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System Development Corporation
Falls Church, Virginia

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VOLUME II

NEEDS AND REQUIREMENTS

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FIVE YEAR PLAN STUDY
VOLUME II
Needs and Requirements

29 August 1966

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ABSTRACT

This document is the result of a three-month study by the System Development Corporation, conducted for the Defense Documentation Center in fulfillment of Contract DSA-600-12301. The report consists of three volumes:

Volume I	Five Year Plan
Volume II	Needs and Requirements
Volume III	State of the Art Study

Three alternative plans are presented for the operation and development of DDC for the Fiscal Years 1967 through 1971. Estimates of workload, equipment, personnel, and costs are given to Fiscal Year 1971 for each of the alternatives.

The first two years will be used to clean up the existing systems and to develop an Internal Integrated System that would serve as a basis for future growth in both documentary and management information operations. This integrated system will provide the basis for management and control of the total DDC operation including technical processing, ADP operations, and reporduction and distribution. It will include generalized ADP programs for use in documentary and management information processing as well as procedures necessary for efficient operation of non-ADP activities within the integrated system. The system will provide flexibility and efficiency by reducing the

number of operational procedures and computer programs developed each time a new requirement is placed upon DDC.

The last three years will be spent in a continuing upgrading of the basic Internal Integrated System by incorporating new advances in the state-of-the-art in document and management processing into the system as well as any new missions that DDC is asked to perform.

A development program in document processing and user services utilizing both in-house and contractor personnel shall be activated. In addition to advancing the state-of-the-art in document and user services, studies shall be made to define future integrated system elements that will be utilized by DDC in later years.

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A. INTRODUCTION

This volume contains descriptions of current operations of the document system, the management information systems and the Automatic Data Processing (ADP) system. An assessment of the ADP system is included.

Current Requirements are delineated in the form of existing directives and working agreements. Future Requirements are stated as possible alternative missions that could be undertaken by DDC in the next five years.

Current Needs are postulated as those needs which should be met in the first two or three years to increase the effectiveness of the operations at DDC. Future Needs contains similar needs for improvements and developments in the three-to-five year period.

B. CURRENT SYSTEM DESCRIPTION

1. AUTOMATED DATA PROCESSING (ADP) SYSTEM

A functionally oriented description of DDC's ADP resources, with enough technical detail provided to outline current DDC capabilities, covers the following:

The physical items of significant equipment

The software employed in the programming, operating, and monitoring of tasks.

The procedures for allocation, management, and utilization of these ADP resources.

The management, systems analysis, computer programming, operational procedures, personnel, and activities.

a. ADP Equipment

(1) Current Computer Configuration

This grouping of equipment (See Chart 1) is nominally independent, functionally serving a Sperry-Rand Univac 1107 computer which is the major element of DDC computer configuration.

(a) Univac 1107 Computer

When this general-purpose digital computer was developed early in this decade by Sperry-Rand, it represented a most advanced computer in terms of computation speed, thin-film memory utilization, and multi-programming capability (parallel, overlapped computer program execution).

Computer Element	Basic Size	Overall Capacity	Usage	Remarks
Computer Memory	36-bit fixed-length computer word.	65,536 words	Storage of computer instructions; data, and tables of values.	Memory equivalent to 393,216 (6-bit) characters of information.
Thin-film Memory	36-bit, fixed length computer word.	128 words	Special, high-speed memory for repetitive, modified instruction execution.	Speed of 125 nanoseconds (125 billionths of a second) per access.
Transistorized Core Memory		65,408 words	Storage of computer program instructions; input and output data, and tables of information.	Main memory of the computer. 2 microseconds (millionths of a second) per reference (cycle).
Mode of Data Representation in Memory	Basically, one 36-bit word of memory per binary numerical data item. 6 bits (1/6th of a word) of memory for each character of alphabetic or decimal numeric information expressed in (military) FIELDATA coding.	All of core memory not occupied by computer instructions (instructions in binary numeric form).		
Computer Instructions	One 36-bit computer word of memory per instruction.	62 basic types of instructions. Two cycles (4 microseconds) per "average" instruction execution.	Execution of computer programs; control of 1107.	Basically a "standard scientific instruction repertoire," with limited textual data (character) manipulation capacity. Good set of input-output instructions.

Chart 1. DDC 1107 (and related 1004/5) Computer Characteristics

Input and Output Devices: Random Access (Magnetic Drum) Subsystems

Computer Element	Basic Size	Overall Capacity	Usage	Remarks
Univac Fastrand II Drum	22,000,000 36-bit words of storage (132,000,000 characters).	1 in use at DDC.	Storage of data, tables of information.	Large, fairly fast access, cheap mass storage device.
Univac FH880 Drum	786,432 36-bit words of storage (c. 4,500,000 characters.)	2 in use at DDC.	Storage of 1107 programs and data.	Fair-sized, high-speed access storage.

Chart 1

Input and Output Devices: Magnetic Tape Subsystems

Magnetic Tape Servo Synchronizer	Up to 16 per 1107. 1 in use at DDC; 2 more to be installed in 9/66.	Up to 16 servos per synchronizer.	Management of operation and data flow to and from multiple servos.	Essential for fast high volume, high-speed magnetic tape data transfer.
Univac IIIA Units	1800-, 2400-, or 3600-foot reels. 14 on DDC 1107.	Up to 16 per control unit. 1000 characters per inch.	Major (magnetic tape) data file computer program storage medium at DDC.	$750 per month 120 KC transfer rate. Excellent magnetic tape system (not industry compatible).
Univac VIC Unit (on Univac 1004 (1005) linked to 1107).	2400-foot, industry compatible reels. 1 in DDC system.	Up to 3 per 1107 VIC Control Unit; only 2 per 1004 (1005).	Used to: (1) Store DDC-processed Tab. (2) Serve as input to DSA 1410/1401 TAB processing for GPO. (3) For CFSTI processing.	$500 per month (as master), $300 per month (slave) 8.5,23.7 (DDC), or 34.2KC transfer rates. No longitudinal parity check. BCD-FIELDATA hardware translation option $100/month. Backward read.

Chart 1. DDC 1107 (and related 1004/5) Computer Characteristics (Continued)

Printing Devices				
Computer Element	Basic Size	Overall Capacity	Usage	Remarks
Univac Line Printer (Up to 4 per Control Unit; 2 in DDC System).		600 lines per minute (63-character font) (alphabetic; numeric, and punctuation symbols).	For on-line printing of DDC 1107 outputs.	A non-typical use of equipment in semi-automated AIP documentation processing.
Univac 1004/5 Printer (1 per 1004; 2 in DDC System).		400/600 lines per minute. 63-character font.	Available for off-line printing of DDC 1107 output.	See Section C for prospective uses of this device.
IBM* 1443 Printer (on IBM 1440 ATS System).		150 lines per minute (48-character font).	Available for off-line printing of DDC 1107 output.	See Above.

* Included because IBM 1440 ATS System is functionally a part of DDC central (Univac 1107) system.

Chart 1. DDC 1107 (and related 1004/5) Computer Characteristics (Continued)

The 1107 is a "second generation" general-purpose digital solid-state and thin-film computer. It may be described as a relatively high-speed scientific computer with a fairly large core memory. It is magnetic-drum-oriented in terms of its input/output philosophy, and is designed primarily for use in three major types of ADP application:

1 Batched (collective) execution of computer programs in a non-real time environment, with a capability for executing a series of computer programs in the required order and for "mixing" program execution on the basis of input/output unit, memory, and storage requirements. Assignment of operational priority is another feature of the basic hardware-software design philosophy of the 1107.

2 The real time execution of tasks is another design basis of the Univac 1107. However, the nature of the current DDC operational system, DDC's executive software and hardware, and limitations on communications elements, and DDC immediate needs make this 1107 operational philosophy of limited concern in this analysis.

3 Within either of the above philosophies, the 1107 may be used as a multiprogramming/parallel processing

computer, with up to 29 more programs sharing the computer memory during concurrent operation under executive control.

A capability found in most real time systems, and which therefore exists in the DDC 1107 system, is central computer printing of output data. In most document handling systems, this task is assigned totally to a satellite computer (which prints central computer output from magnetic tape). Since printing is a relatively slow computer process, most systems allot this task to a small peripheral computer, thus freeing the faster central computer for other processing.

The overall functional hardware-software system characteristics of the existing DDC (1107) ADP system are well-designed for the DDC application, except for on-line printing and certain other items, explicated in Section D, Current Needs.

(b) Peripheral Computers

There are two (small) Univac 1004 computers at DDC, both of which serve the input and output functions of the Univac 1107. They are to be replaced ("upgraded") by two Univac 1005 computers in September of 1966. There also is an IBM 1440 computer system at DDC.

1 Univac Equipment. The Univac 1004 is externally programmed, i.e., instructions are "wired" on a plugboard in the mode of EAM equipment. The memory of the 1004 has 961 characters (optionally 1,922) for instruction, data, and table storage. The memory cycle of the Univac 1004 is 6.5 microseconds, which is fairly fast for a peripheral or satellite computer. The core memory is so small, however, that no data records of significant size may pass through the 1004 (as input to, or output from, the Univac 1107).

The Univac 1004 computers each include one magnetic tape servo unit for tape data input and output. One has a Univac IIA Unit, compatible with the servos of the U. S. Navy David Taylor Model Basin facility's Univac LARC computer, which produces USN management information for DDC. The other has a Univac VIC (IBM DCD-compatible) servo, used in preparing the TAB for DSA and GPO composition and printing.

Both 1004 computers, being scheduled for replacement by internally programmed Univac 1005 computers with 4096 characters of memory, the basic input/output capability of DDC's Univac peripheral computers, will be increased to a considerable degree. (This capability will be dealt with in Section D, Current Needs.)

