- Optically reads printed numbers as well as imprinted numbers in either font or reverse image.
- A line is selected for scanning via a selector dial.
- Maximum of 32 characters can be read and punched during a single pass.
- Field selection and punch suppression are controlled by a premarked program card.
- Reading accuracy is ensured by a self-checking number error detection feature.
- The punching of 5-digit ascending or descending serial numbers is provided as an optional feature.
- An optional optical mark reading feature permits the reading of 5, 6, or 12 positions of hand-marked data on 80-column cards and 5 or 6 positions on 51-column cards.
- An optional feature permits a single unreadable character to be corrected in a self-checking field.
- Cards can be automatically scanned up to four times, where required, prior to rejection.
- Constant information can be entered into a group of cards via gang punching or control panel wiring.

The IBM 1285 optical reader enters data directly into the central processor from continuous journal rolls. It optically reads digits and selected alphabetic characters. This unit utilizes the flying spot scanning technique in which a cathode ray tube uses an electronic beam to locate the print line, determine the position of the character, define the character's extremes, and scans the character to determine the presence of predetermined characteristics. The use of solid-state circuitry results in high-speed, reliable, direct conversion of source data to computer input. Specific characteristics of the 1285 include:

- Reads information at up to 3K lines per minute. Speed is actually dependent upon the number of characters per line and lines per inch.
- A visual display tube and console keyboard permit on-line correction.
- Reads up to 25 characters per line.
- Has a 200-foot type reel capacity.
- Threads journal rolls automatically.
- Off-line correction procedure marks line with a dot.
- Throughput can be increased via operator setting of scanning limits.
- Overall throughput is increased by passing blank space at high speeds between reading scans.

The IBM 1287 optical reader reads hand-printed numbers, machine-printed numbers, imprinted numbers, and marks from cut form documents. It also reads continuous journal tapes. The 1287 reads a single line or multiple lines from documents of various sizes and enters the data directly into the central processor. The unit's scanning system provides high resolution and superior recognition logic yielding accuracy and reliability. Specific characteristics include:

- Reads hand-printed digits and special alphabetic characters.
- Reads documents vertically and horizontally.
- Reads journal tapes at up to 3,296 lines per minute for a 10-character printed line.
- Rescans characters to increase recognition reliability.

- Automatically handles different formatted documents during the same run via programmed format control.
- Selective on-line correction to a single number or entire line is provided via a display scope and keyboard.
- Operates on-line to a central processor in time-dependent or time-independent fashion.
- Automatically threads journal tape.

(b) <u>NCR (National Cash Register)</u>

The NCR class 420-1 optical reader integrates original entries with central processing. It scans journal tape at 26 lines per second, 20 characters per line, or a total of 520 characters per second. Accuracy features and checkinc circuits are built into the photoelectric reader. These are designed to ensure that all data sent to the central processor are identical with those printed on the journal tape. Where off-line processing is desired, the unit will transcribe the printed journal tape into punched paper tape via a connected punch.

(2) <u>Equipment Characteristic Table</u>

(See following page.)

Document Readers

Manufacturer	Model	Description	Speed: Maximum Char/Sec	Speed: Maximum Doc/Min.	Document Type and Size	Character Set	Type Fonts	Output Media	Comments and Options
Burroughs		Typed page reader	75	10	8-1/2 inches by 11 inches	Letters Numerals Punctuation	Standard elite (etc.)		
Control Data	915	Page reader	370	180	Typed copy 2-1/2 inches by 4 inches to 4 inches by 12 inches	Alpha-numeric Punctuation		Computer	Mark Sense Edit Symbols
IBM	1428	Optical reader	500	400	Paper or card 2-3/4 inches by 5-7/8 inches to 3-2/3 inches by 8-3/4 inches	Alpha-Numeric	IBM 1428	Computer	
	1231	Optical mark page reader	500 marks	33.	8-1/2- by 11-inch preprinted forms	Mark sensing		Computer	
	1418	Optical character reader	500	420	2-3/4 inches by 5-7/8 inches to 3-2/3 inches by 8-3/4 inches	Numeric Special symbols	IBM 407, 407-1, 407E-1	Computer	
	1282	Optical card reader	2,500	200	51 or 80 col. cards	Numerals 7 symbols	IBM 1428F, 1428EF, 1428ER	Punched card	
	1285	Optical tape reader	365	2,190 lines	1-5/16- to 3-1/2-inch widths	Numerals Special symbols	IBM 28 NCR NOF	Computer	
	1287	Optical reader	375	2,250 lines	2-1/4 inches by 3 inches to 5-7/8 inches by 9 inches	Numerals Special symbols		Computer	
NCR	420	Tape reader	842	1,560 lines	1-5/16- to 3-1/4-inch width	Numerals Special symbols	NCR Self Chek		
UNIVAC		Readatron	560	200	Credit cards	Numerals	No. 281		

d. Punched Card Equipment

(1) Automatic Card Renders

(a) Selected Vendors

(i) Burroughs Corporation

The B 122 card reader is a compact, general-purpose unit. It reads 80-column cards at the maximum rate of 200 cards per minute. Cards are read serially by photoelectric sensing. Read circuitry is automatically monitored between card cycles with complete margin checking. The hopper and stacker each hold 500 cards, and cards may be added or removed while the unit is in operation. The B 122 provides the ability to process multiple line print cards.

The B 124 card reader processes 800 cards per minute while feeding data into the central processor through an 80-character input buffer. Punched cards of 51, 60, 66, or 80 columns, of either standard or post-card thickness, can be read. To ensure accuracy, in addition to continuous invalid character monitoring, the B 124 checks its internal circuits for proper operation after each card is read and before the information is acted upon by the central processor. The card hopper and stacker, each with a capacity for 2,400 cards, can be loaded and unloaded while the unit is in operation.

(ii) Collins Radio

The 8861A-1 card reader is a 1,200-card-per-minute card reader that provides a high-speed card input to a computer system. The unit contains an integral control unit and one-card buffer to facilitate high-speed data transfers. Dual photoelectric read stations are used for maximum reliability. The 80-column cards are read at 1,200 cards per minute, 51-column stub cards at 1,600 cards per minute.

(iii) CDC (Control Data Corporation)

The 1729 card reader connects to the 1720 card/paper tape data channel. It is a 100-card-per-minute photoelectric reader with a feed hopper capacity of 500 cards. The automatic feed can be disabled to permit entry of a single card.

The 405 reads punched cards photoelectrically at speeds of 1,200 cpm (80-column) and 1,600 cpm (51-column). Optional features allow either columnar data or Hollerith data (converted to BCD) to be read directly into a line-printer for off-line card-to-printer or card-to-tape conversion. A low-speed (100 cpm) photoelectric card reader is also available.

(iv) DEC (Digital Equipment Corporation)

Both low-cost 100-card-per-minute and heavy-duty 200-card-per-minute readers are available from Digital Equipment Corporation. The type CR01E card reader handles standard 12-row, 80-column punched cards at a rate of 100 cards per minute. The cards are read by column, in either alphanumeric or binary mode. The bin of the type CR01E has a capacity for 430 cards.

The type CR02B card reader handles standard 12-row, 80-column punched cards at 200 cards per minute. Either alphanumeric or binary mode can be selected.

(v) GE (General Electric)

General Electric computers may be equipped with a card reader with the following features:

- Intermixed Hollerith data cards and binary program decks can be read. Corrections to binary program decks can be made in familiar Hollerith Code, and can be inserted in the program deck.

- The 80-column cards may be read at any speed up to 900 cards per minute, and 51-column cards may be read at any speed up to 1,200 cards per minute.
- Cards are read column-by-column into either of two output pockets.
- The input and output hoppers have 2,000-card capacities. The operator can load and unload card hoppers while the reader is reading.
- A validity check is performed on Hollerith codes. Card synchronization checks are performed to ensure accuracy.
- The reader has a last batch switch. This switch is depressed by the operator when the last batch of cards is placed in the hopper. When the hopper empties, a special signal is sent to the program.

(vi) EDP Division of Honeywell

Two high-performance devices are offered for use in Series 200 systems to optically read 80- or 51-column punched cards: a 400-card-per-minute reader Type 123 (available only with the Model 120); and Type 223, an 800-card-per-minute reader. Processed cards are sent to an output stacker, and those that fail data-protection checks can be offset-stacked under program control. End feeding substantially reduces the time normally required by edge-feed (row-by-row) readers for data transfer to and from main memory; therefore, other peripheral data transfers and computing can be performed during more than 99.9 percent of a card read cycle. Solid-state electronic components are incorporated in both card reader models to ensure optimum reliability.

(b) Automatic Card Readers

(See following page.)

Automatic Card Readers

Manufacturer	Model	Reading Speed (cards/min)	Hopper Capacity (Number of Cards)	Number of Stacker Bins	Stacker-Bin Capacity (Number of Cards)	Checking Features	Comments
Burroughs	BC 128	200	500	1	500	Misfeed detection validity checking read checking	
	BC 129	475/800/1400	4,000	1	4,000	Dual read, misfeed detection, validity checking, read checking	
Control Data	405	1,200/1,600	4,000	1	4,000	Dual read, misfeed detection	Photoelectric sensing, optional card reject stacker bin available
	9200	1,200	4,000	1	4,000	Dual read, misfeed detection timing check	Photoelectric sensing
Friden	ACR	572	200	1	200	Misfeed detection	
Honeywell EDP	223	800	3,000	1	2,500	Validity checking, timing check	Photoelectric sensing
NCR	EM-DI	2,000	5,000	1	5,000	Validity checking	Photoelectric sensing
Soroban	ERS I	1,100/1,250	2,000	1	2,000	Validity checking	Compact console with 1000 card bins available, photoelectric sensing
	ERC-1	1,100	1,000	1	1,000	Validity checking	Photoelectric sensing
UNIVAC	0704	400	1,200	3	1,000	Misfeed detection	
	0706	600/800	2,500	1	2,000	Misfeed detection	Optional card reject, stacker-bin available
	2007	615	1,200	1 or 3	1,500	Misfeed detection	Reader mechanism only
Uptime	SR 400	400	1,400	1	1,000	Transport check, stacker-jam check, misregister check, photodiode check	Photoelectric sensing
	SR 800	800	2,500	1	2,000	Same as SR 400	Photoelectric sensing, optional card reject stacker bin available
	SR 1500	1,500	2,500	1	2,000	Same as above	Same as SR 800

(2) Card Punches

(a) Selected Vendors

(i) Collins Radio

The 8862A-1 Card Punch provides card output at the rate of 250 cards per minute and contains an integral control unit and one-card buffer. The punched data is read after punching for reliability, while an error card is detected and offset in the output stacker.

(ii) CDC (Control Data Corporation)

The 3300/3500 System's 415 can handle up to 250 80-column cards per minute. A postpunch read station is included to facilitate complete card checking.

(iii) Burroughs Corporation

The B 303 is a general-purpose card punch that has a potential capacity of 48,000 cards per 8-hour day. It will feed, punch, check, and stack 80-column cards in both standard and post-card thickness at the maximum rate of 100 cards per minute. Functional controls are located on the operator's control panel. The hopper and the stacker each hold 800 cards. This unit punches cards a row at a time through an electronic row buffer.

The B 304 is a card punch that operates at the rate of 300 cards per minute. When an 80-character output buffer is set aside in the central processor, the card punch is permitted to operate simultaneously with the other units of the system. The input hopper and the output stacker hold 3,500 cards each. However, the unit has an unlimited capacity, since the hopper can be loaded and the stacker unloaded while the punch is in operation. To ensure the validity of the punched card output, any variances are detected and the punching halts at the end of the card cycle, indicating a punch-error condition.

(iv) GE (General Electric)

Two models of card punches are available for the 400/600 series: 100 cards per minute and 300 cards per minute. Cards may be punched in Hollerith or binary modes. Checking features include: read after punch, card feed and positioning check, alert when input hopper is empty, output stacker full, chad box full, feed failure, or card jam. The 300-cpm subsystem automatically directs error cards to an error pocket when a card-punching error is detected. The card punches operate at full speed while other peripherals and/or the central processor are operating.

(v) EDP Division of Honeywell

The Type 214-1 Card Punch operates at speeds of up to 400 cards per minute, depending on which column is punched last. High-speed column skipping is available as an option. This feature provides an automatic increase in card advance speed when unused card columns are detected. This device also incorporates another new feature, dual-character punching, which employs a dual-die mechanism to punch two characters (columns) simultaneously and adds significantly to the high speeds and reliability of the unit. There are no cams, gears, or sliding parts in the feed mechanisms, making points lubrication completely unnecessary. The 214-1 enjoys the simultaneity advantages afforded other end-feed card devices. Thus, other processor and peripheral activities can occur during 99.9 percent of a card punch cycle. Punching errors are detected by a punch check; recognition of an error causes a program-accessible indicator to be set.

(b) Card Punches

(See following page.)

Card Punches

Manufacturer	Model	Punch Speed (cards/min)	Hopper Capacity (no. of cards)	Comments
Burroughs	B303	100	800	
	B304	300	3,500	3 output stacker bins
IBM	2520 A2/B2	500	-	-
	2520 A3/B3	300	-	-
Soroban	EP-4	400	None	Head only
	EP-4 Con	400	2,000	-
	EP-4 C	200	-	Compact version of EP-4
Uptime	120	120	1,000	-

Card Reader-Punches

Manufacturer	Model	Read Speed (cards/min)	Punch Speed (cards/min)	Input Hopper Capacity (no. of cards)	Output Hopper Capacity (no. of cards)	Comments
Honeywell	224	300/400	50/91	1,200	1,300	2 output bins
	227	800	250	3,000	1,000	3 output bins
	214-2	400	400	1,200	1,300	
IBM	2540	1,000	300	-	-	-
	2520 A1/B1	500	500	-	-	-
	1442 N1	300	91	-	-	-

e. Paper Tape Equipment

(1) Paper Tape Reader

(a) Selected Vendors

(i) Burroughs Corporat.

The B 141 Paper Tape Reader is buffered and reads strip or reeled tape at the rate of 1,000 characters per second. The unit reads 5-, 6-, 7-, or 8-level code. It starts and stops on a character. A series of buttons allow the operator to select any stop code in the paper tape. The tape halts at the eightieth character if no stop code is encountered.

(ii) CDC (Control Data Corporation)

The 1721 Paper Tape Reader converts information on punched tape to electrical signals for use by the computer. It includes the control and connects directly to the computer. By means of a photoelectric read station, 5-, 7-, or 8-level tape of standard width is read at rates of up to 400 characters per second. All parts of the unit have been designed for long life with minimum maintenance. Adjustments are easily made. The 1722 is the same as the 1721 Paper Tape Reader, with the addition of supply and take-up reels.

(iii) DEC (Digital Equipment Corporation)

The PDP-9 has as standard equipment the PCO-1 Paper Tape Reader and Punch. A 50-character-per-second paper tape punch is mounted on the same chassis as the reader. A single ouput instruction causes an 8-bit character to be transferred from the PDP-9 accumulator to a punch buffer, from which it is punched on the tape. Fanfold paper tape is normally used with the paper tape reader and punch.

(iv) Facit

Facit, a Swedish firm, has developed an unusual sensing technique they call "dielectric reading." In this technique the punched tape forms the dielectric of a computor whose capacitance is changed coincident with the hole passing the read station. The problems avoided by this technique include insensitivity to dust and low-quality paper, as well as the long-term drift and aging experienced with lamps and photo cells.

(v) IBM (International Business Machines)

The 2671 Paper Tape Reader reads strips or rolls of 5-, 6-, 7-, or 8-track codes at speeds up to 1,000 characters per second from 11/16-, 1-, or 7/8-inch chad tape. Its features include:

- Optional spooling facilities that provide for center roll or reel feeding and rewinding.
- Buttons and switches that allow changes in end-of-record codes, tape codes and widths, parity, and delete recognition.

The 2822 Paper Tape Reader Control for this unit performs the functions that allow the 2671 paper tape reader to be used as input to the multiplexor channel of a System/360, Model 30, 40, or 50.

(b) Equipment Characteristics Tables

(See following pages.)

Paper Tape Readers

Manufacturer	Model	Maximum Reading Speed	Maximum Asynchronous Speed	Sensing Element	Track or Channels	Tape Movement	Block or Line Reader	Comments
Burroughs	B141	1,000 char/sec			5, 6, 7 or 8	Bi-directional		Compatible with most data collection and transmission devices
California Technical Industries	171	15 blocks/sec		Pin contacts	8	Uni-directional	Block (10 lines)	Includes verifier panel
	220 B	55 char/sec	40 char/sec	Pin contacts	5, 6, 7 or 8	Uni-directional	Line	
Choice Engineering	SBR-642	10 blocks/sec	3.5 blocks/sec	Pin contacts	8	Bi-directional	Block (16 lines)	
	701	20 blocks/sec	2.5 blocks/sec	Pin contacts	8	Bi-directional	Block (24 lines)	
	501	55 char/sec or 15 blocks/sec	150 char/sec	Photocells	5, 6, 7 or 8	Bi-directional	Line or Block (8 lines)	Reads blocks or lines
Digitronics	2500	300 char/sec	300 char/sec	Photocells	5, 6, 7 or 8	Uni-directional	Line	Various options available
	B2500	Same as 2500	Same as 2500	Same as 2500	Same as 2500	Bi-directional	Same as 2500	Same as 2500
	3000	700 char/sec	700 char/sec	Photocells	5, 6, 7 or 8	Uni-directional	Line	Various options available
	B3000		Same as 3000			Bi-directional		Same as 3000
	5000			Photocells	5, 6, 7 or 8	Bi-directional	Block (20 lines)	Block reader memory module
Electronic Engineering	1000	8,000 char/sec		Photocells			Line	Militarized
	PR-8105	18 blocks/sec	18 blocks/sec	Photocells	8	Uni-directional	Block (5 lines)	Also available in other block sizes
	TP-4105	10 blocks/sec	10 blocks/sec	Pin contacts	8	Uni-directional	Block (5 lines)	Bi-directional models available
Ferranti-Electric	196D	600 char/sec	400 char/sec	Photocells	5, 6, 7 or 8	Bi-directional	Line	
	196 E	400 char/sec	300 char/sec	Photocells	5, 6, 7 or 8	Bi-directional	Line	
	260	46 char/sec	40 char/sec	Photocells	8	Uni-directional	Line	Militarized
	422	600 char/sec	400 char/sec	Photocells		Bi-directional	Line	Militarized
	425 R	600 char/sec	400 char/sec	Photocells	5, 6, 7 or 8	Bi-directional	Line	Built-in tester
	425 D	600 char/sec	400 char/sec	Photocells	5, 6, 7 or 8	Bi-directional	Line	Desk-top unit

Paper Tape Readers
(Continued)

Manufacturer	Model	Maximum Reading Speed	Maximum Asynchronous Speed	Sensing Element	Track or Channels	Tape Movement	Block or Line Reader	Comments
GE Printer-Reader Section	PTR-80/81	500 char/sec	200 char/sec	Photo-cells	5, 6, 7 or 8	Uni- and Bi-directional	Line	Reflected light reading
	PTR-90/91	1000 char/sec	225 char/sec	Photo-cells	5, 6, 7 or 8	Uni- and Bi-directional	Line	Reflected light reading
	PTR 80C	200 char/sec	135 char/sec	Photo-cells	5, 6, 7 or 8	Uni-directional	Line	Reflected light reading
	625	500 char/sec			5, 6, 7 or 8			
Honeywell EDP	209	600 char/sec			5, 6, 7 or 8	Bi-directional	Line	Special control unit for on-line
	409	1,000 char/sec			5, 6, 7 or 8		Line	Special control unit for on-line
	809	1,000 char/sec			5, 6, 7 or 8		Line	Special control unit for on-line
IBM	2671	1,000 char/sec			5, 6, 7 or 8			
UNIVAC	R-118		35 char/sec	Photo-cells	5, 6, 7 or 8	Uni-directional	Line	
	R-125		200 char/sec	Photo-cells	5, 6, 7 or 8	Uni-directional	Line	
Navigation Computer	1200		30 char/sec	Pt. contacts	5, 6, 7 or 8	Uni-directional	Line	Without drive or advance circuits
	1291	30 char/sec	30 char/sec	Pin contacts	8	Bi-directional	Line	Self-contained desk top
Potter Instruments	PSR-200	200 char/sec		Photo-cells	8	Bi-directional	Line	Militarized
	PTR-500	500 char/sec	100 char/sec	Photo-cells	5, 7 or 8	Bi-directional	Line	
	3277	200 char/sec		Photo-cells	8	Bi-directional	Line	Militarized
	PT-5000	500 char/sec		Photo-cells	8	Bi-directional	Line	Militarized; dual-speed
	HSL-1000	1,000 char/sec		Dielectric	5, 6, 7 or 8	Bi-directional	Line	
Rheem	RR 702/1002	700 char/sec	140 char/sec	Photo-cells	5, 7 or 8	Uni and Bi-directional	Line	
	RR 302/302	300 char/sec	100 char/sec	Photo-cells	5, 7 or 8	Uni- and Bi-directional	Line	
	RR 5000	1,000 char/sec	200 char/sec	Photo-cells	5, 7 or 8	Uni- and Bi-directional	Line	
Roytron	200	20 char/sec	20 char/sec	Pin contacts	5, 6, 7 or 8	Uni-directional	Line	Price does not include housing, timing or mechanical drive. Complete systems available
	550	50 char/sec	30 char/sec	Pin contacts	5, 6, 7 or 8	Bi-directional	Line	
	750	75 char/sec	45 char/sec	Pin contacts	5, 6, 7 or 8	Bi-directional	Line	
Soroban	FFR	150 char/sec	300 char/sec	Fluid-flow	5, 6, 7 or 8	Uni-directional	Line	Complete with source supplies
	PR-2	60 char/sec	60 char/sec.	Pin contacts	5, 6, 7 or 8	Bi-directional	Line	
	PR-401 S	20 char/sec		Pin contacts	5, 6, 7 or 8	Uni-directional	Line	Read head and solenoid drive
Tally	424		60 char/sec	Starwheel	5, 6, 7 or 8	Bi-directional	Line	Panel-mounted
	464		120 char/sec	Starwheel	5, 6, 7 or 8	Bi-directional	Line	Panel-mounted
	625		25 char/sec	Starwheel	5, 6, 7 or 8	Bi-directional	Line	Panel-mounted
	824		60 char/sec	Starwheel	16	Bi-directional	Line	Panel-mounted

(2) Paper Tape Punch

(a) Selected Vendor

(i) Teletype

The Teletype DRPE high-speed punch can receive and punch characters in paper tape at 240 characters per second (2,400 words per minute) or less, without any changes or readjustments. It punches 10 characters to the inch, and is available for any 5-, 6-, 7-, or 8-level code on 11/16-, 7/8-, or 1-inch wide tape.

It is an asynchronous, electromechanical, parallel-wire punching device. Its punching mechanism consists of cantilevered reed armatures attracted to magnets (one of each code and the feed level) which, when released, drive punch pins through the tape in response to the received parallel-wire signal. Since the DRPE's mechanism is not in motion while the unit is on-line waiting for a signal, longer unit life is expected.

The Teletype BRPE is a high-speed paper tape punch that has found widespread use in many data communications systems. In these systems, the BRPE punch serves as a receiving terminal for data being transmitted from distant points over conventional telephone channels.

The BRPE tape punch can be used to combine data from various sources on one master tape, which can then be relayed by high-speed or standard-speed tape reader sets to other offices or to associated equipment. The BRPE punch can also serve as a high-speed output device when connected with computers or other business machines.

Operating at 105 characters per second (1,050 words per minute) or less when required, the teletype BRPE punch produces fully perforated tape at 10 characters to the inch. It is available for punching 5-, 6-, 7-, or 8-level codes into 11/16-, 7/8-, and 1-inch tape.

The BRPE is a synchronous, parallel-wire input electro-mechanical unit. Its punching mechanism continuously operates at rated speed under electric motor power, but punches only when permitted by magnet coils (one for each code level) in response to the received parallel-wire signal.

The Teletype Model 35 ROTR (receive-only typing reperforator) is used in many data communications and processing systems. At communications relaying stations, the Model 35 ROTR will automatically receive and store data for later transmission by high-speed or standard-speed tape readers to various locations. The clearly printed characters on the tape assure quick identification for accurate disposition.

The Model 35 ROTR can also serve as a monitoring unit to provide a byproduct tape that contains a record of all outgoing data traffic on a specific circuit. This byproduct tape can be used to duplicate any part or all of a message that has been previously transmitted.

In data processing systems, the Model 35 ROTR can be used to combine information from several sources into one composite tape. Since it operates on an 8-level code compatible with the American Standard Code for Information Interchange (ASCII), it can accept direct output from computers and other business machines. Also, the tape can be used many times over again thus eliminating costly, time-consuming repetitive manual typing.

This unit operates at 10 characters per second (100 words per minute) or less when required. It records data in fully perforated 1-inch-wide paper tape. The punched tape is automatically wound and conveniently stored on an optional plastic reel mounted on the left of the unit. Up to 3,000 feet of tape can be processed before the waste chad bin need be emptied.

The Teletype Model 35 ROTR provides versatility through a number of optional features. For example, a gear shift mechanism is available that allows instantaneous manual switching for operation at 100, 75, and 60 words per minute. Code reading contacts are also available for receiving parallel-wire input, enabling the ROTR to accept signals directly from computers and associated business machines.

Optional visual "warning alarms" indicate when the tape supply is low and when the waste chad container is full. Another optional feature is a "tape feed-out" audible and/or visual signal. The Model 35 ROTR includes a backspacing feature to facilitate local error correction.

(b) Equipment Characteristics Tables

(See following page.)

Paper Tape Punches

Manufacturer	Model	Maximum Punching Speed (char/sec)	Track or Channels	Parity Error Sensing	End of Tape Sensing	Tape Supply Level Sensing	Packaging Styles	Comments
Burroughs	B341	100	5, 6, 7 or 8	-	-	Yes	Console	Complete buffered operation
GE Printer Reader Section	ETR-7	600	5, 6, 7 or 8	Yes	Yes	No	Rack, console	Electrostatic recorder
Honeywell EDP	210	120	5, 6, 7, 8	Yes	Yes	Yes	Console	Special control unit for read-punch operations
	410	110	5, 6, 7, 8	Yes	Yes	Yes	Console	
NCR	EMB1	120	5, 7, 8	No	Yes	No	Rack, console	Punching mechanism
	EMB2	120	5, 7, 8	No	Yes	Yes	Rack, console	Punching mechanism plus tape transport
Raytron	200	20	5, 6, 7, 8	Optional	Optional	Optional	Rack, desk-top console	
	500	50	5, 6, 7, 8	Optional	Optional	Optional	desk-top console, rack	
	700	75	5, 6, 7, 8	Optional	Optional	Optional	desk-top console, rack	
Soroban	LP-2	150	5, 6, 7, 8	Optional	Yes	Yes	desk-top console, rack	Also available as punch heads only
	GP-2	300	5, 6, 7, 8	Optional	Yes	Yes	desk-top console, rack	
	PT-2	100	5, 6, 7, 8	Optional	Yes	Yes	Console	
Tally	P-30	30	5, 6, 7, 8	Optional	No	Yes	Rack, console	
	P-120	120	5, 6, 7, 8	Optional	Optional	Optional	Rack	
	P-150	150	5, 6, 7, 8	Yes	Yes	Optional	Rack	
	420	60	5, 6, 7, 8	No	Optional	Optional	Rack	
Teletype	DRPE	200	5, 6, 7, 8	No	No	Yes	Rack, desk-top	Feed reel included, features turn read punching
	BRPE	110	5, 6, 7, 8	No	No	Yes	Rack, desk-top	Feed reel included
	35 ROTR	10	8	No	No	Yes	Desk-top console, rack	
	28 LPR	10	5	No	No	Yes	Desk-top, rack	
	28 LARP	20	5, 6, 7, 8	No	No	Yes	Desk-top	Parallel input only

5. Microforms

a. Selected Vendors

(1) Carson Laboratories

Carson Laboratories is the producer of a laser system for recording, producing, storing, and automatically randomly accessing and retrieving data recorded on a crystal storage medium.

The crystals used are 2 inches square by 0.1 inch and have a resolution capability of 1,000 line pairs per millimeter. Each crystal contains approximately 1,024 frames of data processed from documents 8-1/2 by 11 inches in size and is prepared in such a manner that the user may handle it without resorting to special techniques. The crystal is designed to retain its resolution after 5 years of storage at temperatures up to 100 degrees Fahrenheit.

The storage and retrieval device associated with the crystal allows the user to select any one frame and have it displayed within a maximum time of 200 milliseconds. A hard copy capability is available.

A KBr (potassium bromide) crystal is currently being used. This crystal type was selected for use because the only available laser at the time of the initial research was a red-light laser (helium-neon). The KBr cyrstal is red light sensitive and was thus selected.

(2) Eastman Kodak

The Eastman Kodak Company has participated actively for many years in the development of microfilm information storage and retrieval systems. The Recordak MIRACODE System (Microfilm Information Retrieval Access Code) is an automatic file, storage, and retrieval system that uses microfilm for the storage media. With the MIRACODE System, after selecting a specific film magazine, it is possible to automatically search the magazine and retrieve the desired document in seconds. The document may be identified by its assigned number and/or key words that describe it by characteristics. The documents containing the desired information can be retrieved and graphically displayed within seconds. Paper prints can be produced also in seconds by push-button selection.

The EDS-0009 and EDS-0016 Systems utilize Kodak's MIRACODE System as the center of their formulation. The MIRACODE System is currently used to select components by characteristics of the item and to store and retrieve engineering specifications and data sheets that support the engineering drawings. Eastman Kodak has recently announced equipment that will further enhance the MIRACODE System in the EDS-0009 and EDS-0016 Systems by converting engineering drawings mounted in 35mm aperture cards to 16mm microfilm with MIRACODE indexing.