2 IBM Equipment. In addition to the two Univac 1004 (1005) peripheral computers, DDC recently acquired (by rental) an IBM 1440 and, with it, the Administrative Terminal System (ATS).

The 1440 has an 11.1 microsecond cycle; 16000 characters of memory; a 20,000,000-character 1301 magnetic disk store; a double 2,000,000-character 1311/1316 magnetic "disk pack" store; two 7335 tape units (20 KC); a 1443 printer (150 lines per minute), and 12 (ultimately 20) IBM 2741 remote consoles for use in on-line input keyboarding. Two major software features are the ATS system package, which is to be used in on-line keyboarding of DDC input, and a complete set of IBM 1440 utility programs.

A major characteristic of this system is the difference between the IBM 1400-series commercial BCD coding of data in the ATS and the binary/Fieldata coding of data in the Univac 1107 system. ATS-generated output (DDC's AD input records for use in TAB) (on magnetic tape) must be transmitted to the 1107 through the Univac 1004 (1005) computer (which has the Univac VIC tape servo), whereas any 1107 output requiring (possible) IBM 1440 processing

requires the reverse process (the 1107 itself having no IBM-compatible tape units).

The 1440/ATS may be characterized as a moderately slow, extremely economical, and relatively non-compatible input keyboarding device processing reliable, error-free hardware; comprehensive software, and relatively simple operational supervision requirements.

(2) Future Computer Configurations

The production and delivery (in 1965) of the Univac 1108, a higher-speed 1107-compatible digital computer, indicated the start of "obsolescence" for the Univac 1107 in terms of the state-of-the-art in hardware. In addition, a "third generation" of computers announced and under production by various manufacturers (discussed in Hardware and Software sections of Volume III) represent: development of industry-compatible families of computers featuring complete business and scientific instruction repertoires; the ability to store and process data in either fixed-word memory or character memory representations; strong inter-manufacturer input and output unit compatibilities, and effective software standardization on assembly languages (with macro instructions, and input/output control systems) -- Cobol, Fortran IV, and (probably) PL/I (a Cobol/Fortran "combination" yet to be defined).

Chart 2 compares characteristics of the "third generation" computers, of the Univac 1108, and of the 1107. It should be noted that the ultimate cycle times and access times of the first five entries in Chart 2 represent large and expensive machines. However, these computers represent considerable increases in computational speed and memory size over a comparably priced 1107 configuration. Note the omission of the very powerful General Electric 600 Series and the "super" Control Data Corporation 6000 Series from Chart 2; neither series features a comparable instruction repertoire for character data manipulation, nor do these series exhibit character-mode memory or the other compatibilities found between items 1-5 (except in magnetic tape).

A primary conclusion reached in an analysis of DDC's ADP is that the Univac 1107 has adequate capacity to execute foreseeable DDC tasks for about 2 years, provided that certain recommended systems analyses, programming, and computer operations are initiated (and maintained) by the Defense Documentation Center. These activities are spelled out in later portions of this report.

Another primary conclusion is that DDC will require a new computer by Fiscal Year 1969. This is a firm conclusion in the case of DDC System Alternatives 2 and 3; a conclusion

Chart 2.

Comparative Capabilities of Computer Systems

Name of Computer or Computer Series	Computers Within Series	Fastest Basic Cycle Time in Series (in nanoseconds**)	Fastest Access Time in Series (in nano-seconds)	Largest Memory (in characters)
Honeywell 200 series	H200* H1200* H2200* H4200 H8200	About 200	About 50	4,000,000
Univac 9000 series	9200 9300 9500 (and more)	Comparable to above.	Comparable to above.	Comparable to above.
IBM S/360 series	Model 20* Model 30* Model 40* Model 50* Model 60* Model 65 Model 67 Model 75 Model 91 (and others)	Comparable to above.	Comparable to above.	Comparable to above.
RCA Spectra 70 series	Model 15* Model 25* Model 35* Model 45* Model 55* (and more)	Comparable to above.	Comparable to above.	Comparable to above.
Burroughs series	2500 3500 6500 (and more)	Comparable to above.	Comparable to above.	Comparable to above.
Univac 1108*	(1107*)	750 (Can be 375 if data is efficiently organized, by bank).	About 150	790,000
Univac 1107*	(1108)	2,000	About 700	390,000

*Equipment is in operational use at this time.

**Billionths of a second.

would be reached in the case of Alternative 1 as a result of the recommended computer evaluation. This requirement is predicated upon: (a) the increasing size of the AD document file, and of management information files; (b) availability of developed (and properly tested) software for such a new computer; (c) availability of proven computer hardware for an entire manufacturer's series, and (d) provision of adequate time for completion of:

1. Current system need related activities, by DDC;
2. The recommended design and implementation of an integrated DDC system;
3. Evaluation of comprehensive computer hardware and software as an initial key element of the recommended system effort, to be initiated by January 1967, and completed in less than six months from its inception. (This evaluation/selection process should utilize expert consultant advice.)
4. Training and indoctrination of DDC personnel in operation and maintenance of the new system and, particularly, in use of any new hardware and/or software adopted during design of and implementation of the new integrated system.

A corollary conclusion is that selection for procurement of new ADP hardware or major software should be undertaken only

in conjunction with the above indicated design analysis and operational activities.

b. Personnel

(1) Functions

Personnel functions include: (a) the allocation of DDC equipment, personnel, and funds to ADP tasks, in accordance with DDC missions and internal managerial and professional requirements; (b) the performance of ADP-related planning, systems analysis, computer programming, computer operation, and auxiliary activities (e.g., EAM); and (c) general ADP-related functions. (The current DDC modes of carrying out such general functions are portrayed in Chart 3).

(2) Personnel Currently Performing ADP-Related Functions

There are approximately 60 people in DDC who have direct, daily, operational assignments in ADP-related systems analysis and computer programming. The number of personnel should be re-evaluated when and if:

(a) DDC undertakes the activities cited in Section D, Current Needs;

(b) The recommended integrated system design, analysis, and implementation is undertaken; and

(c) There is a change in foreseeable DDC missions and workloads.

It is concluded that the six-man DDC computer operator staff should be increased to a total of 18, because of:

ADP-Related Activity	Managerial and/or Administrative Action(s)	Functional and/or Technical Action(s)	Remarks
Allocation of ADP resources to proposed major DDC systems.	Informal agreements (not formally promulgated) between DDC management and affiliated directorates.	Informal agreements between Programming Branch Heads of DSD and DDC/C.	There should be a DDC-wide, technical review board or group established to assess: - ADP feasibility of new system; - resource availability; - prospective analysis, programming, and operational needs. (a stated DDC-C function)
Planning of ADP-related activity.	Procurement of personnel from existing DDC ADP activities. New activities on project basis.	Generally, planning to share resources between ADP missions.	There is no DDC-level managerial group specifically engaged in full-time planning of ADP activity (a stated DDC-C function).
ADP-related systems analysis.	Generally on a de facto project basis.	General reliance on use of ADP procedures designed for previous DDC systems.	There is no centralized group assigned to this function task on DDC level; DDC practice is assignment of analysts to functional projects. (Systems analysis is a stated DDC-CS function).
ADP computer programming.	Carried on by heads of ADP Programming Branch and project programming groups.	By programming functions (retrieval; output; reports; input preparation). Also, IBM 1440 programming.	The tasks assigned are ad hoc, and ADP-functional groups have multiple-mission assignment.

Chart 3. ADP-Related Managerial and Technical Functions at DDC

ADP-Related Activity	Managerial and/or Administrative Action(s)	Functional and/or Technical Action(s)	Remarks
ADP computer operations.	Carried out by DDC-C.	Operation of batch-processing, multi-programming system.	See Sections A and C on equipment and software, respectively.
ADP auxiliary operations.	Carried out through DDC-C.	1. Traditional preparation of punched card input. 2. Manipulation of Form 1 cards. 3. IBM ATS input keyboarding.	
Interaction between DSD professional personnel and those of other directorates on joint ADP related endeavors.	Agreement between directorates and lower levels but no centralized or centrally controlled procedures evident (current responsibility assigned to DDC-CS.)	No integrated, systematic DDC-level coordination of required or desirable ADP services between ADP and non-ADP professionals.	Many installations have integrated systems with standardized "check-off" managerial and professional coordination procedures.
Selection and acquisition of ADP-related equipment (computer; EAM; telecommunication; etc.)	Use of DSA resources in this area. A DDC function exercised by DDC-DSD.	Reliance on DSA-Vendor materials and presentations.	See Section C, Current Needs.
Evaluation of ADP-related software.			See Section C, Current Needs.
Response to external-to-DDC requests for ADP products.	Coordinated by DDC management, and heads of projects, directorates, divisions, and branches and by resident contractor personnel.	DDC Civil Service (and resident contractor) personnel.	See Sections D and B, Future Requirements and Current Requirements, respectively.

Chart 3. ADP-Related Managerial and Technical Functions at DDC (Continued)

ADP-Related Activity	Managerial and/or Administrative Action(s)	Functional and/or Technical Action(s)	Remarks
Scheduling of utilization of DDC ADP computer equipment.	Informal agreements between DDC-C and ADP-related DDC project heads is the DDC modus operandi.	Direct submission of program by computer programmer for testing and production; DDC-C apparently makes decisions on ADP utilization.	See Section C, Current Needs, on system production control; integration and enhancement are factors.
Acquisition of information, on a systematic or positive basis, on comparable problems and methods from agencies and organizations using ADP in their operations.	No evidence of planned systematic activity by DDC (a DSA function).	No evidence of planned inter-organization program for contacts between professional working people.	See Section C, Current Needs, on selection and acquisition of ADP-related equipment, and evaluation of ADP-related software.