EDS-0016, being almost completely automated, is a refinement of the EDS-0009. Information from documents is stored directly on magnetic tape using an optical scanner; the data on the tape or from a computer, can be exhibited on a cathode ray tube and microfilmed directly from the CRT. The CRT also generates the MIRACODE indexing format on the microfilm. The document can then be retrieved by characteristics or assigned numbers in the MIRACODE System.

The MIRACODE System can also be used as an integral part of total data systems. The Army Materials Command has joined this retrieval system with an Alden Research facsimile scanner in Alden's "Dial-a-Document" System.

(3) 3M Company

The 3M Company (formerly Minnesota Mining and Manufacturing Company) has continued to be one of the important innovators in the microform field. Their microfilm cartridge system and a complete line of supporting readers and reader-printers were developed and marketed at the beginning of the forward surge in the microform industry. Recently, 3M introduced a new system for recording data from tape to microfilm called EBR (Electron Beam Recording).

The EBR process utilizes a "dry silver" process in which the silver-bearing chemical on the film's surface is activated by electron bombardment in a vacuum. The silver-bearing molecules are raised to a higher energy state, so that when the film is passed through a heat bath, the silver is released from combination; such portions of the film are blackened to form the desired image. The developed film can be duplicated easily and hard copy prints can be made from it.

The EBR utilizes 16mm or 35mm film. The present technique for 16mm film performs at 132 columns per line in a frame with 64 lines in the frame and a capability of processing 20 frames per second.

(4) NCR (National Cash Register)

National Cash Register has recently announced a new concept in miniaturization with its PCMI (Photochromic Micro Image) technology. Essentially, the final product is a 4- by 6-inch transparency with approximately 3,200 images represented on it in matrix form. The transparency can then be reproduced for dissemination copies, and each copy is laminated in a plastic that precludes contact printing of any additional copies. This controls unauthorized duplication and provides protection for the original publisher.

NCR photochromic coatings consist of a molecular dispersion of dyes that are light sensitive in a transparent coating material. Photochromic coatings differ from silver halide emulsions in several respects:

- Image is visible upon exposure and no development is required.
- Coatings are reversible permitting stored information to be optically erased and rewritten repeatedly.
- Coatings are grain free with inherently high resolution.

An image appears on the photochromic surface when the individual molecules are switched from either the colored or colorless state by light of the proper wave length. The image is semipermanent and dependent on the ambient temperature of the coating. Image life is hours at room temperature but can be extended with proper environmental control.

Semipermanence prohibits usage of PCMI for archival storage. However, a method has been developed for transferring PCMI to high-resolution photographic film. The steps utilized in forming a PCMI transparency are as follows:

- Document is recorded on high-quality microfilm.
- With appropriate filtration, near-ultraviolet light is directed through the transparent microfilm and into micro-image optics forming a miniature image on the photochromic coating.
- By a step-and-repeat process, multi-image matrices of these miniature images are formed.
- The matrix is then transferred to high resolution photographic emulsion by contact printing
- The photographic emulsion is developed under controlled conditions, resulting in a 4- by 6-inch master.

- The master can be used to publish duplicate 4- by 6-inch cards.

The microfilm mentioned in the first step is reduced another 20 times, resulting in an image 200 times reduced from original. Approximately 10^6 document pages can be stored in micro-image form at 200-to-1 reduction on less than 400 cards (a stack of PCMI cards less than 6 inches high).

For full automation with document storage in the millions of document pages, the system contains an automated file and an automated viewer. The file and viewer are controlled by a general-purpose or special-purpose computer. In the fully automated system, a search is instituted in the computer for documents matching specific search parameters. When a match is made, the location of the document is transmitted to the PCMI system for automatic retrieval of the card and automatic positioning of the viewer table.

Viewers presented thus far provide the enlargement of the micro-image to approximately the original document size for screen viewing. This approach provides the following additional output features, where required.

- A full-size, fully processed hard-copy printout is obtained using standard photographic techniques.
- A standard microfilm (16mm or 35mm) of the micro-image may be obtained, using standard photographic techniques. The microfilm may then be used as input to other standard techniques, e.g., xerography, copy flow printing.

(5) <u>Stromberg-Carlson, Data Products Division</u>

Stromberg-Carlson was the pioneer in the development of the microfilm recorder. The recorder's purpose is to print computer output directly onto microfilm at computer speeds. The steps in the procedure are as follows:

- The output of the computer, in digital form, is translated into alphnumerics by using the CHARACTRON (Registered Trademark) cathode ray tube. Graphics are created by joining line segments under computer control.
- The alphanumerics or graphics are then photographed directly from the tube face onto 16mm roll film, with options for 35mm film or microfiche.
- Various options include a special projector that superimposes standard business forms over the text, hard copy capability, and simultaneous coding for use with storage and retrieval systems.

The CHARACTRON tube generates information by passing an electron beam through characters etched on a matrix. The image produced is of exceptional quality and has good resolution. An advantage in using it is the consistency of the micro images in type face and line width. Assuming that the recorder is used, a reader-printer can be designed that is uniquely and ideally suited for the output.

The output speeds of the line of recorders are as high as 70,000 pages in 8 hours, with input speed of 90,000 characters per second. Input is accepted from 7- or 9-track tapes and the recorders are compatible with most third-generation computers.

Stromberg-Carlson has expanded on its initial microfilm recorder concept into an entire line of microfilm systems, which they call their "Micromation" technology.

The SC-4060 is a stored program recording system that provides alphanumerics, point plotting, vectors, PERT charts and other graphics, and records output on microfilm or produces optional hard copy. The SC-4060 has all solid-state circuitry and integrated circuit logic. A Honeywell 3C516 computer is utilized as a product control unit and complete software routines for the graphics are supplied by the vendor. The camera used provides

600-foot magazines of 16mm or 35mm film. The input speed is 90,000 characters per second. Some options included are an on-line film processor and an on-line hard copy printer, which provides hard paper copy in 2 seconds.

The SC-4060 is presently the most versatile and fastest of the Micromation line. Other equipments are the SC-4360, SC-4400, and SC-4440 printers that have input speeds of 30,000, 62,500, and 90,000 characters per second, respectively. The SC-4440 and SC-4360 have an optional microfiche camera capable of producing 4- by 6-inch or 3-1/4- by 7-3/8-inch fiche, with 60 or more images each at a rate of 2-1/2 to 5 per minute. The SC-4460 is comparable with the SC-4440, but has the additional capability of producing charts and other graphics.

The complete line of stromberg-Carlson microfilm recorders and printers and some of their more important capabilities are represented in Exhibit B-5.

Other Micromation equipments are

- SC-1700 Inquiry Station, which accepts Stromberg-Carlson 16mm magazines with magnification of either 19 or 22 times.
- SC-3400 Hard Copy Printer, which produces an electrostatically formed image on paper at the rate of 60 feet per minute using 16mm microfilm as input.
- F-89 Film Developer, which develops 16mm or 35mm perforated or unperforated film at a speed of 24 feet per minute.
- Several Kalvar Film Copiers and the SC-1325 Microfiche Inquiry Station, which displays an image from a 4- by 6-inch microfiche on an 11- by 14-inch viewing screen.

EXHIBIT B-5 STROMBERG-CARLSON MICROFILM RECORDERS AND PRINTERS

Capability	SC-4060	SC-4360	SC-4400	SC-4440	SC-4460
Maximum Input Speed	90,000 cps or more	30,000 cps	62,500 cps	90,000 cps	90,000 cps
16mm Output P= Perforated N= Nonperforated	$X_{P\&N}$	X_N	X_N	X_N	$X_{P\&N}$
35mm Output P= Perforated N= Nonperforated	$X_{P\&N}$				$X_{P\&N}$
Graphics	X				X
Feet of Film Per Magazine	600	100	600	600 or 1,000	600
Throughput Speed in Pages/8 hours		20,000	50,000	70,000	
<u>Options</u>					
Microfiche Camera with speeds of output in Fiche per minute		X 1-2		X 2 1/2-5	X 1-2
Hard Copy Printer	X				
Superimposed Business Forms Projector	X	X	X	X	X
On-Line Film Processor	X				

(6) The Mosler Safe Company, Information Systems Division

The Mosler Selectriever is a random access retrieval system that can accommodate up to 200,000 individual documents of EAM card size (3-1/4 by 7-3/8 inches). The documents may be either aperture, microfiche, or even ordinary cards with written information on them.

The methodology for access is based on notches along the bottom edge of the card. The Selectriever file consists of two parallel walls, each containing 1,000 plastic cartridges with each cartridge having a capacity of 100 cards. A cartridge is identified by a 4-digit address; therefore, every document has a unique 11-digit key.

In a maximum of 10 seconds, the Selectriever can access a specific document, present it to the operator, display it, or prepare a hard copy of the information. Average access time is 6.5 seconds. The equipment can be interfaced to a computer and operate on a computer command.

(7) Xerox Corporation

Xerox is currently producing several equipments that fulfill the definition of a microform as a reproduction medium that reduces the size of a document or a drawing without loss of the document's intelligence.

The first of these is the Xerox 2400-IV. It was developed as an answer to the inherent problems of computer printouts. These problems include the following:

- Multiple copies are difficult to produce on the ordinary line printer because of the use of carbon paper. It is usually true that copies beyond the third or fourth are almost entirely illegible, forcing costly additional runs on the computer.
- The ordinary tab runs require bursting and deleaving.

- The standard 11- by 15-inch printout is bulky and requires special filing facilities and special binders.

The 2400-IV solves these problems by taking an original, sharp copy printout and reducing it to a standard 8-1/2- by 11-inch size copy. The equipment is capable of reproducing forty copies per minute and sorts automatically by means of a 10-bin sorter, which can accommodate a 150-page report. The 2400-IV allows the user to have clear copies of his computer output in a more desirable size for reading and filing. Extra copies of individual pages can be made without collating the report. An additional feature of the 2400-IV is a business form transparent overlay that can be reproduced along with printout text. This feature eliminates preprinted forms or software formats that describe columns, title, etc.

Another equipment recently announced is the System 3-2-1, a dry process that reduces documents to 35 percent of their original size. The speed is rated at one image every 2 seconds. The minimum size document for input is 2-1/2 by 3 inches and the maximum is 14 by 17 inches. As output, the minimum card size is 2-1/2 by 3 inches and the maximum is 8 by 8 inches. As an example of the capabilities of System 3-2-1, an engineering drawing could be reduced to size 2-1/2 by 3 inches and reproduced on a standard 3-1/4- by 7-3/8-inch EAM card. The card could then be punched or notched for insertion into an information storage and retrieval system.

The System 1-2-3 is the dual equipment to System 3-2-1, capable of enlarging small-size documents to three times their original size. The maximum size of the input image is 3-1/4 by 5 inches and the maximum size of the output image is 9 by 14 inches. As many cards as desired can be made from the original document or original imaged card. An image can also be added at a later date to the front or back or previously imaged cards. The system 1-2-3 can be combined readily with an aperture card system.

6. Software

a. Indexing

(1) Selected Vendors

(a) Documentation Incorporated

DOCUFORM is a manual random filing system, using film transparencies in microfiche form. Each document is coded with a number corresponding to a file drawer, drawer section, tab location and number, and row and column, thus simplifying manual access and refiling.

(b) Houston-Fearless Corp.

Storage in the CARD system is by chronologically arranged microfiche, with either alphabetic or numeric divisions. Indexing with CARD may be by subject classification or by any convenient method. Access to a maximum of 70,000 documents is obtained by entering the desired command name, either alphabetical or numerical.

(c) Information Handling Services, Inc.

Information Handling Services, Inc.'s VSMF (Visual Search Microfilm Files) uses coordinate indexing to store information on microfilm and to allow comparison of the relationships of material. This system has been basically used to obtain comparisons of qualifications and performances.

(d) Eastman Kodak

In the Kodak Miracode System, information is stored by assigned numbers or by key words on a microfilm tape. With this system, it is possible to automatically search the tape and have the desired information presented on graphic displays or paper prints.

(e) Micro-Catalog Division of Thomas Publishing Co.

This organization has developed a system to present catalog data on microfiche. Indexing is alphabetic according to the manufacturer's name, and again according to product name to facilitate cross-referencing.

(f) Mosler Safe Co.

The Mosler Selectriever system uses a form of search via command. Cards with microfilm aperture or microfiche are filed in 1,000 plastic cartridges, each of which has a capacity of 100 to 200 cards. The search may be either automated or manual. Each card, numerically indexed in the cartridges, is retrieved when a command for the card number is received. Commands are received by the selectriever from the keyboard, a punched paper tape, or the computer interface.

(g) Soundex Corporation

The Soundex Corporation system of indexing is like that used by the social security system. Volumes of subjects and names are transformed to code numbers. All vowels in a name are dropped and the remaining consonants after the first letter are numbered by three figures according to a predetermined classification scheme. (For example, classification 1 might contain the letters BFPV, 2 would contain CGJKQSXZ, 3 would contain DT, 4 would have L, 5 would have MN, and 6 would have R. Thus, the name Jones would be coded J520, the 0 filling out the code to 3 figures.) The codes would then be filed numerically.

(2) Information Processing Systems

The following lists of information processing systems occur under the five major headings listed below:

1. General System Information

Manufacturers, system designations, and brief descriptions of systems operations are given in Exhibit B-6.

2. File Preparation

Coding systems for later retrieval are indicated, techniques for entry of the material into the system are described, and the rate of input is given in Exhibit B-7.

3. Storage Characteristics

The type and size of the unit storage medium are given, the capacity of the unit record is listed, and pertinent data are stated to describe system capacity in Exhibit B-8.

4. Search and Retrieval Information

The method, operation, and retrieval rates of the systems are presented in Exhibit B-9.

5. System Component Data

The various components that constitute the systems are listed, sizes and costs are indicated where known, and availability of the equipment is discussed in Exhibit B-10.

6. Summary Statements

Pertinent characteristics of each system are summarized with respect to the IS&R function in Exhibit B-11.

b. Other Software

(1) Selected Vendors

(a) Collins Radio

Standard Collins software is based on a modular approach. Application programs as well as computer

EXHIBIT B-6 INFORMATION PROCESSING SYSTEMS CHARACTERISTICS: GENERAL SYSTEM INFORMATION

MANUFACTURER	SYSTEM	DESCRIPTION
Aeronutronic Division, Ford Motor Company	ARTOC DATAVIEW (AN/MSQ-19)	Army Tactical Operations Central (ARTOC) and DATAVIEW, the display system, being developed for USSC. Graphic information received, electronically processed, and displayed. Hard copy provided.
Avco Corporation	VERAC	Storage and retrieval system for graphic information. Stored image can be displayed, transmitted by TV, or printed. Separate search system required.
Benson-Lehner Corporation	FLIP	Console storage and retrieval unit for display of recorded information.
Eastman Kodak, or Recordak	DACOM	Datascope Computer Output Microfilmer (DACOM) converts computer machine language recorded on magnetic tape to human language on microfilm. Simultaneously combines output image with background format. Utilizes flying-spot character generator.
Eastman Kodak, or Recordak	MINICARD	Complete IS&R system incorporating analysis, coding, recording, storage, and retrieval of graphic information. Provides duplicate record, viewing, or enlarged copy.
Eastman Kodak, or Recordak	FICO	File Control (FICO) is a method of filing and retrieving documents by blending microfilm and EAM cards. Output can be viewed or printed.