Chart 3. ADP-Related Managerial and Technical Functions at DDC

(a) The number of hours of daily operation (18-22);

(b) Operation with a large-scale computer system including a multiprogramming environment, which extends magnetic tape-changing requirements beyond "serial system" levels;

(c) The DDC ADP application being essentially an input/output-oriented system, which includes many Sorts and Merge programs operating upon very large magnetic tape-stored data files.

The personnel assigned to keypunching tasks may have to be augmented temporarily during file updating and purging activities (recommended under Current Needs, Section D) and during the implementation of the integrated DDC system.

It is also concluded that DDC should assign people duties that are primary and exclusive in the areas reflected in Chart 3. Systems analysis and design, and state-of-the-art analysis (hardware, software, and techniques of comparable installations) are areas in which an on-going effort is required for optimum DDC operation. This capability should be acquired by DDC through:

1 Integrated system design, analysis, and implementation;

2 Concomitant instruction and indoctrination of DDC personnel in associated professional task and skill areas; and

3 Where necessary, acquisition of highly qualified expert personnel (consultant or permanent) from external sources.

c. Software and Documentation

This section discusses software (including manuals; standards; charts; computer program documentation, computer programs) used to define, control, schedule, operate, explain, and utilize DDC ADP equipment. The computer software philosophies are also discussed.

(1) Manuals and Standards

Standards (which include "Standard Operating Procedures") for ADP-related professional performance include Department of Defense materials, and DDC materials outlining DDC tasks in ADP-related and other areas. These should be available for use in one integrated, up-to-date reference volume.

ADP systems analysis charts are not maintained centrally or elsewhere in DDC in an updated fashion -- DDC practice is to rely on current verbal descriptions of subsystem component and lower-level logical and procedural practices, due to the pressure of workloads and necessity for frequent change.

There is no centralized DDC system to establish and review such documentation, which incorporates non-ADP data; computer programming; systems analysis; computer operations, and DDC

technical management data, all of which have a role in DDC system(s) operations using ADP resources.

(2) Computer Software Philosophies

This summary is functional and will describe the Sperry-Rand Univac 1107 software, IBM 1440 ATS software, and software selection and utilization. The separate IBM software discussion is felt to be necessary because of fundamental system concept differences and equipment differences.

(a) Sperry-Rand Univac 1100 Series. It was said earlier (ADP Equipment, Section B.1.a) that DDC has a computer with a multiprogramming system concept. This is true of the design philosophy of the Univac 1107 Computer's Executive System and of the Univac 1107 itself. The use of mass storage as the central element of input/output storage; exchange of concurrently operating programs between memory and the FH880 Drum Subsystem; accession of output materials through drum, and other hardware and software features demonstrate that the 1107 configuration is designed for multiprogramming operation under Executive System software control.

The 1107 Executive System (master control and working computer program monitor) allocates utilization of the computer among batched (grouped) programs operating within a priority-of-program-execution scheme.

five or more individual programs simultaneously. It has the ability to meet the basic requirements for DDC operation. However, several features not utilized by DDC (nor available in the 1107) should be considered as necessary for:

Enhancing current DDC Univac 1107 utilization;

Allowing optimized 1107 usage during later use of this computer, and

Permitting orderly software transition to another computer within the next 3 years.

The current Executive System (which is here defined as Univac 1107 and Univac 1004/5 software) has the features outlined in Chart 4. Later sections outline features felt necessary to be added to extant software.

(b) IBM 1440 and ATS Software. The IBM 1440 ATS (described above) has two basic software philosophies. The generic purpose of the ATS Control Program is to allow random use of up to forty IBM 2741 remote consoles, to be used: to keyboard textual information into 1440 memory; to print this keyboard data; to replace any erroneous character(s) within the keyboarded input item; to store keyboarded items on a magnetic disk file; and to selectively place contents of this disk onto magnetic tape (in IBM 1400 Series BCD code only). The generic function is non-redundant keyboarding of single-font textual symbols (alphabetical/numerical/punctuation). When this

Major Software Element	Included Elements	Special Features	Used by DDC	Remarks
Assemblers/Compilers	Sleuth I Assembly Language.	Sleuth I has macro instruction capabilities.	Sleuth I	Univac 1107/8 Compatibility only. Sleuth II (comparable) available; not used at DDC.
	Cobol Business Compiler.	DOD Codasyl Extended, 1961	No	Compatible on all Vendor lines. Not used operationally at DDC.
	Fortran II Scientific Compiler.		No	Inappropriate for DDC use; limited I/O; restricted character-handling efficiency.
	APT Machine Tool Control Compiler.		No	Not germane to DDC needs.
	Beef (Business-Enriched Fortran)		No	See Fortran.
	Lion-Sleuth I Input/Output Subroutine generator.	Codes efficient input/output procedures for Sleuth I Programs.	Yes	As efficient as competitive manufacturers' routines.
Executive (Control) Programs	Equipment use allocation procedures; parallel processing (multiprogramming); program scheduling; "snapshot" and "post morten" memory dumps, and other utility features.	DDC 1107 Utilization Report shows time each working program started; ended; amount of central computer time it used.	Yes	Existing multiprogramming executive programs report input/output equipment utilization data.

Chart 4. Sperry-Rand Univac 1107 Computer Software

small-memory (16,000 characters), medium-speed (11 microsecond cycle) computer is used as an IBM 1440, software is essentially oriented (in a DDC-type installation) per se, towards such functions as: utility programs (card-to-tape; tape-to-card; tape-to-tape, etc.); manipulation and editing of small data records, and fairly high-speed printing (using IBM 1403 printer). Incompatibility of hardware between the two systems (internal memory form; internal data coding; magnetic tape data coding, and data collating sequences) pose problems for optimum 1440 ATS usage in the existing DDC System.

d. ADP and Other Procedures

Most material germane to this topic will be found in the following locations in the report:

(1) Chart 3 in this section, which is concerned with systematic techniques used at DDC as related to:

(a) Current DDC regulations

(b) Current DDC de-facto practices

(c) SDC-recommended design, analysis, and implementation of an integrated internal DDC system, with production and quality control in DDC, under centralized DDC control, and hardware/software evaluation.

(2) Section D, Current Needs, relating to:

(a) Recommended changes and innovations in ADP-related systems tasks at DDC;

(b) Recommended changes in working ADP task applications and equipment/software usage at DDC.

(3) Section F, Future Needs.

2. MANAGEMENT SYSTEM

The management system at DDC is designed to receive periodic management progress reports, in machinable form, i.e., magnetic tape, punched cards, and in some cases hardcopy. Figure 1 shows, functionally, the input processing and storage of these reports in the system. There are now about 19,000 reports in the system, each stored in its entirety in the computer storage.

The reports are received by the mailroom personnel who verify classification and prepare the necessary security control forms. The reports are then forwarded to the Data Processing Division where security and form checks are made. If the reports are not in machinable form, the sender is requested to provide machinable input. ARPA, DASA, and CD are encouraged to provide reports in hardcopy form. In cases where no machinable input can be obtained, hardcopy reports are keypunched onto cards and the card and magnetic tape inputs are sorted, edited, and formatted on the Univac 1107. A record of the reports are then added to the direct file and the inverted file for storage. Results of the sort and edit, the valid transaction list,