EXHIBIT B-6 (Continued)

MANUFACTURER	SYSTEM	DESCRIPTION
Ferranti-Packard	RAPIDAC	Rapid Access Lookup System (RAPIDAC) is a storage and retrieval system for graphic information. Provides display capability.
FMA, Inc.	FILE-SEARCH	Search, storage, and retrieval system for graphic information. Console provides display, hard copy, and duplicate record.
General Electric	SEARCH COMPARATOR	Search system designed to furnish address of stored information by selection from a descriptor index file.
Heatwole Associates	H-44	Console stores coded descriptive information and retrieves a list or count of documents.
Information Retrieval Corporation: Information for Industry, Inc.	CRIS	Command Retrieval Information System (CRIS) is a mass-image search and retrieval unit designed for compatibility with external coding systems. Provides hard or soft copy.
International Business Machines	WALNUT	Operational system for CIA with storage and search functions separated. Stored document duplicated on aperture card for off-line viewing or printout.
Jonker Business Machines	TERMA-TREX	A manual search and retrieval system, utilizing a special drilled card for each term, to furnish item location.

EXHIBIT B-6 (Continued)

MANUFACTURER	SYSTEM	DESCRIPTION
Laboratory for Electronics	RD-900 RASTAD	Provides electronic display of alphanumeric and line drawings stored in digital form.
Magnavox Corporation	MAGNACARD	Digital storage on magnetic cards. Provides hard-copy printout.
Magnavox Corporation	MAGNAVUE	Includes film aperture with magnetic card, and provides soft-copy option.
Magnavox Corporation	MEDIA	Appears to be "poor-man's MINICARD." Provides storage and retrieval of graphic information.
Minnesota Mining and Manufacturing	FILMSORT	Records graphic information on punched aperture card, and provides display and duplication components. Search capability provided by standard EAM equipment.
National Bureau of Standards	RAPID SELECTOR	Storage of graphic information in conjunction with hard-copy retrieval.
National Bureau of Standards	MICROCITE	Mass-image storage medium; projected image determined by illuminated card coordinates.
National Cash Register	CRAM	Stores digital information on magnetic cards to furnish a reference list for computer use.
Radio Corporation of America	RACE	Random-access card system for storage and retrieval of alphanumeric and pictorial information.

EXHIBIT B-6 (Continued)

MANUFACTURER	SYSTEM	DESCRIPTION
Radio Corporation of America	VIDEO FILE	Utilizes video techniques for storage and retrieval of documentary information, and furnishes rapid, hard-copy printout.
Rese Engineering, Inc.	FINDAFACT 2510	Transcribes punch-card data to magnetic tape, retrieves information on request, and maintains magnetic tape files.
System Development Corporation	RAP 600	Stores graphic information in slide form, and provides viewing capability. Used on teaching machine.
Dr. Jacques Samain, Paris	FILMOREX	Film-chip search, storage, and retrieval system; output used for viewing, enlarged print, or duplicate.
Houston-Fearless Corporation	AUTOMATIC IMAGE RETRIEVER	Electronically controlled, random-access photographic storage and retrieval system with viewing station and enlarged printout.

EXHIBIT B-7 INFORMATION PROCESSING SYSTEMS CHARACTERISTICS: FILE PREPARATION

SYSTEM	CODING	INPUT METHOD	INPUT RATE
ARTOC	14-bit, edge-notched holder	CRT, camera, processor, and slide	6-second film processing; 1-second Kalvar print
VERAC	Location specified by row, column, and plane; 7-digit address	Optical reduction (140:1 and 70:1)	Camera can be fed at 15 pages per minute
FLIP	Location indicated by binary-coded bits	Optical reduction (48:1)	Normal microfilm roll preparation limitations
DACOM	--	Magnetic tape character generator, and microfilm	14,000 characters per second
MINICARD	Alphanumeric, photographic (294-2,730 bits)	Optical reduction: text 60:1; maps 39:1; photos 20:1. Code paper tape to camera. Automatic selecting and sorting	Code: 35 characters per second Information: 500 pages per hour
FICO	Punched-card coding plus reference marks on film	Operator makes punched card for each original, which is then photographed	Scanning of original card-punching speed, photographic exposure, film advance, and processing control rate
RAPID ACCESS LOOKUP SYSTEM	3-character, 18-bit digital code.	Photographic	440 pages per hour
FILE-SEARCH	Maximum of 392 code bits; photographic	Code: punched card to camera. Information: 25:1 optical reduction	500 pages per hour

EXHIBIT B-7 (Continued)

SYSTEM	CODING	INPUT METHOD	INPUT RATE
SEARCH COMPARATOR	Digital	Normal input equipment	200 bits per inch 100 inches per second
H-44	Numerical	Victor portable keyboard	5 digits per second
CRIS	Location numbers	Photographic: master negative to Kalvar positive	Unknown
WALNUT	Address only; search via magnetic tape for abstract list in RAMAC	Optical reduction: first to microfilm, then to Kalvar. Final record, 35:1	1,500 frames per hour
TERMATREX	Card = term. Hole = item (inverted system)	Holes drilled in term cards to indicate items (manual)	Depends on speed of operator, probably 10-20 holes per minute
RD-900	Digital	Unknown	Unknown
MAGNACARD	6-bit alphanumeric maximum: 126 characters per card	Via MAGNACARD reading station, paper tape reader, punched cards, or magnetic tape	Read station: up to 5,400 cards per minute
MAGNAVUE	Digital; maximum characters, 756	Same as above and optical reduction	Same as for magnetic data
MEDIA	Binary-coded decimal form	Optical reduction; manual sorting and filing	Unknown
FILMSORT	Standard punched-card coding, 55-68 characters	Optical reduction (30:1) onto film or aperture card	Cutting and mounting; up to 400 frames per hour

EXHIBIT B-7 (Continued)

SYSTEM	CODING	INPUT METHOD	INPUT RATE
RAPID SELECTOR	Binary dots on film; 6 bits, machine information	Optical reduction (10:1 to 25:1)	Normal microfilm roll preparation limitations
MICRO-CITE	Address only; coincides with card coordinates	Optical reduction onto transparent cylinder	Unknown
CRAM	8-bit binary (edge notches)	From computer via tapes or cards	80,000 characters per second
RACE	14-bit binary, edge notching	Normal digital photographic, or video techniques	Digital: 140,000 bits per second Video: 2.7 documents per second
VIDEO FILE	Digital coding along tape edge (4 tracks)	Camera unit converts images to video signals for tape storage; index number recorded on digital track at same time	1 sheet per second (both sides), 2 sheets per second (one side). Read-in: 4.8 inches per second
FINDA-FACT 2510	Numeric	Magnetic or paper tape, punched cards	1,000 cards per minute
RAP 600	10-bit address	Optical reduction (variable)	Unknown
FILMOREX	Digital coding by photographi means	Optical reduction on 30-meter roll of 70-mm film	Unknown
AUTOMATIC IMAGE RETRIEVER	7-digit alphanumeric code	Optical reduction (40:1 or 80:1); address on magnetic drum	Unknown

EXHIBIT B-8 INFORMATION PROCESSING SYSTEMS CHARACTERISTICS: STORAGE CHARACTERISTICS

SYSTEM	SIZE AND TYPE	UNIT CAPACITY	SYSTEM DATA
ARTOC	Film-slide (Kalvar)	1 image per slide	1,000 slides for group display; 750 slides for console display
VERAC	High-resolution film sheet or plate, 8 by 12 square inches	Matrix: 100 by 100 images; 10,000 legal-size pages per plate	Basic capacity; 1,000 plates, 10 million legal-size pages
FLIP	16-mm, 1,200-foot microfilm reels	72,000 frames (1 image per frame)	Manual reel changes; number of reels limited only by requirements and financial considerations
DACOM	16-mm, 100-foot microfilm magazine	160,000 lines of data	Manual magazine change; number of magazines limited only by requirements and financial considerations
MINICARD	16 by 32 mm, high-resolution film chip	Maximum: 12 legal-size pages per chip	2,000 chips per file stick; 800,000 chips per file cabinet; number of cabinets limited only by financial considerations and requirements
FICO	100-foot roll of 16-mm film in magazine (4 by 4 by 1 inch)	Up to 3,000 frames	Manual roll change; number of rolls limited only by requirements and financial considerations
RAPID ACCESS LOOKUP SYSTEM	16-mm film loop	1 image per frame (800 to 1,000 pages)	Unknown

EXHIBIT B-8 (Continued)

SYSTEM	SIZE AND TYPE	UNIT CAPACITY	SYSTEM DATA
FILE-SEARCH	35-mm, 1,000-foot microfilm reel	30,000 pages per reel	Number of reels limited only by requirements and financial considerations; manual change
SEARCH COMPARATOR	2,400-foot magnetic tape reel	900,000 seven-character words	Number of reels limited only by requirements and financial considerations; manual change
H-44	1/4-inch, 10-1/2-inch audio, magnetic tape reel	5-subject codes for 30,000 documents	Number of reels limited only by requirements and financial considerations; manual change
CRIS	Kalvar film scroll (2 by 400 feet)	500,000 8-1/2- by 11-inch page.	Number of scrolls limited only by requirements and financial considerations
WALNUT	0.9- by 15.5-inch Kalvar film strip	99 images per strip	990,000 images per bin. Potential: 100 million pages
TERMATREX	9-5/8- by 11-1/2-inch (1-size) term card	10,000 to 40,000 items, depending on card size	Term capacity unlimited; item capacity limited by hole capacity of card
RD-900	High-density magnetic file drum	1.5 million alphanumeric characters	33 file drums: 50 million alphanumeric characters
MAGNACARD	1- by 3-inch magnetic card, mylar base	756 characters	3,000 cards per magazine; system capacity: 50 million characters

EXHIBIT B-8

SYSTEM	SIZE AND TYPE	UNIT CAPACITY	SYSTEM DATA
MAGNA-VUE	1- by 3-inch magnetic card, including film chip; 1 inch reserved for image	450 characters and 1 image	Two 10-magazine file blocks; 27 million alphanumeric characters and 60,000 images
MEDIA	16- by 32-mm film chips	2 document pages and digital data	200 chips per capsule; 100 capsules per drawer; 20 drawers per file (400,000 chips)
FILMSORT	Punched card with microfilm window	1 image plus code	Number of cards limited only by requirements and financial considerations
RAPID SELECTOR	35-mm, 3,000-foot microfilm reel	24,000 frames	Number of reels limited only by requirements and financial considerations
MICRO-CITE	15- by 4.75-inch diameter film cylinder	18,000 abstract images	Number of cylinders limited only by requirements and financial considerations
CRAM	3-1/4- by 14- by 0.005-inch magnetic card	21,700 alphanumeric; 35,500 decimal	255 cards per magazine; 16 magazines per computer system (additional magazines require manual change)
RACE	16- by 4.5-inch magnetic card, or microfilm	Digital: 940,000 bits Video: 16 pages	Based on 128 magazine system: 30.8 by 10^9 bit (digital), or 524,000 pages (video) or combinations

EXHIBIT B-8 (Continued)

SYSTEM	SIZE AND TYPE	UNIT CAPACITY	SYSTEM DATA
VIDEO FILE	2- by 14-inch by 7,200-foot magnetic tape reel	36,000 pages	Number of reels limited only by requirements and financial considerations
FINDA-FACT	2,400-foot magnetic tape reel	200 characters per inch	Number of reels limited only by requirements and financial considerations
RAP 600	Standard 2- by 2-inch, 35-mm slide	1 image per slide	600 slides
FILMOREX	70- by 45-mm film chip	2 document pages plus code. Maximum format of text: 30 by 45 cm	Manual feed to selector; number of chips limited only by requirements and financial considerations
AUTOMATIC RETRIEVER	63- by 87-mm film	850 pages per chip	Basic module stores 10,240 chips or 8,704,000 pages

EXHIBIT B-9 INFORMATION PROCESSING SYSTEMS CHARACTERISTICS: SEARCH AND RETRIEVAL INFORMATION

SYSTEM	INDEXING	CONTROL	RETRIEVAL RATES
ARTOC	Localized random access	MOBIDIC computer and symbol generator	1 image out of 1,000: 0.05-minute micro-film copy at 2 frames per second
VERAC	External alphabetical or magnetic tape index searched for location; then location dialed	Manual or paper tape	1 image out of 1 million: 1 second
FLIP	External index; user requests location number	Keyboard	60 inches per second or 300 frames per second
DACOM	Code format between film images	Plugboard	1 page out of 180,000: 15 seconds
MINICARD	Multiple entries; duplicate chip for each level of indexing to reduce search time	Plugboard; selector-sorter	1,200 chips per minute
FICO	Search card specifies roll and frame; film is marked every 10 frames	Manual or machine index search; Lodestar reader controls film	Average look-up time: 5 seconds Print time: 30 seconds for first print; 17 seconds for duplicate print
RAPID ACCESS LOOKUP SYSTEM	Address only; IBM card-punch supplies 3-character request	Keyboard	1 of 880 pages: 3 seconds
FILE-SEARCH	56 characters per frame; can be serial or by descriptors	Punched card via Flexowriter	4.5-minute average for 1,000 foot reel
SEARCH COMPARATOR	Digitally coded search words	Keyboard, card reader, paper tape or magnetic tape	900,000 words in less than 5 minutes

EXHIBIT B-9 (Continued)

SYSTEM	INDEXING	CONTROL	RETRIEVAL RATES
H-44	Up to 5-subject codes	Keyboard	Search per count: 1,500 five-subject documents Search per print: 1,000 five-subject prints
CRIS	External index; user requests location number	Keyboard	Estimates average from 7 to 20 seconds
WALNUT	Location punched on card, transferred to magnetic index with keywords	Keywords punched on paper tape that initiates magnetic-index search RAMAC	Index search 500 records per second; 6-second average access to document
TERMATREX	External listing for each hole	Coincidence viewing on light table	Manual listings; speed depends on ability and quantity
RD-900	10-character word identifies drum, track, starting sector, number of sectors to read	Keyboard control from computer	30 displays per minute
MAGNACARD	Table look-up for magazine, then automatic	CDC-160	90 cards per second; 500 lines per minute
MAGNAVUE	Same as MAGNACARD	Same	Average retrieval: 17 seconds
MEDIA	Random access through photographic code	Automatic equipment	Unknown
FILMSORT	Standard punched card	Sorter, collator, or manual	Duplicate cards: 2,000 per hour Enlargement: 10 to 15 seconds

EXHIBIT B-9 (Continued)

SYSTEM	INDEXING	CONTROL	RETRIEVAL RATES
RAPID SELECTOR	1- to 6-word machine "code" for document information	Bank of photocells scan code	300 feet per minute; 2,400 to 3,000 pages per minute
MICRO-CITE	Address only; keyed to inverted card system	Mechanical	--
CRAM	Digital	NCR 315	Card selected and read: 1/6 second or 170 milliseconds Reaccess: 1 millisecond
RACE	Digital Identification	Computer or special control unit	Access to retrieval information: From 1st magazine: 0.18 second From 32 magazines: 0.45 second Read: 400 inches per second
VIDEO FILE	Sequential index number	Paper tape input to merge control unit	Search: 300 inches per second Readout: 4.8 inches per second Print: 2 pages per second
FINDA-FACT	Serial search and punch card control	Plugboard and manual console	1,000 look-ups in 1 hour in file of 1 million 80-character records
RAP 600	Address stored in G-15 computer	Keyboard	0.12 minute for standard load (average)