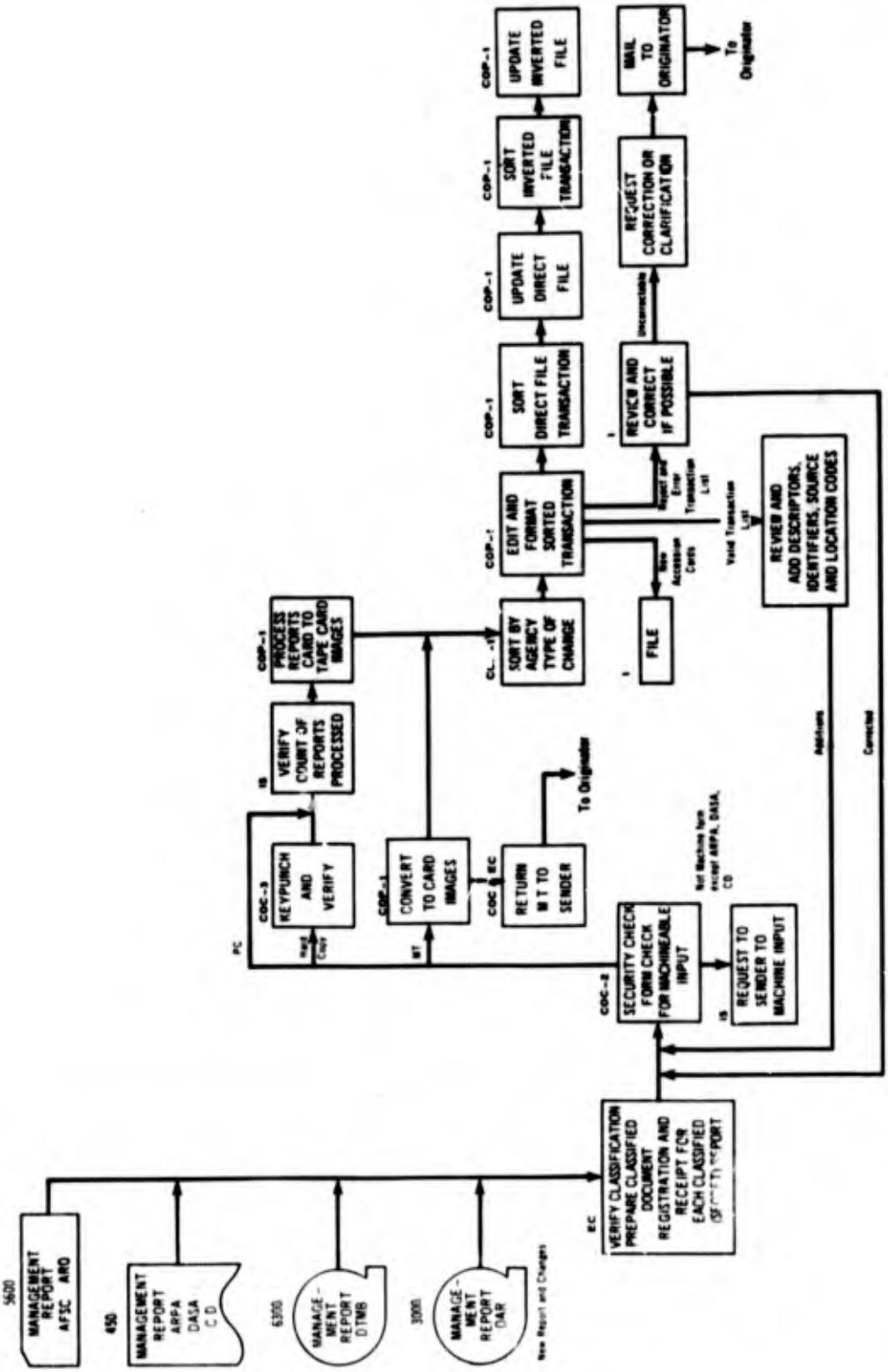

Figure 1. Management Report Input Processing

the reject-and-error transaction lists, and newly made accession cards are all sent to the Directorate of Accession and Analysis for reviewing, necessary correcting, and adding of descriptors, identifiers, source codes, and location codes. If corrections cannot be made by the analysis staff, the sender is requested to correct or clarify the report.

Figure 2 shows, functionally, the management report request process, starting with a user's request for certain reports or information. This information could be of an accounting nature, e.g., How much money was spent in a certain field during this year?, or of a technical nature, e.g., What contracts were let by a certain agency in the field of thermodynamics during the last six months?, or a combination of both. DDC is required to give the requestor any such data he requires, in any format he desires.

The mailroom receives the request and routes it to the Directorate of Data Systems whose personnel check its validity with higher authorities. They also contact the requestor if the request is unclear to them. The request is then sent to the Bibliography Branch where the computer search criteria are determined. At the same time, if a special format is necessary to fulfill the request, the Management Report Output Branch writes a program which will put the final report in the proper format.

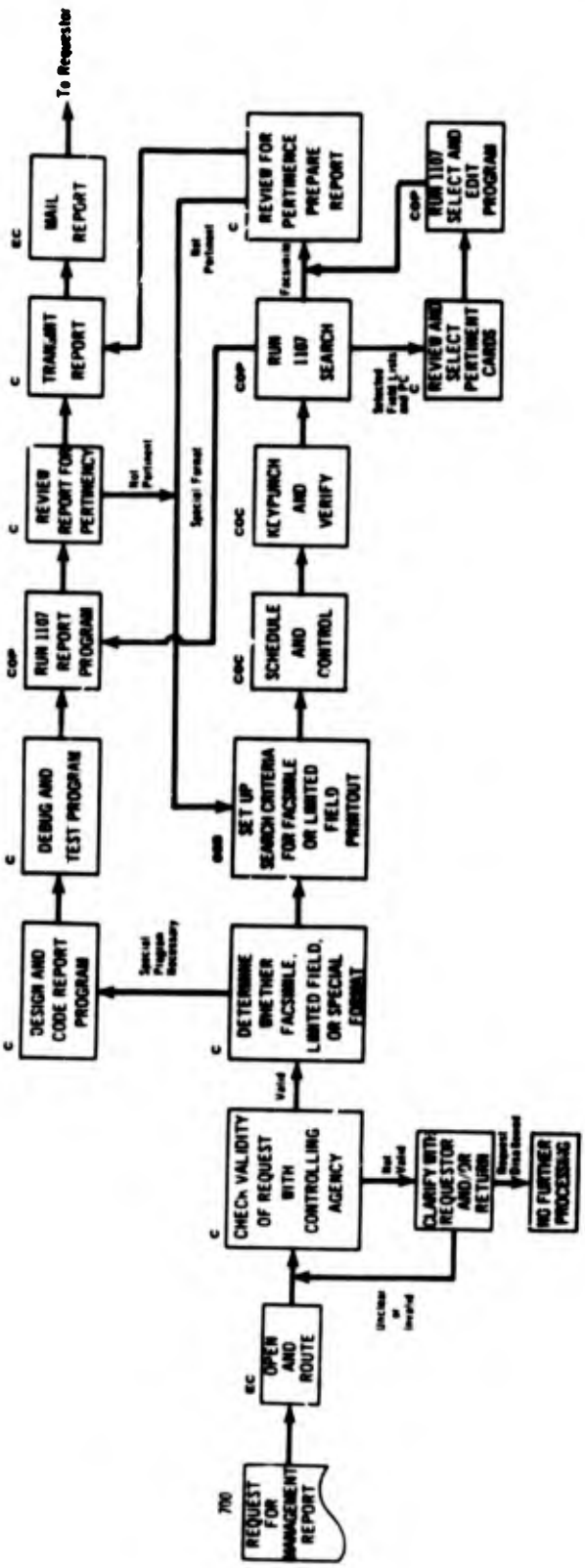

Figure 2. Management Report Output Processing

After the computer search has been run, the results of the search are reviewed for pertinency. If the request is for a report which includes selected field lists, those outputs of the computer search deemed to be relevant by the analyst are run through a select-and-edit program on the 1107 computer and again reviewed for pertinency. If the result of the search is felt to be not pertinent, another search is set up and the process repeated. After a valid report has been assembled, it is mailed to the requestor.

There were about 700 requests for reports in FY66 and there are expected to be about 4,200 requests in FY67.

3. DOCUMENT SYSTEM

The Document System is made up of three functional entities: (a) document input processing and Technical Abstract Bulletin (TAB) production; (b) document request processing; and (c) bibliography request processing.

a. Document Input Processing and TAB Production

Documents and their associated descriptive DDC 1473 forms are received at the average rate of about 220 per day (see Figure 3). The mailroom opens the packages and segregates by classification and limitation. Approximately 20 documents per day are Secret, the rest either Confidential, Unclassified Limited or Unclassified Unlimited. If any Secret documents arrive which should not have been sent to DDC they are returned to the originator after a

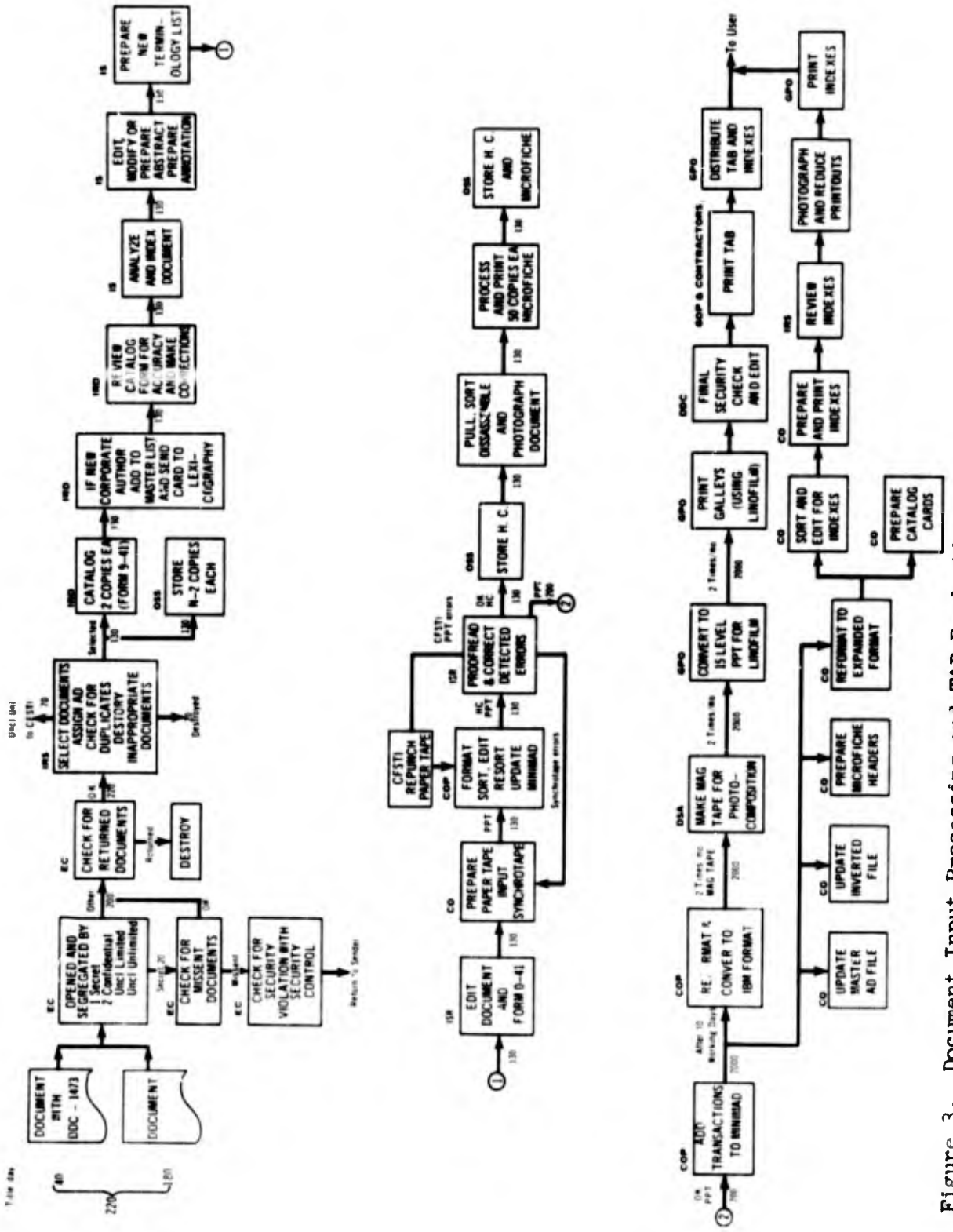

Figure 3. Document Input Processing and TAB Production

security violation check. Any AD document returned by a user is destroyed. In the Selection Branch of the Accession Division the documents are selected, the AD numbers are assigned and manual duplicate checks are made. Of the 220 documents received daily, about 200 are selected for DDC's collection. The 20 or so not selected are destroyed.