EXHIBIT B-9 (Continued)

SYSTEM	INDEXING	CONTROL	RETRIEVAL RATES
FILMOREX	Coding capability for 20 descriptors of cross references	Manual	Selector handles 600 cards per minute
AUTO-MATIC IMAGE RETRIEVER	Address only	Keyboard accepts 1 to 64 address requests simultaneously	Single unit (average): 4.8 seconds Group of 64: 2.5 minutes

EXHIBIT B-10 INFORMATION PROCESSING SYSTEMS CHARACTERISTICS: SYSTEM COMPONENT DATA

SYSTEM	COMPONENTS	SIZE	DOLLAR COST	AVAILABILITY
ARTOC	MOBIDIC computer, symbol generator, camera, processor, console display, projectors	--	275,000	Developed for Signal Corps
VERAC	Step-repeat camera, storage and retrieval unit, optical or television unit, hard-copy reproduction machine	Library of 70,000 square feet into 1,000 square feet		No prices until market study made
FLIP	Self-contained console	56 inches deep by 31-1/2 inches wide by 53-1/2 inches high; weighs 900 pounds	50,000	Operational
DACOM	Module containing character generator, display tube, 16-mm camera, and logic and control subsytem	--	--	--
MINICARD	Typewriter, tape punch, copy cameras, film processors, film lubricator, film cutter, viewers and printers, selector-sorter, and computer-duplicator	--	2.5 to 3.5 million	Four installations for Government; one at Kodak

EXHIBIT B-10 (Continued)

SYSTEM	COMPONENTS	SIZE	DOLLAR COST	AVAILABILITY
FICO	Camera, EAM equipment, Lodestar reader-printer	Reader-printer 31 inches high by 16 inches wide by 28 inches deep	2,650 (reader-printer	In production
RAPID ACCESS LOOK-UP SYSTEM	Filming table, look-up and display unit, interrogator	--	34,000	--
FILE-SEARCH	Recording unit retrieval unit	71 by 55 by 50 inches (retrieval unit)	115,000	First commercial installation at Bureau of Ships, 1961
SEARCH COMPARATOR	Console, optional alphanumeric printer	72 by 30 by 40 inches	100,000	Prototype displayed
H-44	Console, keyboard, and printer	67 by 22 by 43 inches	9,500	Developed and tested
CRIS	Basic unit is console with film control, projector and display, and keyboard; other features optional	Console is desk size		Manufactured by Litton Systems, Inc.
WALNUT	Microfilm unit, card punch, tape punch, image converter, tape reader, RAMAC computer	--	--	No plans for marketing

EXHIBIT B-10 (Continued)

SYSTEM	COMPONENTS	SIZE	DOLLAR COST	AVAILABILITY
TERMA-TREX	--		1,000 to 6,000	In production
RD-900	File drums, symbol generator, viewing console, control units	--	--	Developed for Corps of Engineers.
MAGNACARD	Card handler, control unit, printer, CDC-160 computer	--	Component price list available	12 months from order
MAGNAVUE	Same as MAGNACARD plus display station	--	250,000 to 450,000	--
MEDIA	Copy equipment, storage capsules, and control equipment	--	Supposed to be "low cost"	Under development
FILMSORT	Filmac reader-printers, mounters, and copiers; standard EAM equipment	--	10,000 to 25,000	In production
RAPID SELECTOR	Camera and encoder, microfilm copier	--	--	A National Bureau of Standards development
MICROCITE	Uniterm cards, camera, machine with viewer and printer	--	--	A National Bureau of Standards development
CRAM	--	--	38,000/ month rental	Developed in early 1962; with NCR 315 system

EXHIBIT B-10 (Continued)

SYSTEM	COMPONENTS	SIZE	DOLLAR COST	AVAILABILITY
RACE	Control mechanism, hard- and soft-copy equipment	--	--	Under development
VIDEO FILE	Merge control, printer, monitor, soft-copy reader, status and switching panel, video recorder	Recorder: 72 by 47 by 22 inches Merge control: 72 by 19 by 22 inches		Under development
FINDAFACT	Control unit, tape stations, input-output	--	--	--
RAP 600	G-15 computer, random-access projector, standard photo equipment		8,000	Presently available
FILMOREX	Filmorex camera, Filmorex selector	Selector: 75 by 50 by 40 cm	France, 10,000 Estimated U.S., 25,000	Operational; a French product
AUTOMATIC IMAGE RETRIEVER	Camera, keyboard, selector, viewer, printer		250,000	Developed for USAF

EXHIBIT B-11 INFORMATION PROCESSING SYSTEMS CHARACTERISTICS: SUMMARY STATEMENTS

SYSTEM	COMMENTS
ARTOC	Designed specifically for military field use as display system; limited storage capabilities
VERAC	Primarily a storage system; requires separate search system and is virtually impossible to update
FLIP	Display console utilizing microfilm reel storage; requires separate search system; serial access and manual reel change; no hard copy provided
DACOM	Designed for business applications and may not be suited for IS&R: fills component role in system that requires microfilm output from computer
MINICARD	Large storage capacity and random-access filing; very expensive, separate chip required for each indexing level and cross reference; chip combines index with storage; manual selection of file sticks
FICO	Manually operated microfilm storage system utilizing punched cards for item addresses; designed for office records; low cost; slow operation
RAPID ACCESS LOOKUP SYSTEM	Temporary individual display of limited library requiring little updating; requires separate search system
FILE-SEARCH	Combines search and storage function in console utilizing microfilm reels; manual reel change; updating possible by splicing; slow retrieval
SEARCH COMPARATOR	Search system only utilizing magnetic tape storage; may contain abstracts; could be used in conjunction with separate document storage
H-44	Search system only utilizing magnetic tape storage; limited storage; printout capability
CRIS	Storage system only; updating virtually impossible; manual scroll change; requires external search system

EXHIBIT B-11 (Continued)

SYSTEM	COMMENTS
WALNUT	Complete IS&R system with human interrupt between search output and retrieval input; very expensive; image storage accessed by address randomly
TERMATREX	Manual search system only by coincident viewing; inverted card files with each card a term and each hole an item
RD-900	Display system utilizing drum storage and symbol generator; generates line drawings from digital storage
MAGNACARD	Computer-controlled, random-access card file; stores digital information only; table lookup for magazine reference
MAGNAVUE	MAGNACARD with film aperture; includes display stations
MEDIA	Film-chip storage system; information on characteristics lacking; chip similar to MINICARD with less unit storage
FILMSORT	Standard punched cards with film aperture; partly manual operation with automatic card sorting, mounting, and duplicating; a complete IS&R system when fully implemented
RAPID SELECTOR	Modified version of an old microfilm storage system; large reel-storage capacity; microfilm printout; updating only by splicing
MICROCITE	Manual-mechanical system primarily for browsing through abstract collection on film cylinder
CRAM	Random-access magnetic card storage for NCR 315 system; designed for business applications
RACE	High-speed, random-access, card-storage system; operation with or without computer; storage in digital, video, or microfilm form; hard- and soft-copy output
VIDEO FILE	Mass document storage in video form; computer controlled; high-speed serial access; updating, transmission, and reorganization capability; hard and soft copy

EXHIBIT B-11 (Continued)

SYSTEM	COMMENTS
FINDAFACT	Component in system for manipulating magnetic tape files; limited IS&R application
RAP 600	Temporary group display of limited library; teaching machine application; computer-controlled random-access slide file for projection
FILMOREX	French film chip system available through Benson-Lehner; not known to be in use in U.S.A.; similar to MINICARD but 70-mm chips
AUTO-MATIC IMAGE RETRIEVER	Computer-controlled film-slide storage system; being developed for RADC; random access, large storage fast retrieval

system control programs are constructed of macro instructions. This provides a flexible, integrated capability to respond to varying user requirements.

The C-8500 software language provides byte (8 bit), half word, single word, single word (32 bits), and double-word addressing (allowing indexing at any level) to provide a character-oriented, logical and/or numeric processing capability. The instruction set provides character, logical, fixed, and floating-point operations.

The software capability is divided into three major areas: computer system control programs, programming aids, and application-oriented macros. The various system programs provide software support for standard system configurations.

The computer system control programs operate the multiplex communication loop and supervise record channel communications. Access to the common file and efficient use of shared storage are also provided by the system control programs.

Programming aids include two language processing systems: a compile and execute FORTRAN IV system that provides conventional scientific computer capabilities and a macro assembler that provides direct access to system features as well as a means of constructing programs and systems from previously programmed macros. An automatic program test system is also included.

To assist in general operation of the application program, Collins Radio furnishes a system control package consisting of the following subroutines:

- Program Request--provides the necessary functions to request a new program from storage.
- Control Message Processor--a general control message language and required decoding facilities.
- Relocatable Loader--loads object programs from secondary storage to core memory and places it in the location specified by the programmer.

- Directory Maintenance--maintains a listing and provides the interface to the system library.
- Error Control--provides a known environment for the software package so that errors can be detected.

Information transmitted to or from the multiplex communications loop is under control of the Multiplexer Processor Program. This package reduces initial programming time by providing multiplex supervisory and device-oriented macros.

The CCP (Communication Control Program) handles all requests pertaining to input/output operations involving the record channels. The CCP places all communication requests in a queue to be served on a first-in/first-out basis. Control is obtained through an interrupt or through an applications program request for I/O data.

A basic concept of the system is the use of a common data base. The FSP (File Service Program) controls all references to secondary storage. The FSP provides a common interface serving both as a real-time checkpoint and for organization of secondary storage backup as required.

A section of core storage is used by the FSP as a core buffer for data base activities. This permits all transfers to be on a record basis optimizing all references to secondary storage.

The macro assembler provides a consistent language and assembly system that reduces the total programming effort by making available a set of macros. The program does the following:

- Translates the symbolic assembly language into programs capable of direct loading and execution by the computer.
- Inserts predefined macros into the assembler stream.
- Requests the loading and execution of preassembled programs.
- Allows the user to define commonly used sequences of symbolic machine language instructions as macro statements.

Collins FORTRAN IV contains as a subset the proposed ASA FORTRAN Compiler. Several additional features have been implemented in the Collins version, permitting increased logical capability, more powerful computation, and greater flexibility.

Some of these features are

- Multiple replacement statements.
- Arbitrary origin permitting negative and zero subscripting.
- An Else path implemented on the logical IF statement.
- Numeric variable types (integer, real, double precision, and complex) freely intermixed in arithmetic expressions.

To reduce the checkout and test time of previously assembled programs, a Program Test System is provided. It is controlled by user-supplied parameters, and no changes are required in the program to be tested. The test program contains a file generator that produces and conditionally displays specified files.

A generalized sort/merge program is provided. The file to be sorted may be either on disk or drum. Output is also on a random access device. As an added feature, user-coded subroutines may be added before the sort is performed, or after sorting, and before the data is written on the output file.

Many standard utility routines are offered to the user including card to tape, card to disk, card to printer, etc.

(b) CDC (Control Data Corporation)

The MICRO assembly system provides a convenient means for producing machine language programs for the 5400 Digital Computer. The assembly system consists of a source language, a translator, and an object language. The source language, MICRO Assembly Language, is the symbolic machine language for the 5400. The translator, MICRO, operates under the Control Data 1604 CO-OP or 3600 SCOPE Monitor Systems. MICRO accepts MICRO source language and outputs binary object language and an output listing of the source and object languages.

The simulator operates the Control Data 1604 CO-OP or 3600 SCOPE Monitor Systems. It provides for bit-by-bit simulation of the 5400 object language program's output by the MICRO assembly system. The simulator can be used with the MICRO assembler to assemble and simulate a 5400 program in one computer run, or the simulator can use as input the object language programs that have been output by the MICRO assembly system on a previous run. The simulator provides debugging aids such as snapshot dumps, traces, time limits, and bound limits.

The tape preparation routine inputs binary language programs that have been output by the MICRO assembly system and produces a paper tape of the programs in a format acceptable for input into the Control Data 5400 Digital Computer.

The arithmetic routines that are available include: sine, arcsine, cosine, arccosine, and square root.

Fault isolation programs designed for preventive and diagnostic maintenance of the 5400 Digital Computer include memory tests, command tests, stop test, interrupt test, and input/output.

Standard software packages for the Control Data 1700 include a monitor or executive system that will oversee the operation of other standard or special packages within its framework; an extensive, modular, industrial control package; basic and expanded assemblers; an efficient FORTRAN IV compiler; and various utility, I/O, and arithmetic packages. All standard Control Data 1700 software will operate on-line and in real time and has been designed to expand system utility by minimizing the need for specially designed software routines.

The software package for the 6400/6600 Systems is designed to complement and to maximize the operating characteristics of the hardware. Organized in product sets, the package offers an overall operating system and subordinate programs. The approach is traditional, making the languages used familiar to most programmers.

The operating system is designed to reside in peripheral processor memory, requiring little central memory space or time while in operation, performing housekeeping chores and monitoring the flow of data into and out of the system.

Specifically designed for use with the operating system are

- Assemblers with symbolic instruction, system macros, programmer-defined macros and pseudo-commands.
- Compilers featuring a new, powerful FORTRAN with ASA compatibility and an automatic, built-in capability for fully utilizing the concurrency of the central processor. Other compilers include COBOL and ALGOL.
- Special programs are available to help with the management of information. These include file/manager for automatic file maintenance, sort/merge, and PERT-time.
- SIMSCRIPT for simulation programming. APT for numerically controlled machine tools.
- LP for linear processing.
- KWIC for fast retrieval of information from data files.
- Special subroutines for performing statistical functions, matrix algebra, and for the use of extended core storage.

(c) DEC (Digital Equipment Corporation)

The PDP-10 software features include the following:

- Monitors 10/10, 10/20 and 10/30 single-user monitors for 8K paper tape, 8K DECtape, and larger systems respectively with I/O controller; run time selection of I/O devices; job-to-job transition; job save and restore features; memory dumps; system builder permitting creation of custom tailored monitor; and I/O systems.

- Monitor 10/40 is a field tested and proven multiprogramming time sharing system with powerful command structure incorporating all of the features of monitor 10/30 with concurrent real time processing, batch processing, and time sharing.
- Monitor 10/50 is a full range disk swapping multiprogramming time sharing system incorporating all of the features of monitor 10/40 with greatly extended capacity.

Complete utility software includes:

- FORTRAN IV, an ASA standard single-pass compiler with highly optimized object code fully exploiting PDP-10's instruction set.
- MACRO Assembler, a flexible assembly language with sophisticated macro facilities and many special data generating, conditional assembly, listing and control pseudo-operations.
- TECO, a context editor with sophisticated macro facilities and iterative string search, match, and substitution operations.
- DDT, an on-line symbolic debugging aid with more than 50 commands, permitting dynamic interaction with running programs.
- Linking Loader, loads and links independently assembled or compiled relocatable or absolute binary programs. Twenty special options including automatic library search and chaining facilities.