The Unclassified Unlimited documents, about 70 per day, are sent to the Clearinghouse for Federal Scientific and Technical Information (CFSTI) for further processing. The Secret, Confidential, and Unclassified Limited documents are then stored at DDC except for one or two copies which are used to catalog the document. About 130 documents per day go through this process. If the cataloger finds a new corporate author in a document he adds it to the master list and sends a card with the new corporate author to the Office of Lexicography. After a review of the cataloging, the document is sent to the Scientific Analysis Division where it is analyzed and indexed, an abstract is prepared if none exists, or edited and modified if there is an author abstract with the document, and the title is annotated. Any new descriptors used to index the document are added to the New Terminology List. The document and associated forms are then edited for completeness and correctness.

The hardware-software design philosophy of the Univac 1107 lends itself to great system versatility. The instruction set is a fixed-word scientific repertoire, with limited character-handling augmentation; which allows reasonable efficiency in coding for a text-processing application. However, the current DDC technical report and management data systems are dominated by three computer system factors:

1 Requirements for input validation and maintenance;

2 A large (magnetic tape stored) master file (AD System);

3 Voluminous and continuous printing requirements (AD and Management Data).

Bearing in mind that there are 16 magnetic tape units connected to this system (and 1004's), the DDC application is essentially "input/output bound," with limited central processor time being required in comparison with input/output time for individual programs, regardless of batching and parallel processing. This key factor will be analyzed in Section D.

Nevertheless, this Sperry-Rand Univac 1100-series' philosophy per se is valid and logical, and has strong features, such as the demonstrated ability to operate

The next step in the process is the preparation of punched paper tape on the Synchrotape machines. This is the basic input to the TAB. It is used as input to the Univac 1107 computer which formats, sorts, edits and updates the so-called Minimad master file (miniature, master AD file) daily. The computer prints the input tapes. The printouts are proof-read and any detected errors are corrected. CFSTI printouts are sent back to the Clearinghouse for corrections if necessary. After the new entries are corrected they are added to the computer file for the TAB. The hardcopy of the document is sent to storage. From there it is pulled, photographed and put on microfiche and stored.

After ten or eleven working days the Minimad (MAD) file has accumulated about 2,000 entries sufficient for a new TAB issue. The accumulated entries are reformatted, composition codes and standard text inserted and converted to IBM format on the 1107 and written onto magnetic tape. The tape is then sent to the Defense Supply Agency (DSA) for processing on the IBM 1401 computer. The 1401 makes another magnetic tape suitable for a photocomposition process. This tape is sent to the Government Printing Office (GPO) where it is converted to the fifteen level paper tape necessary to run the Mergenthaler Linofilm printing system. After GPO prints the galleys, DDC performs a final security check and edit, making changes if necessary.

At the same time the 1107 computer prepares microfiche headers, catalog cards, and prints the indexes for TAB. These are reviewed, photo-reduced by DDC and sent to GPO. GPO or its contractor does the production printing of the indexes and the announcements in TAB and handles the distribution of the bulletin, which is issued twenty-four times per year.

Finally, the master AD file, master Inventory file, and the inverted file are updated with the 2,000 new entries contained on the Minimad file.

b. Document Request Processing

Figure 4 shows the document request process. Requests for documents come to DDC in the form of DDC form 1, a punched card at an average rate of about 6,000 per day; letters and telegrams, about 250 per day; and telephone and in-person requests each day. Additionally, applications for service, DD Form 1540, are received at the rate of about 125 per day.

The mailroom receives and separates all of the written requests into the following categories:

(1) Identified - has AD number

(2) Unidentified - has no AD number

(3) Mutilated - card needs repunching

(4) ARB

(5) TIP and ATI

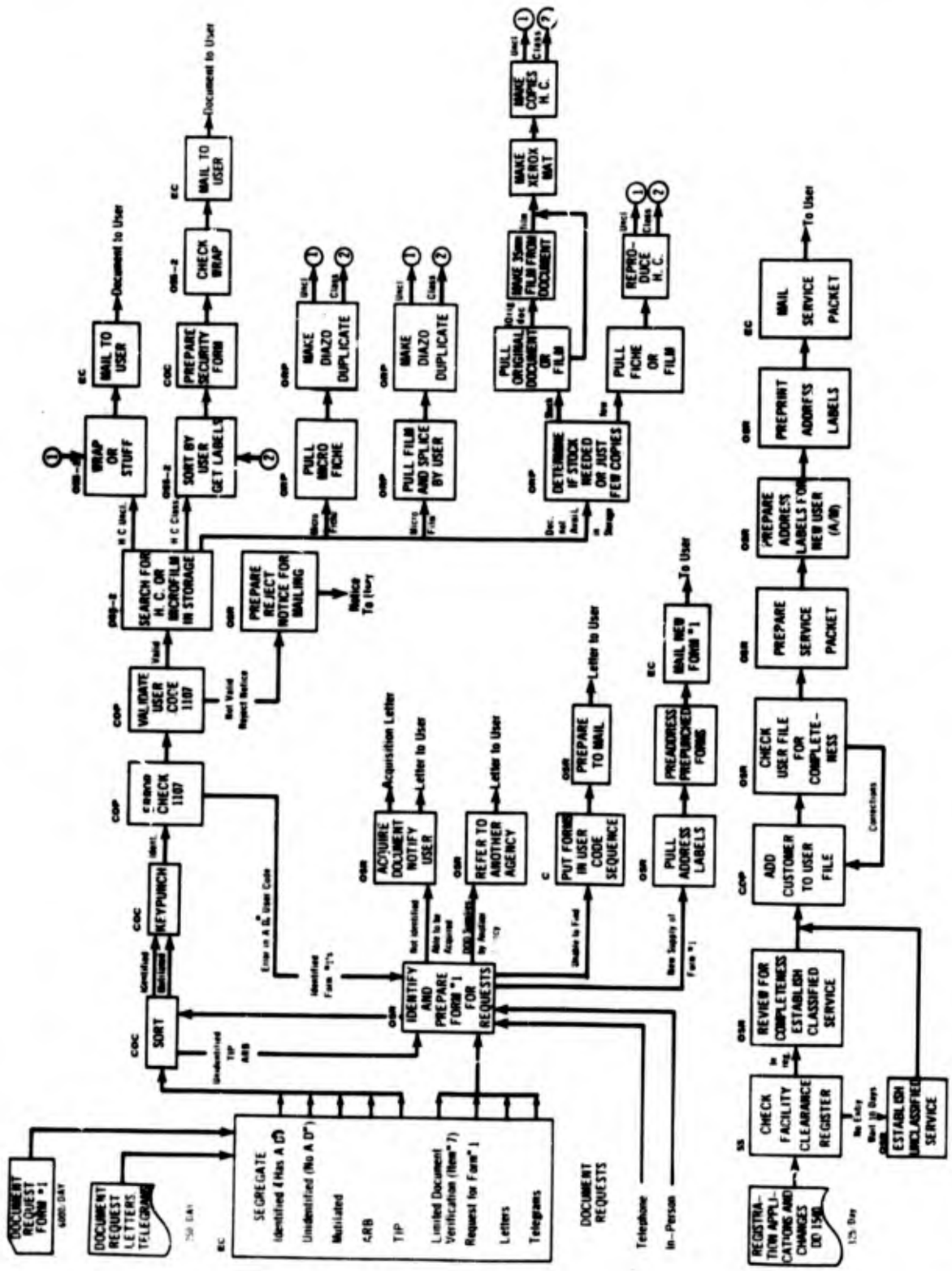

Figure 4. Document Request Processing

These requests, which come in on punched cards, are sent directly to computer operations for processing.

(6) Limited document verification - Item 7 checked

(7) Request for form 1

(8) Letters for all types of documents

(9) Telegrams for all types of documents

These requests all go to the reference branch for identification, preparation of form 1, and processing of requests for new blank forms 1 for users. All telephone and in-person requests are referred to the reference branch.

Computer Operations sort the requests manually and keypunch the identified and mutilated requests. They send the unidentified, ATI, TIP, and ARB requests to the reference branch for identification. The identified requests are then sent to the 1107 for an error check run. Errors in AD numbers and user codes are printed out and sent to the reference branch for filling and reject notices are printed for invalid user codes. The reject notices are sent to the reference branch which notifies the requestor.

The reference branch manually tries to identify all requests sent there. They also prepare forms 1 for those requests which do not come in on the form 1 card. If a request is not in DDC's collection and it is felt that it should be, an acquisition letter is sent to the author and the requestor is notified to this effect.

Periodic follow-up is indicated if the document is not received by DDC. If the request is for a document supplied by another agency such as NASA, the requestor is referred to that agency for service. If the reference branch is unable to find the document requested, the requestor is notified that the document is unavailable at DDC.

The reference branch handles all requests for replenishments of form 1. They check the validity of the user codes, send the cards to be punched in computer operations and prepare the forms for mailing to the user.

The service support branch fills all requests for documents which are valid and available. Requests for unclassified documents in hardcopy form which are in stock are pulled, wrapped, and mailed to the requestor.

Requests for classified hardcopy must go through another step. A security form is prepared on the 1107 computer, checked by service support, and then the document is wrapped and mailed. Requests for microfiche and microfilm are handled similarly. Diazo duplicates of the fiche or film are made, and then wrapped, checked and mailed.

If a requested document is not available in storage, a determination is made whether to prestock the shelves with the document or

just make a few copies for immediate needs. If only a few copies are desired, the fiche or film is pulled and reproduced in hard-copy form and wrapped, checked, and mailed as stated above. If restocking is needed, a Xerox matte is made from film if available or a film made from the original document.

The desired number of copies are run, the orders filled and the rest of the copies are stocked for later use. The requested documents are then wrapped, checked, and mailed.

Registration Applications for service (DD 1540) are also functionally part of request processing since all users must be registered with DDC to receive documents. When these applications arrive they are checked in Security on the Facility Clearance Register. If the user is in the Register, the reference branch establishes service at the proper classification level. If the user is not on the register, unclassified service is established after ten days. After an initial check by the reference branch, the user is added to the computer stored user file, and the reference branch prepares a service packet which is mailed to the user. The pocket contains information about service, how to use DDC's facilities and a supply of request forms 1.

c. Bibliography Request Processing

Figure 5 shows the functional processing of bibliography requests an average of 70 bibliography requests per day are received; 65

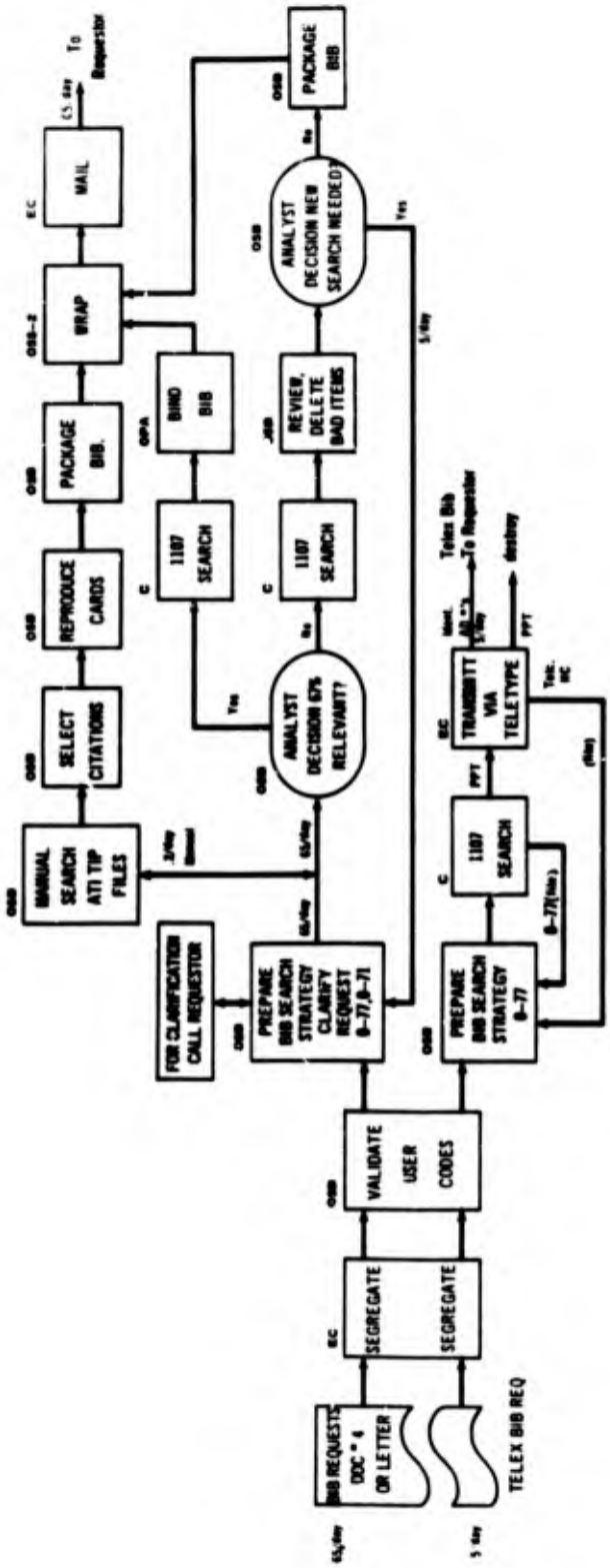

Figure 5. Bibliography Request Processing

by DDC form 4 or letter and 5 by teletype. The requests come through the mailroom where they are segregated. They are then sent to the Bibliography Branch where the user codes are validated and the search strategy prepared. If clarification is necessary the requestor is called.

The requests received by teletype are called rapid response bibliographies. After the search strategy has been determined, a computer search is run on the 1107 and a list of document AD numbers is punched out on paper tape. This tape is then taken to the teletype machine and sent directly to the requestor.

A very few requests (about one per week average) require manual searching of card indexes. The personnel in the Bibliography Branch select the citations, reproduce the pertinent cards, package the bibliography, and send it to the service support branch for wrapping and mailing.

The largest workload, 65 per day, utilize computer searches. After the analyst has determined a priori that the search strategy employed will or will not yield 67% relevancy, the computer search is made. For those which were thought to be 67% relevant before the fact, the computer printouts are sent for binding, wrapping, and mailing. For those not thought to be 67% relevant, an analyst reviews the computer printout and decides whether a new search is

needed. In about five cases per day, a new search is necessary. If a new search is not needed, the bibliography is packaged, wrapped, and mailed to the requestor.

C. CURRENT REQUIREMENTS

Major policy guidance governing DDC's operations are contained in Department of Defense (DOD) directives, instructions, memorandums, and letters. Among the major documents are:

1. DOD Directive 5100.36, Department of Defense Technical Information.
2. DOD Instruction 5100.38, Defense Documentation Center for Scientific and Technical Information (DDC).
3. DOD Instruction 3200.8, Standards for Documentation of Technical Reports under the DOD Scientific and Technical Information Program.
4. Working agreements for the processing of DOD unclassified/unlimited documents between DSA/DDC and Department of Commerce/CFSTI.
5. Agreements with DDR&E to process and provide management information to DDR&E designees.
6. Agreement with NASA which specifies procedures for citing DOD documents published by NASA.

D. CURRENT NEEDS

1. EXTERNAL NEEDS

There is a need for more feedback on the relevance and timeliness of all DDC's products including TAB, management report inputs and requests, document acquisition and requests, and bibliography requests. Functional studies are needed in this area, as are studies of interfaces between DDC and other data centers. A time-phased chart of the development of user services is shown in the five-year plan (see Vol. I).

Maximum recall (retrieval of all documents in a collection which could be pertinent to a request) makes additional provision of maximum relevance (retrieval of those documents specifically pertinent to a request) expensive in time and resources, while provision of maximum relevance implies expensive elimination of "false drops" and "noise responses" produced in "total recall." DDC has chosen maximum relevance of response, which optimally requires a retrieval pass designed for "maximum recall," followed by a manual and/or automated process of reduction of non relevant retrieved items. This goal, when optimally processed, conflicts with DDC's current very high computer usage (110 hours a week of Univac 1107 operation).

Several actions might enhance relevance and recall, and reduce the high DDC 1107 computer use rate:

a. Expanded use of "standard" or "pre-defined" computer bibliographic (bib) searches, which would reduce the (increasing) time requirements for Bib request formulation and computer usage.

b. Establishment of a firm policy of telephonic contact with all Bib requestors, except in those cases where a long-standing "automatic" request is involved. DDC policy is that Bib requestors may express requests in "their own language." The existence of 65,000 to 70,000 terms in the DDC thesaurus (7,000), and in groups of free indexed (50,000+), and nomenclature terms (7,000) (of which thesaurus terms are "published"), indicate that such telephonic contact would improve recall efficiency through better request formulation. Such a practice of telephonic communication with external requestors of bibliography is required practice at several major documentation retrieval centers.

c. Establishment of rigid, programmed limits on the amount of 1107 computer time allowed per Bib request.

d. Establishment of a programmed limit to the number of document (AD) citations that a given machine Bib request program can produce.

The second step will help eliminate cases where overly broad or poorly defined Bib requests result in excessive output of AD document citations. The Univac 1107 computer can utilize "wall clock values" in the third step in timing its own execution of a request (or of a group of requests). The Univac 1107 could be instructed to terminate processing a Bib request

after a defined, time period. The result would be a saving of redundant computer search time; a reduction in the very high DDC computer printing time usage and indication of occurrences of poor request formulation.

The fourth step (programmed limitation of printing of Bib requests) would afford a means of reducing DDC's computer printing burden. Since it is official DDC policy that 300 output AD document citations per request are the maximum allowable (without special exception), this limitation on output to be printed (which could be changed only by special exception) would reduce the very high DDC Bib request printing computer time (which can total as much as four or more hours per day). A comparative guideline for DDC is an absolute limit of 1,000 output citations for any request, which is used by comparable major installations.

Direct feed back on relevance and timeliness of published DDC AD products can and should be planned in the immediate future. An immediate means is a well-designed, simple form (of the SDI feedback type) to be included with:

Hardcopy or microform responses to selected, heavy users of document (Form 1)

Requests and

Responses to selected AD Bib requests (Form 4).

Although the liaison personnel of DDC attempt to obtain user reactions, a more specific means of assessment of relevance, and timeliness would be helpful.