- Peripheral Interchange, transfers alphanumeric or binary data from or to any I/O device with optional editing, sequencing, merging, and syntax checking features.
- FORTRAN IV Operating System, a library of more than 100 routines including double precision and complex functions, dump and chain facilities, and dynamic assignment of I/O devices.
- LISP Interpreter, a desk calculator with macro facilities, and a library editing and updating system.

The PDP-9 ADVANCED software system is a relocatable software package combining sophisticated programming features with flexibility and ease of use. This package includes a FORTRAN IV compiler, a macro assembler, an on-line debugging system, a symbolic editor, a peripheral interchange program, a linkage loader, an input/output programming system, and a monitor.

Two versions of the PDP-9 software system were supposed to be available by July 1967: (1) a simple input/output monitor system with paper tape input/output or card input facilities; (2) a more sophisticated monitor-based, device independent system for users with one or more forms of bulk storage. Both systems will be compatible.

(d) EMR (Electro-Mechanical Research)

EMR supplies a complete set of software packages designed for use with data systems. Available software packages include:

- The EMR processing system readiness and set-up program, which accepts modular telemetry processor (MTP) control parameters in engineering terms and generates the computer data required to control the

MTP units. The program determines whether the parameters entered comply with the equipment configuration. The program then verifies that the parameters entered generate a valid system data path. When these checks are successful, the parameters are entered into the units and control is returned to the calling program.

- The EMR system diagnostic program is designed to evaluate the performance characteristics of the peripheral modular telemetry processors. The program consists of a structured group of investigative routines written to isolate malfunction areas. These routines provide both a diagnostic tree for use during system preventive maintenance and a set of test loops for use in conjunction with corrective maintenance.
- The one-pass complete FORTRAN compiler includes subroutine and function statements, arithmetic function statements, and Boolean algebra statements. The one-pass feature provides output in machine language binary from the FORTRAN program input. Program chaining permits programs whose size exceeds that of the processor memory to be run in segments with one magnetic tape unit.
- The EMR one-pass symbolic assembler is an assembly program that permits the use of standard macro coding of such functions as floating-point routines and input/output routines. Special features of the symbolic assembler include pseudo codes such as ENTRY, COMMON, and LINK, which permit flexible linkage, data sharing among subroutines, and program overlay. The symbolic assembler provides for the acceptance of source program from cards, paper tape, and magnetic tape.

- The operating system, MONITOR, briefly increases programming and operating efficiency with the minimum requirement of storage space and computing time. It is designed to make maximum use of a very small resident monitor program that maintains continuity of job processing and provides input/output control in interrupt-processing capabilities. Additional routines for utility operations, program debugging, library editing, and program voting are stored in the system file and called into storage when needed.
- The real-time executive is a modularized program designed to provide the user with a flexible and efficient means to generate, organize, and test on-line programs for such applications as remote terminal experiment processing and special systems control. Any object program may be written in FORTRAN for assembly language, compiled or assembled, tested and integrated into a specific system while the system is operating on-line and performing its main process-monitoring functions. Batch processing programs, such as data analysis, utility routines, and commercial and report programs, may be time-shared and run concurrently on the system while the executive is monitoring the on-line functions being performed.
- EMR provides an extensive set of mathematical subroutines and utility routines that allow tape reproduction, conversion of cards to tape and tape to cards. Memory dump, paper tape updating, etc., are also available.

(e) General Electric Company

The operating system for the General Electric Time-Sharing System consists of four parts: the master executive program; the editing, translating, executing, and bookkeeping programs; the programming languages; and the system library.

- The master executive program is used by the DATANET-30 to control the remote consoles. This program permits the system to operate in two modes real-time and spare-time. The real-time portion of the executive program scans the DATANET-30 communication lines for incoming and outgoing data by means of clock-controlled interrupts 110 times per second per active user. The spare-time part of the program carries out the DATANET-30 spare-time tasks, such as catalog listings. Spare-time tasks are done in the intervals between real-time functioning.
- The editing, translating, executing, and bookkeeping programs are performed by the GE-235. The executive routine permits simultaneous use of the card equipment, magnetic tape drives, and high-speed printer, during time-sharing operation.
- Three algebraic languages, BASIC, FORTRAN, and ALGOL, are available for the system. These languages are fast, requiring typically 1 to 4 seconds for the compilation and execution of a program. Because of this speed and because of the speed with which file changes are made, the program is recompiled at each run. Thus, no special debugging is required, and program development is straightforward and rapid. In addition, both of these languages allow interaction by the user with his program as it is being

executed. Thus results can be printed out on the Teletype unit, or on-line input statements may be used to read-in values of integers and floating-point numbers to control the course of program execution.

- The system library contains a wide selection of programs available to any user of the system.

(f) EDP Division of Honeywell

A summary of the Honeywell 400 and 1400 software includes:

- AUTOMATH, a scientific compiler for the H-400 and H-1400 that translates mathematical notation (FORTRAN II) into machine instructions and then executes the programs. The total compatibility with non-Honeywell compiler languages affords users easy access to the vast numbers of available, previously compiled programs. The AUTOMATH 400 and 1400 compilers operate in a load-and-go fashion.
- Routines that generate coding which reads punched cards, edits the card data, and stores the data in memory.
- COBAL, a business data processing compiler that translates the description of a data processing problem written in common, standardized business English into machine code.
- EASY I, an assembly system for the 1024-word H-400 designed to simplify programming through a standard language. The EASY I system includes programs for updating, tape handling, loading memory, memory and tape dumps, and other common data processing operations.
- EASY II, a programming and operating system designed to assist the H-400 and H-1400 computer users. The

system includes an assembly program; a master program updating and selection run; a library and maintenance program; a monitor; sort and collate programs; and other utility routines.

- LAMP/PSP, a program that combines a program for maintaining the library of subroutines and macroroutines available through the EASY assembly systems, and a program for selecting specific tape programs from a master tape for checkout or production runs.
- A tape-oriented linear programming package that will optimize a function subject to a system of linear restraints. As many as 300 equations can be accommodated. This package is designed to assist management with operational problem analysis and decision making.
- Monitor, a system of programs and routines that supervises the loading and operation of checkout, production, and systems runs. The functions include: controlling test data distribution, providing memory and tape dumps, Orthocorrection routine, loading and starting programs, etc.
- PERT (Program Evaluation and Review Technique), a management control aid for estimating the time required to complete a project and for evaluating the project's status, based on the principle that a small percentage of the activities involved in a major project control the schedule for the entire project.
- Pilot, a system that creates, updates, and maintains a file of H-400 EASY I master programs on tape.
- A routine that performs the editing, output, and control operations required when printing a report in a specified format, when writing a tape to be printed off-line, or when punching a card deck.

- A matrix package that consists of programs involving matrix theory (matrix inversion, solutions to systems of linear equations, etc.).
- A statistical package that computes correlation coefficients and standard deviations, performs curve fitting, and a program to compute multiple regression. Other programs include finding solutions to systems of differential equations, interpolation, evaluation of trigonometric functions, etc.
- Routines that read and write tape data, and perform all associated control functions, eliminating the preparation of detailed coding for each tape file by the programmer.
- TABSIM (Tabulator Simulator), a simulator program to speed the conversion of tabulating equipment tasks to computer processing. It is a "load-and-go"-type package that permits users to run tab jobs, as they exist, on the H-400/1400.
- Sort and collate programs that provide a fast and versatile method of ordering a file and of combining several pre-ordered files. The programs may be used separately or together as the situation demands. High sorting speeds are achieved with the polyphase technique developed by Honeywell.

A summary of Honeywell 800 and 1800 series programs includes:

- ADMIRAL (Automatic Dynamic Monitor and Immediate Relocation, Allocation, and Loading), a dynamic monitoring system designed to control the scheduling, loading, and starting of programs and to supervise their execution on H-1800 and on H-800 computers with large memories.

- ARGUS (Automatic Routine Generating and Updating System), a central assembly system that reduces programmer effort and increases the efficiency of program preparation. All H-800 and H-1800 series software, except COBOL, PERT, AUTOMATH, and the scientific programs, are tied into ARGUS.
- AUTOMATH, a scientific compiler that translates mathematical notation into machine instructions. The AUTOMATH 800 will accept FORTRAN II language; AUTOMATH 1800 (which will also run on large H-800 systems) will accept FORTRAN IV.
- Boot Strap and Loader routines that load systems programs into memory.
- COBOL (Common Business Oriented Language).
- A report writer that produces reports in any specified format. Using parameters, it creates routines that obtain data from a source location, edits it, and records it on tape or prints it on-line.
- Executive, an H-800 system that facilitates the daily scheduling and operating of programs by the user and reduces the number of housekeeping programs that must be written for data processing applications.
- FACT (Fully Automatic Compiling Technique), a business data processing compiler that provides for easy and uniform handling of all aspects of data processing, including input editing, sorting, processing of variable-length records, and report writing, all in a standardized English language.
- LAMP (Library Additions and Maintenance Program), a program that maintains the library of subroutines and macroroutines available through the ARGUS assembly system.

- A Management Control Aid, consisting of two major packages that employ mathematical techniques for operational problem analysis for attaining operational optimization.
- PERT (Program Evaluation and Review Technique).
- PSPA (Program Selection Process A), the process that selects from the symbolic program tape the programs and test data to be executed during a checkout run.
- PSPB (Program Selection Process B), a routine that prepares a master relocatable tape of checked-out programs for input to an executive scheduling and production run.
- PTS (Program Test System), a system that checks out object programs, producing diagnostic information where necessary to aid in production run optimization.
- A series of programs to aid in the solution of problems in the areas of matrix handling, differential equations, and statistics.
- A differential equations package designed under the Runga-Kutta and Clippinger-Dimsdale methods.
- A package of routines that perform computations to determine means, standard deviations, correlation coefficients, random numbers, to perform curve fitting, and to compute multiple regression.
- A matrix package that contains routines for solving systems of linear equations, data analysis requiring matrix inversion, and finding eigenvalues and eigenvectors in factor analysis. Provision is made for both symmetric and nonsymmetric matrix inversion.

- Mathematical subroutines that perform trigonometric and complex functions, floating-point simulation, exponential and logarithmic functions, polynomial routines, and interpolation.
- SCOPE (System to Coordinate the Operation) of a group of macroroutines that optimize the use of peripheral devices during parallel operation. Card readers, card punches, and high-speed printers are controlled for simultaneous operation at nearly full speed.
- A series of routines that create sort programs using new programming techniques for more efficient operation, faster speeds, and more universal application.
- STAMP (System Tape Additions and Maintenance Program), a program that simplifies making up the file of systems programs on the symbolic program tape or master relocatable tape; it reduces significantly the time and effort in updating, correcting, and maintaining the systems programs on these tapes.
- Routines that read and write tape data and perform all associated control functions, relieving the programmer of preparing detailed coding for each of his tape files.
- THOR (Tape Handling Option Routines), a utility program that positions, copies, corrects, and edits tape; it also locates data on tape, compares the contents of two tapes for discrepancies, and performs general tape maintenance.

(g) Honeywell, 3C

The Honeywell 3C FORTRAN compiler has been designed to accept statements and translate them into the machine language of the DDP-224, and will also translate Boolean statements that provide capabilities for logical operations with full words or any part of a word all in the same FORTRAN program. These capabilities are provided for the basic system (4K, paper tape reader and punch, and typewriter).

The DAP (symbolic assembly program) is a two-pass assembly program that will translate a language that is more closely oriented to the machine language of the DDP-224. The language format conforms with SHARE standards and DAP accepts all of the basic instruction mnemonics plus extended machine and pseudo-operations. The following are some of the operations that are included in the language and are familiar to most programmers: ABS, BCI, BES, BSS, DEC, EQU, OCT, ORG. Object output may be either relocatable or absolute; symbolic output is in the form of a side-by-side listing on the typewriter (unless the programmer specifies that he does not want a listing). Subroutine linkage is provided permitting FORTRAN compatibility.

DIP (scientific interpretive programming system) is a programming aid that is especially designed for the occasional user. With little training, personnel with minimal programming experience can use the DDP-224 for scientific computation with ease. As a training tool, DIP's simplified structure (which eliminates number system conversions, scaling, and other rules unfamiliar to the inexperienced) makes it helpful as an introduction to the fundamentals of digital programming.

DEP (executive control program) is a self-loading program that interprets commands entered through the typewriter. This program would typically remain in memory most of the time and would perform, upon demand, functions such as the following; dump specified memory locations; load a program; load consecutive memory locations; punch out memory; clear selected memory location, etc.

The utility routines include paper tape I/O routines, typewriter I/O routines, program load routines, formatted memory dumps, data conversion routines, card I/O routines, magnetic tape routines, etc.

The service routines include double-precision, fixed-point routines, transcendental functions, program diagnostic routines, hardware diagnostic routines, etc.

(h) IBM (International Business Machines)

Operating System/360 provides a fully monitored operating environment for users having 32K or more of core storage and one or more disk or drum units for system residence. Design emphasis is upon meeting the needs of users who will benefit from the more comprehensive services that a larger operating system can provide. This system permits the user to select from a wide range of control program features and from a number of different compilers and service programs. Operating System/360 emphasizes the following capabilities:

- Device-independent operation via symbolic assignment of I/O devices that permit user to specify the devices to be used at program execution time.
- Object program compatibility, provided via compiled and tested object programs which operate with a wide range of different control program configurations and features, as well as with different system configurations.
- Execution time supervisor services, provided to the object programs at program execution time, upon request to the system supervisor programs. Such services include I/O functions, allocation of main and secondary storage space, dynamic program linkage, parallel processing, checkpoint, and interval timer service.
- Data management service programs, provided for identifying all data and programs to be used, along

with uniform methods for organizing, storing, and retrieving data, and cataloging its physical location.

- Remote terminal controls and message-switching facilities that can be handled concurrently with other processing without the need for a separate processing system.
- Priority controls that allow job input, scheduling, execution, and output transcription to be performed according to job urgency rather than upon actual sequence or time of entry, shortening the cycle from entry to completion.
- A wide range of compilers that operate under Operating System/360. These include compilers for the COBOL, FORTRAN, PL/I, Assembler, and RPG source languages. A selection of different compilers is available, at design points of 13K, 44K, and 200K core storage.
- Service programs that include a complete sort/merge system that automatically selects sorting techniques according to the data to be sorted and the configuration of equipment available for use in the sort. Up to 16-way merges may be performed. Intermediate storage may be tape, drum, or disk storage units.
- A variety of data editing and utility-type programs.

(i) RCA (Radio Corporation of America)

Software-controlled operations for Spectra 70 are designed to permit progress in easily managed steps and with minimized expenditure of programming effort and operator intervention during system evolution from file maintenance with a mass data base to total management information.

Multilevel operating systems embody the elements required for the performance of a particular task in an application. The software integrates the modular capabilities of Spectra 70, automatically coordinating and executing all input/output instructions; initiating error recovery techniques; monitoring the scheduling and performance of multiple programs within the same or among a number of different processors; and switching, queuing and relocating programs as necessary.

Advanced concepts are incorporated in the operating systems for the various RCA processors. In general, these software systems will be provided at steps of increasing power, reflecting memory capacity, and in magnetic tape and random access versions. This concept has simplified stepping-up from lower to higher level software systems when memory increments are added for more workpower. Continuity is maintained for the user through common sets of commands and standardized operational control.

The multilevel operating systems provide technical people with executive control, language processors, system maintenance routines, assembly systems, peripheral control system, file control processor, and numerous other standard operating system components (both magnetic tape and random access oriented). The higher level operating systems also provide multiprogramming capability.

Priority multiprogramming is oriented toward the concurrent operation of several types of applications. Assignment of priority levels is at the discretion of the user. For example, one priority level can be reserved for a program that must provide rapid responses to real-time devices, such as communications control. Another can be reserved for the peripheral control package to accomplish several media conversions, such as card to tape, tape to printer, etc. The third priority level could then be used to run either a production or monitor job.

When languages fail programmers in conveniently expressing unique problems, programmers can call on the new RCA extended assembly system to coin, in effect, their own languages. This system contains directives that enable programmers to essentially define a new assembly language particularly suited to their needs. A case in point might be when programmers cannot express the solution to a problem concisely in one of the standard languages, such as COBOL or FORTRAN.

Spectra 70 is scientifically oriented. Its design characteristics offer large core storage of up to one million numerics. It provides 44 floating-point and 35 fixed-point instructions. This system features complete interchangeability of data format; implements three-dimensional addressing capabilities; supplies 32 priority interrupts; and includes hardware double-precision, coupled with ease of multiple precision. In combination with its variety of external devices, these features provide the user with the power required to implement the advanced scientific and management science applications.

RCA is taking advantage of these features to provide the user with a wide spectrum of operations research applications. These will include powerful statistical analysis techniques, an efficient matrix manipulation package, a comprehensive linear program code, and numerous other powerful tools for the use of the manager in his decision-making problems.

(j) Raytheon Company

The Raytheon 703 software system has been specifically designed for use in on-line, real-time applications including data acquisition, message switching, inventory control, and supervisory control.

Software for the Raytheon 703 includes two assemblers and loaders. A one-pass assembler is available for systems without mass-storage capabilities. This program permits direct on-line assembling using the ASR 33 as the primary input device. A more powerful two-pass assembler is available for sy ms with magnetic tape or disk storage. This version includes mac capabilities and other advanced features. The loaders will process absolute or relocatable programs and provide loading and linking of library subroutines.

X-ray software includes debugging aids and utility routines operating under executive program control. The software has been organized to take full advantage of the real-time, on-line capabilities of the 703. For example, X-ray permits operation in the conversational mode with a variety of control directives that provide simplified software generation, operation, and debugging. X-ray also provides automatic and rapid access to a program library stored on disk or magnetic tape. The 703 has an extensive library of utility programs and debugging routines that allow memory dumps, trace, program and library editing, and on-line program correction.

Particular emphasis has been placed on the design of a comprehensive library of diagnostic programs. These programs are designed for ease of maintenance. The functions that are performed include verification of correct operation, fault isolation, and assistance in equipment adjustment. Diagnostic programs are organized and documented for utilization by technicians with minimum training and experience.

An extensive library of mathematical subroutines is provided. This library includes subroutines that perform floating-point arithmetic and double-precision, fixed-point arithmetic. Subroutines that perform sine, cosine, arctangent, logarithmic, exponential, and square root functions are also provided.

(k) SDS (Scientific Data Systems)

SDS provides software that includes operating systems, FORTRAN compilers, assemblers, and a complete package of business software. This array of modular software expands in capability and speed as a system grows, without reprogramming.

Sigma programming systems automatically perform many routine functions, freeing the user to concentrate on the problem to be solved. As a result, user programming costs are reduced.

SDS software employs programming techniques to minimize storage requirements and operating time, and to produce efficient object code. For medium and large configurations, the software makes use of the SDS RAD (Rapid-Access Data) file to increase throughput. In addition to a basic programming package, Sigma allows users to select higher level and intermediate-level programming languages.

Sigma 5 and Sigma 7 operating systems include the following:

- A basic control monitor, designed for real-time systems with concurrent general-purpose processing which permits simultaneous operation of a real-time foreground problem and a general-purpose background process which can be independent of or related to the real-time problem.
- A batch processing monitor that is a natural superset of the basic control monitor. Designed for a typical production environment in which many jobs are being processed from a job queue, batch processing monitor permits background and foreground operation simultaneously with many concurrent buffered peripheral operations.
- A universal time-sharing monitor for Sigma 7 that is also an operating system specifically designed to efficiently control conversational time sharing. It handles all of batch monitor capabilities as well as automatic swapping to or from secondary storage,

tertiary mass storage control, and tasking in a time-sharing environment. It provides for multiple users in a variety of modes (batch, conversational, real-time, etc.) and permits multi-use of common reentrant processes.

- FORTRAN IV-H exceeds ASA specifications for FORTRAN IV. It is compatible with the compilers for other large-scale computers. SDS FORTRAN IV is a compatible superset of FORTRAN IV-H. It provides a large number of important additional language features. The debug mode of SDS FORTRAN IV places special emphasis on diagnostic error-checking of user programs. The high-efficiency mode of SDS FORTRAN IV uses advanced compilation techniques to produce efficient object code. A Conversational FORTRAN IV is also provided for time-sharing applications.

System applicable assemblers include:

- Symbol, which accepts symbolic input from various media and translates standard SDS Sigma mnemonics and symbolic expressions into machine language.
- Meta-Symbol, a compatible superset of Symbol, which provides additional capability including functions and procedures. It is a powerful tool for developing software systems for any object computer.
- SDS COBOL-65 provides a convenient, and widely accepted programming language for business applications. The language specifications conform to proposed ASA standards. They include the sort/merge, a report writer, and a table-handling feature. A 1401 simulator package minimized the problems associated with converting 1401, 1440, and 1460 programs. The generalized sort/merge package uses improved techniques

based on the high-performance rapid-access data file for fast sorting and merging.

- Maintenance software for the standard off-the-shelf system interface units includes analog calibration and checkout programs, which operate under a stand-alone diagnostic control program. Standard analog and digital input/output handlers are provided. More than 230 utility and mathematical programs are available in the system library.

(1) UNIVAC

In the 9000 Series, programming capabilities are matched with equipment configurations. The operating system covers the range of equipment capability; programming languages for the smaller 9000 Systems are actually subsets of the languages for the larger configurations. The programming transition from one system to another is a growth process toward greater flexibility.

UNIVAC 9300 configurations with at least four tape units and 16K memory are tape oriented and incorporate control stream operation. Introduced through the card reader, control stream governs system operation and introduces transaction data to be processed by the programs. With this approach, one properly organized card deck allows the system to process a series of jobs in an automatic, controlled sequence, without operator intervention.

In addition to control stream operation, tape-oriented 9300 Systems gain the advantage of a complete range of tape software, including an assembly system, FORTRAN IV compiler, tape report program generator and tape utilities. Multiple operations can be performed concurrently beginning with a 32K, five-tape system. With concurrency, one or two peripheral tape programs (card-to-tape, tape-to-print, etc.) can be run along with the central program. This two- or three-way concurrency means faster reporting capability and more flexible program scheduling. The computer's time is utilized more efficiently and its maximum throughput capability realized.

C. Vendor Glossary

Access, Random : The process of obtaining information from or placing information into a memory or storage system when there is no systematic relation governing the successive locations or positions involved.

Access Time: Time required to read or write a character, word or field in a particular location.

Address: A label, consisting of numeric or alphanumeric characters, that identifies a storage location, register, or device containing data.

Aperture Card: A punched card with an opening specifically prepared for the mounting of a frame or frames of microfilm.

Associative Storage: A storage device in which storage locations are identified by their contents, rather than by names or positions. Synonymous with content addressed storage; parallel-search storage.

Asynchronous (Processor): That portion of processor operations in which performance of the next command is started by a signal that the previous command has been completed. Synchronous processors, on the other hand, have a fixed-time cycle for the execution of operations.

ADP (Automatic Data Processing): The processing (classifying, sorting, calculating, summarizing, recording, printing) of data through the use of electronic digital computers, communications channels and devices used with such computers, and associated peripheral equipment. Includes preparation of source data in a form appropriate for such processing.

Batch Processing: Collection of data over a period of time for sorting and processing as a group during a particular machine run.

Baud: (1) A unit of signaling speed equal to the number of code elements per second.
(2) The unit of signaling speed equal to twice the number of Morse code dots continuously sent per second.

Bulk Storage: Large-volume storage used to supplement the high-speed storage; may be addressable as with disks and drums, or nonaddressable as with magnetic tapes. Also called "secondary" and "external storage."

Camera, Planetary (Flat-Bed): A type of microfilm camera in which the document being photographed and the film remain in a stationary position during the exposure.

Camera, Rotary (Flow): A type of microfilm camera that photographs documents while they are being moved by some form of transport mechanism. The document transport mechanism is connected to a film transport mechanism, and the film also moves during exposure so there is no relative movement betweeen the film and the image of the document.

Camera, Step-and-Repeat: A type of microfilm camera that provides a series of latent image frames in a predetermined pattern on a single sheet of film.

Card Punch: A device for punching data in cards. Examples are simple hand punches, and high-speed punches for magnetic-tape-to-card conversion, or for direct output from the processor.

Character: One representation of a numeric digit, letter of the alphabet, or any other symbols that a computer may read, store, or write.

Character Reader: A device for scanning and identifying characters on documents that can also be read by people. Magnetic ink readers work with specially shaped characters printed in metallic ink that is magnetized before reading. Optical readers use ordinary shaped characters printed in ordinary inks.

Communication Channel: Messenger, voice, mail, telegraph, telephone, and microwave available for transmitting business data over short or long distances.

Compiler: A computer program more powerful than an assembler. In addition to its translating function, which is generally the same process as that used in an assembler, it is able to replace certain items of input with series of instructions, usually called subroutines. Thus, where an assembler translates item for item, and produces as output the same number of instructions or constants that was put into it, a compiler will do more than this. The program that results from compiling is a translated and expanded version of the original. Synonymous with (compiling routine) and related to (assembler).

Computer, Analog: A computer that represents variables by physical analogies. Thus, any computer that solves problems by translating physical conditions such as flow, temperature, pressure, angular position, or voltage into related mechanical or electrical quantities and uses mechanical or electrical equivalent circuits as an analog for the physical phenomenon being investigated. In general, it is a computer that uses an analog for each variable and produces analogs as output. Thus, an analog computer measures continuously whereas a digital computer counts discretely. Related to (machine, data processing).

Computer: A device for performing sequences of arithmetic and logical operations, not only on data but also on its own program.

Computer, Digital: A computer that processes information represented by combinations of discrete or discontinuous data as compared with an analog computer for continuous data. More specifically, it is a device for performing sequences of arithmetic and logical operations, not only on data but its own program. Still more specifically, it is a stored program digital computer capable of performing sequences of internally stored instructions, as opposed to calculators, on which the sequence is impressed manually. Related to (machine, data processing).

Computer, General Purpose: A computer designed to solve a large variety of problems; e.g., a stored program computer that may be adapted to any of a very large class of applications.

Computer, Synchronous: A computer in which all operations and events are controlled by equally spaced pulses from a clock. Contrasted with (Computer, asynchronous) and clarified by (frequency, clock).

Configuration, Machine: The pattern of equipment making up a system: size of storage, number of tape units and input/output channel, printer speed, etc.

Console: Equipment that provides for manual intervention and for monitoring processor operations.

Contact Printing: Reproductions made by exposure of sensitized material in direct contact with that which is being copied.

Control, Internal: The procedures used within an organization to achieve accuracy at each stage of processing to ensure adherence to policies and to make reports conform to reality.

Control, Operating: The system used to obtain information about events as they occur, process them against files containing the results of previous events, draw conclusions about developments, make decisions, and implement the decisions.

Control, Program: Descriptive of a system in which a computer is used to direct an operation or process and automatically to hold or to make changes in the operation or process on the basis of a prescribed sequence of events.

Control Unit: The portion of the hardware of an automatic digital processor that directs the sequence of operations, interprets coded instructions, and initiates proper commands to the circuits to execute instructions.

Cycle, Major: (1) the maximum access time of a recirculating serial storage element, (2) the time for one rotation of a magnetic drum.

Cycle, Minor: The time interval between the appearance of corresponding parts of successive words in a storage device that provides serial access to storage positions.

Data: Any representations such as characters or analog quantities to which meaning may be assigned. Data may be expressed in digital, graphic, or symbolic form, such as writings, sound recording, pictorial reproductions, and drawings.

Data Buffer: A storage device used to compensate for a difference in rate of flow of information or time of occurrence of events.

Data Density: The number of characters that can be stored per unit of length, area, or volume. Specifically, for magnetic tape, of number of bits in one row per inch of tape where one bit in each row across the tape makes up a frame representing one character.

Data Reduction: The process of transforming masses of raw test or experimentally obtained data, usually gathered by automatic recording equipment, into useful, condensed, or simplified intelligence.

Data Transmission Equipment: This term includes all digital communications equipment used on the terminal ends of communication lines for the sending and receipt of digital information used in direct support of data processing equipment.

Deck: A collection of cards, commonly a complete set of cards that have been punched.

Develop: To subject to the action of chemical agents or physical agents (as in Xerography) for the purpose of bringing to view the invisible or latent image produced by the action of light on a sensitized surface.

Diazo: An organic, light-sensitive dye coated on a material and processed by ammonia fumes or an alkaline solution.

Digitize: To convert an analog measurement of a physical variable into a numerical value, thereby expressing the quantity in digital form. Synonymous with (quantize).

Direct Image Film: A term used to describe the type of film that produces a negative from a negative and a positive from a positive in one step.

Direct Positive: A positive image obtained directly from another positive image without the use of a negative intermediate. This process will also produce a negative directly.

Disk: A circular metal plate with magnetic material on both sides, continuously rotated for reading or writing by means of one or more read-write heads mounted on movable or fixed arms; disks may be permanently mounted on a shaft or, as a package, they may be removable and others may be placed on the shaft.

Display: Visible representation of data on a console, in a printed report, or by other means.

Display, Direct: Television-like tubes that display various alphanumeric or graphic results from a processor for receiving or photographing for the record. More simply a desk set on which selected facts--for example, availability of a seat on a desired airflight--may be viewed.

Down-Time: The period of time that a processor is malfunctioning because of equipment failure.

Drum, Magnetic: A cylinder having a surface coating of magnetic material, which stores binary information by the orientation of magnetic dipoles near or on its surface. Since the drum is rotated at a uniform rate, the information stored is available periodically as a given portion of the surface moves past one or more flux detecting devices called heads located near the surface of the drum.

Edit: (1) To arrange or rearrange information for the output unit of the processor to print. Editing may involve deletion of unwanted data, selection of pertinent data, and application of standard processes, such as zero suppression. (2) To examine raw data to check or improve their accuracy and reliance before key punching. (3) To examine data during the input operation or at other stages of processing for completeness and correctness.