A similar practice used in connection with DDC management systems outputs would be helpful in assessing effectiveness of those products. In this latter case, a policy of structured, reported telephonic contact initiated by DDC (feasible in terms of number of information requests) to obtain feedback on this class of retrieval products is an alternative procedure to usage of mailed feedback forms.

Adequacy of indexing (from the viewpoints of DDC users and of DDC) may be described as the combined operational status of several factors, including:

a. Depth, level, and congruence of indexing of input materials by descriptor, by subject area(s), and by cataloging-type identification;

b. Provision of error-free and updated indexes (individual and cumulative);

c. Descriptor and associated term lists;

d. Subject group and field code lists;

e. Explanatory tools to significant users of the system and operators of the system;

f. Availability of personnel and equipment resources for indexing, storage and retrieval;

g. Nature of system rules and practices in user-system interactions related to indexing and retrieval;

h. Ability and motivation of users and of system personnel, and

i. The nature of the user group.

These factors identify areas in which it is felt that the Defense Documentation Center has current needs. Provision of frequent comprehensive vocabulary tools to selected heavy users of DDC retrieval services, and to DDC personnel, should aid in refined requests for DDC retrieval, and reduce manual and ADP processing time. This includes frequently updated, consolidated listings of terms from the DDC free indexing and nomenclature ("subject area") vocabularies, in addition to thesaurus terms. This should hold true for document file retrieval and for management information retrieval.

Another need is for more coordination between indexing-type activities of DDC input (management and document) and retrieval request formulation personnel. This can be met by temporary consolidation of these two DDC groups into one (input) organization.

A third need lies in the area of effective DDC-CFSTI joint operations. DDC definitely should exchange very frequent listings of free-indexed terms, descriptors, and nomenclature with the Clearinghouse for Scientific and Technical Information, so that AD document

and retrieval services of the two organizations can be as congruent as possible.

The CFSTI and DDC procedures for input cataloging and indexing do not appear to be analogous for DDC-source document processing. Making allowance for organizational equipment and user-group differences, there should be closer joint coordination of practices in these areas.

Finally, the Clearinghouse and DDC serve different user groups (by charter and by custom) which have differing vocabularies, needs, and data requirements. This is an area where utilization of information on techniques, user-group feedback data and techniques (and on document stockage) would aid both organizations in meeting user needs for DDC-source AD material.

Cognate to this current DDC-CFSTI need area are data and tools for inventory of mutually processed materials. There is a current need for improvement in DDC internal response time on AD inventory change reporting, and for more rapid total updating (including CFSTI data) of the ADP-stored AD inventory file. Both these needs should be met prior to implementation of the new DDC AD Inventory computer programs, since the professional procedures followed in an inventory system effectively determine its utility.

Microform media have been used by the Defense Documentation Center for years as a document storage medium. Distribution of microform

(currently microfiche) in lieu of hard copy is a growing practice at DDC, and at comparable organizations. Planning is being made at DDC for selective dissemination (distribution) of microfiche to user groups; which would represent a major step for the Center.

Without arguing the merits of such dissemination, it is concluded that DDC must take account of computer considerations during such planning, which include:

a. Current heavy demands on the Univac 1107-based DDC computer configuration, which will not be reduced significantly until and unless a new computer is obtained:

b. The absence of prepared, tested Univac 1107-series software that would be needed if computer processing is to be part of this dissemination process within three years;

c. The existing and forseeable tasks assigned the DDC computer analysis and programming staff would indicate ADP activity in such an effort without addition of external support and consultative advisory services;

d. The necessity of analyzing ADP requirements for such selective microfiche (and hard copy?) dissemination during the recommended January, 1967, evaluation and selection of new computer equipment and software (by DDC, with external assistance) for the fiscal year 1969 period.

To summarize, it is concluded that these specific factors should be considered in depth, preferably as part of the proposed integrated DDC system effort.

2. INTERNAL OPERATIONS

a. Document Input Processing

In view of the development of more sophisticated processing techniques, the need for more efficient utilization of automatic data processing equipment, and the demands for more timely user services, it is expedient for DDC to re-evaluate the whole document processing area in terms of speed of document throughput along with the attendant needs for higher accuracy, better indexing, more uniform processing and better quality control. This re-evaluation could have implications on the organization's structure and should lead to the optimization of the total system rather than each of its parts. This is discussed in the five-year plan.

b. Management Input Processing

One of the pressing current needs is elimination and prevention of errors in the major management data file. There are several steps involved, which should be initiated at the first opportunity.

Purging of errors in the current file is the first step. Since the existing input validation ("edit") Univac 1107 program does not check individually-correct fields within file records against other related individually-correct fields for cross-field or

mutual errors, it is recommended that the Center systematically correct errors in the file by manual, professional-level processing. Computer-produced listings of the file can be examined by a group of several analysts, who, in three to six months could:

(1) Detect repeated or large-scale cases of improper report pre-preparation (which is a current DDC data management file problem area).

(2) This would be followed by a concentrated DDC management-level effort to secure standardized input preparation, based upon the file analysis effort.

(3) Remove the most errors from the data management files.

The section on ADP Operations outlines some suggested, ADP-related services to these analysts.

The above-outlined step has been considered necessary because of the need for purging of this file. The experience gained from this activity should be carried on through establishment and activities of a small analytical and clerical group charged exclusively with DDC computer-based file maintenance and purging operations.

c. Production Control

There exists a need at DDC to utilize the production statistics more for control than accounting purposes. The major purpose of collecting such data should be for production control. There is also a need to gather new statistics which are more directly

related to control of the production operation in all areas of the organization. Ultimately the gathering and synthesizing of ct the data should be part of an overall computerized production control system.

d. ADP Operations

Several areas of current needs have been identified in this study which relate to ADP operations. These are outlined below as current DDC needs.

(1) Need fo. Computer-Generated Management and Production Control Information.

The DDC-produced Utilization Report for the Univac 1107 totals the central processing time used by concurrently processed computer programs. Preparation of a modified input/output subroutine for the 1107 should be considered, which could compute usage of input/output units (Univac IIIA servos; Univac 1107 Line Printers, and logically connected (1004) Univac IIA and VIC servos). The routine could compute and report the name of the program; the type and unit number of the individual unit, and the number of computer words transmitted during such usage. Such a routine could be used with any concurrent set of worker programs, and would be used on a "one-time assemble and test run" basis to provide required data to dete: ine actual input/output unit usage.

The reason for such an operation is that actual use of input/output units cannot be determined (by DDC Project, by program, or by functional use) from the existing Utilization Report, and are needed to:

(a) Determine use of types of input/output equipment on the 1107 (by program) to obtain accurate, total data on Project/Directorate/other usage of the 1107;

(b) Serve in reducing the high usage of DDC Univac 1107 computer time;

(c) Aid directly in reduction of 1107 on-line printing; and

(d) Provide necessary data bearing on the need for enhanced input/output equipment.

(2) Need for (Improved) File Update and Maintenance Procedures

A current need in this area is planning of a full-time group of ADP analysts to initiate manual purging of the DDC Data Management file. These analysts should be supported by ADP services to:

(a) Retrieve and print separate, sorted listings of the contents of each field in the record format of this file;

(b) Retrieve and print all erroneous records detected by these analysts from such listings;

(c) Prepare selected output reports counting error types by input source, record type, and other criteria this "file clean-up" activity may require.

(3) Need for Off-Line Printing

This appears to be a major problem in the DDC computer time usage area. The following steps (if possible, done after analysis of products of (1) above) are recommended to lessen DDC's 1107 printing burden.

(a) Modify current DDC practice of using "SERVRO-Line Printer printing" for voluminous printing efforts (particularly Management Information reports). Using appropriate Executive control cards, write this file on a Univac IVC tape unit. Upon completion of the program(s) in a task (e.g., Data Management report generation), use one of the (scheduled) Univac 1005's to print this output. The Univac 1005, with 4,096 characters of memory, a good cyclic rate, and a 600 line-per-minute printer, should meet most DDC printing record size requirements, and provides a rapid, off-line printer.

This step involves placement of a Univac IVC tape servo on one of the Univac 1005 computers. Since comparable tape units are standard at every known comparable center, and the IVC is 1005-compatible, the reduction of 1107 print time (now occupying the third 1107 shift, and parts of the second and first) should justify the low

cost. Also involved is addition of a 62.5 KC Univac IVC servo on the Univac 1107 for the above mentioned off-line printing, and as a means of speeding production of IBM-compatible TAB output for DSA (and GPO) print usage. This usage could be in association with the existing DDC Univac 1107-to-Univac 1004 (1005)-to-Univac(IVC) tape unit process, when the (scheduled) replacement of the U. S. Navy's Univac LARC obviates the current DDC need for a Univac IIA tape unit. This would allow both of the Univac 1005 computers to have a Univac IVC servo for off-printing, TAB production and other peripheral use.

Use of the first alternative above, with associated reduction of on-line Univac 1107 printing, should help in alleviating DDC's time problems. The scheduled addition of two more Uniservo IIIA synchronizers should also help in reducing 1107 operation time.

(b) Three other solutions were considered as means of reducing DDC printing problems.

The first of these was to continue existing Univac 1107 - Univac 1004/5 - IBM 1440 ATS processing. This was discarded as being insufficient to meet DDC needs, since continuation of current on-line Univac 1107

printing should result, within less than two years, in a situation where DDC-generated output cannot be printed during a 24-hour day and current services therefore will have to be curtailed, and because the conclusion has been reached that procurement of a faster computer (e.g., the Univac 1108), without utilization of off-line printing, would simply delay the onset of this "on-line printing saturation point," because

- computer printing is a relatively slow, electro-mechanical process, whose speed is not increased through faster CPU time;
- use of printer input buffer units and logic units to complete printer instruction execution (after CPU initiation) does not markedly reduce printing throughput, since the full printer time cycle is still required to print a line of data, and
- use of additional on-line printers would not be economically competitive with enhanced peripheral computer printing in effectiveness, considering overall computer processing time demands at DDC.