Electronic Data Processing System: A machine system capable of receiving, storing, operating on, and recording data without the intermediate use of tabulating cards. The system is also able to store internally at least some instructions for data processing operations, and to locate and control access to data stored internally.

Electronic Digital Computer: A machine that uses electronic circuitry in the main computing element to perform arithmetic and logical operations on digital data automatically, by means of an internally stored program of machine instructions.

Enlargement Ratio: The ratio of the linear measurement of a micro-image of a document to the linear measurement of the enlarged image, expressed as 15x, 20x, etc.

Executive Program: A permanently stored program that provides master control over all functions of the system.

Exposure: (1) The act of exposing a light-sensitive material to a light source. (2) A section of a film containing an individual image, as a roll containing six exposures. (3) The time during which a sensitive surface is exposed, as an exposure of 2 seconds. (4) The product of light intensity and the time during which it acts on a film, plate, or paper.

Facsimile: A line-scanning system of telecommunication for the transmission of fixed images, with or without half-tones, with a view to their reproduction in a permanent form. Facsimile is a form of graphics.

Field: A set of one or more characters treated as a unit of data. Used for the organization of data on punched cards where enough columns are assigned to each item to handle the longest case likely to occur. Similarly applied to character-addressable processors, although often called "variable word."

File: One or more records concerning people, things, or places that are closely related and handled together for processing.

File Maintenance: Modification of a file to incorporate changes that do not involve arithmetical operations--for example, insertions, deletions, transfers and corrections.

File Processing: Modification of a file to incorporate changes that involve arithmetical operations--for example, receipts, issues, returns, and losses of stock items.

Film: Any sheet or strip of transparent plastic coated with light-sensitive emulsion.

Film Master: That film from the first microfilming of a document. Also known as the original film.

Film Negative: Film in which the image of the dark portions of the subject appears light and of the light portions appears dark.

Film Frame: The area of film exposed to light through the camera optical system for one image, regardless of whether or not the area is filled by the document image.

Fixed Storage: A storage device that stores data not alterable by computer instructions; e.g., magnetic core storage with a lockout feature, or punched paper tape, synonymous with non-erasable storage, permanent storage, read-only storage.

Format: The arrangement of output for printing: page numbering, headings, vertical and horizontal spacing, minor, major and page totals, etc.

Frame, Main: (1) The central processor of the computer system. It contains the main storage, arithmetic unit, and special register groups. Synonymous with (CPU) and (central processing unit). (2) All that portion of a computer exclusive of the input, output, peripheral, and in some instances, storage units.

Graphics: A method of transmitting visual intelligence via electromagnetic means that is received at the far end in a permanent form. (Facsimile is a form of graphics.)

Hard Copy: (1) A human-readable copy produced from information that has been transcribed to a form not easily readable by human beings. (2) A document or reproduction that can be read without optical aids.

Hardware: The electric, electronic, and mechanical equipment used for processing data; consists of cabinets, racks, tubes, transistors, wires, and motors.

Image: A representation of an object or information produced by means of light rays.

Index: (1) A file of locators for documents or information. (2) That which specifies, indicates, or designates the information contents, or topics of a document or a group of documents. Also a list of the names or subjects referring to a document or a group of documents. (3) To prepare an organized or systematic list that specifies, indicates, or designates the information, contents, or topics in a document or group of documents.

Information: Knowledge that was not previously known to its receiver. Information can be derived from data only if the data are accurate, timely, and relevant to the subject under consideration.

Input: The process of introducing data into the internal storage of the processor.

Instruction: (1) A set of characters that defines an operation together with one or more addresses, or no address, and which, as a unit, causes the computer to perform the operation on the indicated quantities. The term instruction is preferable to the terms command and order; command is reserved for a specific portion of the instruction word; i.e., the part that specifies the operation to be performed; order is reserved for the ordering of the characters, implying sequence, or the order of the interpolation, or the order of the differential equation. Related to (code (1)). (2) The operation or command to be executed by a computer, together with associated addresses, tags, and indices.

Instruction, Micro: A small, single, short, add, shift, or delete type of command.

Interface: A common boundary between automatic data processing systems or parts of a single system.

Interrogation: An inquiry, usually of a simple nature.

Kalvar: A trademark for the film and equipment products of Kalvar Corporation.

Language: A system for representing and communicating information or data between people, or between people and machines. Such a system consists of a carefully defined set of characters and rules for combining them into larger units, such as words or expressions, and rules for word arrangement or usage to achieve meanings.

Library: An organized collection; for example, tape-file library or subroutine library.

Machine Processable Form: Data on a medium suitable for machines to accept; commonly magnetic tape, punched cards, or punched tape.

Magnetic Storage: A storage device that utilizes the magnetic properties of materials to store data, e.g., magnetic cores, tapes, and films.

Magnification: The linear ratio of the size of the image to that of the object.

Maintenance, File: The periodic modification of a file to incorporate changes that occurred during a given period.

Matrix: (1) An array of quantities in a prescribed form; in mathematics, usually capable of being subject to a mathematical operation by means of an operator or another matrix according to prescribed rules. (2) An array of coupled circuit elements; e.g., diodes, wires, magnetic cores, and relays, which are capable of performing a specific function such as the conversion from one numerical system to another. The elements are usually arranged in rows and columns. Thus, a matrix is a particular type of encoder or decoder. Clarified by (encoder) and (decoder).

Media: Magnetic tape, punched cards, and punched tape used to hold data and used primarily for input and output.

Microcopy: A facsimile of substantially reduced size.

Microfiche: Transparent sheet film containing micro or miniaturized pages arranged in a grid pattern by rows. Microfiche is used mainly as an intermediate for permanent enlargements.

Microfilm: (1) The recording of microphotographs on film. (2) A processed photographic film containing microphotographs.

Microform: A generic term for describing any miniaturized form containing micro-images. Microcards, microfiche, and microfilm aperture cards are all microforms.

Microimage: A unit of information such as a page of text or a drawing too small to be read by the unaided eye.

Microprogram: (1) A program of analytic instructions that the programmer intends to construct from the basic subcommands of a digital computer. (2) A sequence of pseudo commands that will be translated by hardware into machine subcommands. (3) A means of building various analytic instructions as needed from the subcommand structure of a computer. (4) A plan for obtaining maximum utilization of the abilities of a digital computer by efficient use of the subcommands of the machine.

Millisecond: A thousandth of a second; one thousand microseconds; "msec."

Modular: Standardization of processor components to permit combining them in various ways.

Nanosecond: A billionth of a second: a thousandth of a microsecond.

Off-Line: Operation of a terminal or other input/output device not under control of the system.

On-Line: Operation of a terminal or other input/output device under control of the system.

Operating System: That part of a software package designed to simplify housekeeping programming. May include an input/output control system, sort-merge generators, data-conversion routines, and test routines.

Output: Process of transferring data from internal storage of a processor to some other storage device.

Peripheral Data-Processing Equipment: Automatic data processing equipment associated with, but separate from, the mainframe and interconnected equipment. For example, a punched card to magnetic tape converter.

Photographic Storage: (1) Miniature facsimile copies of readable documents or of direct output of the processor. (2) Photographic copies of data shown on direct-display tubes. (3) High density storage of data in binary form on photographic disks for quick reference purposes.

Photomicrography: The process of making a larger photograph of a much smaller original.

Printer, High-Speed: High-speed printing that makes use of rotating print wheels or a chain with raised type faces and fast-acting hammers to press the paper against the desired character at the instant it is in the correct position.

Printer, Projection: A photographic printer in which the negative is projected onto the print material. The image of a print made with a projection printer may be smaller, larger, or equal size.

Process-Time: The time for translating a source program into an object program through the action of a processor program and a computer.

Processor: (1) Any device capable of accepting data, applying prescribed processes to them, and supplying the results of these processes. Usually internally stored program, but may be externally stored or built-in. (2) An internally stored program electronic computer and peripheral equipment used for business data processing. (3) A program used in compiling a source program to produce an object program ready to execute with data.

Program (noun): A plan for the automatic solution of a problem. A complete program includes plans for the transcription of data, coding for the processor, and plans for the absorption of the results into the system. The list of coded instructions is called a "routine."

Punched Card: A card of standard size and shape in which data are stored in the form of punched holes. The hole locations are arranged in 80 or 90 columns with a given pattern of holes in a column representing one alphanumeric character. The data content is read by mechanical, electrical, or photoelectrical sensing of the hole positions.

Punched Tape: Tape, usually paper, in which data are stored in the form of punched holes arrayed in a frame across the tape.

Read: (1) To copy, usually from one form of storage to another, particularly from external or secondary storage to internal storage. (2) To sense the meaning of arrangements of hardware or visually readable patterns.

Read-Write Head: A small electromagnet used for reading, recording, or erasing polarized spots on a magnetic surface.

Real-Time Operation: Processing data in synchronism with a physical process rapidly enough so that results of data processing are useful to the physical operation. Sometimes called "on-line, real-time control."

Record (noun): A set of data elements closely related in the sense that they pertain to the same person, place, or thing.

Reduction: A measure of the number of times a given linear dimension of an object is reduced when photographed.

Register: A hardware device used to store a certain amount of bits or characters. A register is usually constructed of elements such as transistors or tubes and usually contains approximately one word of information. Common programming usage demands that a register have the ability to operate upon information and not merely store information; hardware usage does not make the distinction.

Resolution: The ability to render visible the fine details of an object; a measure of sharpness of an image, expressed as the number of lines per millimeter discernible in an image. Resolution in processed microfilm is a function of film emulsion, exposure, camera lens, camera adjustment, camera vibration, and film processing. Resolution is measured by examining a microfilmed resolution test chart under a microscope to determine the smallest pattern in which lines can be distinguished both horizontally and vertically.

Roll Microfilm: A length of microfilm on a reel, spool, or core.

Satellite Processor: A small processor designed primarily for card-to-tape conversion, printing of tape contents, and other selected, high-volume operations. Used to support a large processor to increase its productivity.

Scan: To examine routinely every reference or every entry in a file as part of a retrieval scheme.

Scanning Device: A mechanism that permits shifting the film or the entire optical system so that different portions of the microfilm frame or reel may be viewed.

Search: To examine a series of items until one with a desired property is found.

Second Reproduction Microfilm: Microfilm made from the "First Reproduction Microfilm" also called third-generation microfilm.

Selectriever: A random access retrieval system capable of automatic recovery and dissemination of unit documents including aperture cards, tab cards, and microfiche. It has a basic capacity of 200,000 documents, expandable to over one million documents. Output configurations may include local viewers, remote television monitors, and hard copy.

Silver Halide: A compound of silver and one of the following elements known as halogens: chlorine, bromine, iodine, fluorine.

Software Package: The programming aids supplied by the manufacturer to facilitate the user's efficient operation of equipment. Includes assemblers, compilers, generators, subroutine libraries, operating systems, and industry application programs.

Storage: A device capable of receiving data, retaining them for an indefinite period of time, and supplying them upon command.

Addressable Bulk Storage: Storage with the primary function of augmenting capacity of internal storage for handling data and instructions. Data from addressable bulk storage must be transferred to internal storage in order to use them in operations.

Buffer Storage: (1) Secondary storage used exclusively for assembly and transfer of data between internal and external storage. (2) Storage used to facilitate transfer of data between any two storage devices whose input and output speeds are not synchronized.

High-Speed Storage: The quickest access internal storage of a processor; this is composed of magnetic cores in most processors, although some use special cores or thin-film elements for limited amounts of ultra-high speed.

Internal Storage: Storage that is directly accessible to the arithmetic and control units of a computer. It is used for storage of instructions and for data currently being operated upon.

Storage Capacity: Number of units of data that can be stored in a device at one time; variously expressed in terms of bits, characters, or words, depending upon the method of organization.

Storage Density: The number of characters stored per unit length of area of storage medium; for example, number of characters per inch of magnetic tape.

Storage Location: A storage position holding one machine word and usually having a specific address; the character position used to address a data field in a character-addressable machine.

Stored Program: A program for instructing a processor how to manipulate data. Generally taken to mean internally stored program in which data and instructions are placed interchangeably in storage. Also covers (1) special-purpose equipment with instructions designed into the circuitry and (2) externally stored programs set up in wiring boards or plug boards for physical insertion into the machine.

Systems Analysis: An orderly study of the detailed procedure for collecting, organizing, and evaluating information about an organization with the objective of improving control over its operations.

Tape Unit: A device for reading data from magnetic tape and writing new data (after erasing prior data) on tape. Some tape units read in either direction, although they write in only the forward direction. The device also rewinds tape ready for removal and replacement by another reel.

Tape: A strip of material, which may be punched, coated, or impregnated with magnetic or optically sensitive substances, and used for data input, storage or output. The data are stored serially in several channels across the tape transversely to the reading or writing motion.

Teletypewriter: Basically, an electric typewriter that can be operated manually or by reading and reperforating paper tape; it is connected to a leased or dial-switched telegraph grade circuit for transmitting text and also data messages in readable form.

TELPAC Channel: A high capacity communication channel with data-transmission rates up to 100,000 characters per second.

Thin Film: An ultra-high-speed storage device consisting of a molecular deposit of material on a suitable plate.

Time, Turn Around: The time required to reverse the direction of transmission in a communication channel.

Transceiver: Card-reading, modulating, and punching equipment for card-to-card transmission of data over telephone or telegraph grade circuits.

Tube, Cathode Ray: (1) An electronic vacuum tube containing a screen on which information may be stored by means of a multigrid modulated beam of electrons from the thermionic emitter storage effected by means of charged or uncharged spots. (2) A storage tube. (3) An oscilloscope tube. (4) A picture tube.

Update: To process a file according to a specified procedure for inserting, deleting, or altering items.

Word, Machine: A unit of information of a standard number of characters which a machine regularly handles in each transfer; e.g., a machine may regularly handle numbers or instruction in units of 36 binary digits; this is then the machine word. Related to (word, information).

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APPENDIX C

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13. ABSTRACT This report represents the initial phase of a research study of Navy user requirements for technical data handling and the ability of the information processing industry to satisfy these requirements 5, 10, and 15 years in the future. This study fulfills a Navy requirement levied by the DOD (Department of Defense) Engineering Data Systems Standardization Committee.

The DOD Engineering Data Systems Standardization Area Assignment was established in August 1960. This program is supported by studies conducted under the auspices of DOD, the military departments, and NASA (National Aeronautics and Space Administration). The purpose of this program is to assist the Department of Defense and NASA in identifying long-range capabilities and formulating standardization goals for technical data handling and data exchange.

This report describes present and projected 5-year capabilities of the information processing industry to meet current and projected Navy user requirements for technical data handling.

Volume I is a detailed discussion of both current and projected requirements for technical data handling within a sampled segment of the Navy Shore Establishment. It also reviews currently existing information processing capabilities which may assist in the satisfaction of these requirements. Volume II contains a 5-year projection of information processing capabilities to meet the technical data handling requirements identified in Volume I. Volume II will receive restricted and limited distribution in order to protect the integrity of proprietary information contained therein.

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