(c) The second alternative considered was use of the IBM 1440 ATS as a second- and third-shift off-line printer. This step could be adopted, provided that:

1 A Univac IVC tape servo unit is procured for the Univac 1107, as recommended in Section (a). This 62.5 KC tape unit will permit output of 1440-compatible output tape at an acceptable speed;

2 The IBM 1440 tape-to-print program, a utility program already prepared and tested, is utilized for printing Univac IVC-prepared tape, which can be mounted on the two 7335 tape units of the IBM 1440;

3 Output, selected from specific DDC document and management information programs, is translated from FIELDATA to IBM-compatible BCD tape coding, and

4 An IBM 1403 printer (600 lines per minute) replaces the IBM 1443 printer (150 lines per minute).

The third criterion for IBM 1440 printing can be met by one of two means. The first is the use of the Univac 1107 FIELDATA-to-BCD translation (servo) hardware option, which requires a monthly rental charge of $100. If the tape BCD coding produced is IBM 1400-series compatible, and results in coding compatible with DDC's 1440 printer chain, this option is technically feasible. The other means is that of writing a special Univac 1107 subroutine, for use in conjunction with the existing Univac 1107 SERVRO routine, which would translate output

from FIELDATA to BCD for printing on the IBM 1440. DDC's choice between these two means presupposes comparison of the rental cost of $100 per month for the 1107 Univac IVC hardware BCD translation option for a period of at least two years, as compared with the cost and effort of programming and maintaining a Univac 1107 FIELDATA-to-BCD translation routine.

The fourth criterion for IBM 1440 off-line printing involves a cost of about $500 per month for acquisition of an IBM 1403 printer for the IBM 1440. The provision of a Univac IVC servo for (1005 and) 1440 usage, coupled with FIELDATA-to-BCD translation costs for 1440 printing, would require higher-speed printing than the current 1443 printer provides to justify the total cost of IBM 1440 off-line printing. The current 1443 printer is slower (150 lines per minute) than any known peripheral computer printer in use at comparable installations, while the 1403 printer's speed (600 lines per minute) is generally a "standard" rate at comparable centers.

(d) The third alternative considered was installation of a Univac 418 computer for peripheral usage, replacing the two existing Univac 1004/1005 peripherals. The 418 would perform all peripheral off-line printing, as well

as the card and tape conversions and TAB preparation tasks currently involving the 1004/1005 machines. This alternative presupposes continued use of the IBM 1440 ATS system, although it is unusual practice to have two non-compatible, medium-scale peripheral computers at an installation of the size and nature of the Defense Documentation Center. The rationale for this is that neither manufacturer can rapidly provide 1107-compatible hardware and comprehensive software for all DDC off-line functions.

The justification for this alternative would lie in a demonstration of need for major off-line printing activity at DDC. This would be determined after analysis of the effectiveness of performance of the 1005 peripherals replacing the 1004 peripherals in September, 1966, and of the expected processing speed increase to be derived from the two new Univac IIIA synchronizers being added to the Univac 1107 at the same time.

If such an analysis shows that no reduction in overall computer time usage has occured, this alternative of a Univac 418 should be considered, since the growth of DDC processing requirements (under DDC System Alternatives 2 or 3) will require a considerably increased DDC printing effort within the next two years.

The cost of this alternative (based upon appropriate Univac GSA figures) is such that the following capabilities should be incorporated into the 418 configuration to provide sufficient throughput to justify the basic expense entailed in a 418 system.

- Inclusion of one Univac IIA servo, until the US Navy's Univac LARC computer, which produces the only input for this DDC tape unit, is no longer use;
- Incorporation of at least two Univac 0751 printers to allow high-speed, high-volume off-line printing. A case can be made for placement of the two (DDC-owned) 1107 line printers on the 418, yielding a strong off-line printing capability, and providing additional 1107 processing time (currently occupied by on-line printing);
- Provision of at least one, and possibly two, Univac IIIA tape servos on the 418. This would allow high-speed (100 KC) transfer of material for off-line printing from the 1107 to the 418. An alternative to this is a switch allowing the Univac 1107 and the 418 to share the Fastrand II drum, currently linked to the 1107. This alternative

requires manufacturer-tested (off-site), proven, no-cost software allowing optimum use of such shared drum storage;

- Inclusion of at least one Univac IVC tape servo, to allow TAB output tape compatibility for DSA/GPO processing use and reduction of this currently time-consuming DDC TAB output process;
- Provision of no-cost, externally-tested, proven 418 software for control of 418 operations; concurrent operation of multiple card-to-tape, tape-to-card, and tape-to-printer operations and (if utilized), effective 1107-418 sharing of the Fastrand II drum.

The following rental cost considerations are involved, which DDC must weight in evaluating this "418 alternative."

The Univac IIA tape unit would require no further outlay, since it currently is part of the DDC 1004/5 configuration.

The Univac 7299 Printer Control (serving up to four 0751 printers) and two 0751 printers could be rented for $2750 per month (with maintenance). Provision of these two high-speed printers, and placement of the

two DDC-owned 1107 line printers on the 418, could provide strong off-line printing capability.

The provision of a 3010-11 418 Central Processing Unit, with a 4-microsecond cycle; 12,288 characters (4,096 18-bit words) of memory; a 5010 Card Controller, 0706 Reader (800 cards per minute), and an 0600 Punch (300 cards per minute) would require monthly rental charges of $4790 (with maintenance).

The Univac IVC tape unit (with power supply, synchronizer, and servo) would provide Fieldata-BCD conversion, for a rental of $2425 per month (with maintenance). This unit would provide 62.5 or 90 KC tape data transfer, to replace the current (slow) Univac VIC data transfer rate of 23.2 KC.

One, or two, Univac IIIA tape servos would cost respectively $4145 or $5050 per month, including maintenance. These values must be compared with the costs for use of a switching device to allow shared Univac 1107-Univac 418 usage of the Fastrand II drum.

The "basic monthly rental" of such a Univac 417 computer configuration, <u>without</u> Univac IIIA tape units, would approximate $10,000 per month. This figure could be

lower, if single tape synchronizers and/or power supply units permitting combined Univac IIA, IVC (or Univac IIIA) operation can be obtained. A monthly rental equivalent of about $4500 (for the two replaced Univac 1005 computers) should be deducted from this total, yielding an "approximate basic rental" of about $5500 per month. The cost of one or two Univac IIIA units, or of drum sharing switch logic, would have to be added to this total.

The costs of this alternative must be evaluated against the need for high-capacity off-line printing. Another factor is to be considered is the provision of one card reader and one card punch with this configuration, as against the current 1004/5 provision of two card readers and punches.

The effect of the provision of 1005 peripheral equipment in September, 1965; the acquisition of two additional Univac IIIA synchronizers for the 1107, and of implementation of steps outlined elsewhere in the Current Needs section (e.g., reduced Bib printing) should be observed in practice prior to any selection of an alternative means of off-line printing. The Univac 1005 scheme, or the IBM 1440 alternative may well be adequate for DDC

needs, but a continued rise of printing time above-mentioned (after system changes) may indicate a need for the alternative of a Univac 418 configuration. In any case, these alternatives should not interfere with any future (Fiscal Year 1969) installation and operation of a new central computer configuration at DDC, provided the Univac 418 (if selected), and all peripheral equipment is rented.

e. TAB Generation

As part of document input processing, there is a continuing need to try to reduce the amount of lead time for document announcement. In this light, the impact of the IBM 1440 Administrative Terminal System on TAB generation should be closely studied.

There also exists a need to determine if the TAB, as it now exists, is the best method of notification. Because of the diversity of user needs and desires, a study is warrented in this area.

Because the printing and distribution is done by the GPO an extra ten to fifteen days is added to the TAB cycle. There is a need to examine the relationship between DDC and GPO to determine if this relationship is mutually beneficial.

f. Operational Management

There is a need, as the variety and amount of work at DDC increases, and the amount of central control from higher authorities increases,

for DDC to show continuing improvements in the following areas:

(1) Security Control

(2) Cost Control

(3) Quality Control

(4) Resource Allocation Control

(5) Production Control

(6) Inventory Control

The need exists to centralize control of all of these efforts in an integrated management control and information system which will tend to optimize the whole DDC operation and not just each individual part. The system should be capable of supplying management and production information as an integrated part of the control process in a timely and accurate fashion. It should also form the basis for determining the effects on the existing organization in terms of workload, personnel, etc., of new tasks which could be undertaken by DDC in the future.

To achieve this centralized control some organizational changes may become necessary. This is discussed in the five-year plan under DDC Internal Integrated System.

There is a need, caused by both planned and unplanned changes which will affect DDC in the future, for enhanced training and educational programs for personnel. Studies need to be made to determine the best mix of continuing education and on-the-job

training and upgrading of personnel for the changing occupational needs over the next several years at DDC.

E. FUTURE REQUIREMENTS

Future requirements are best presented as possible alternative courses of action which may be taken by DDC. It is not possible to know what missions will be assigned to DDC, but several alternatives can be postulated based on its existing operation, future plans, and judgments of both the people interviewed by SDC and the SDC personnel themselves.

1. DDC can continue under existing directives and agreements to distribute documents and serve as a management data bank for the next two fiscal years. This alternative assumes that DDC will basically remain a document distribution center after the next two fiscal years.
2. DDC can continue to distribute documents and to service management data customers from a subset of a total management information system. This alternative assumes a continuation of the existing document and management information systems which are now being operated for the full five-year period and beyond.
3. DDC can continue to distribute documents and to service management data customers within the framework of a new integrated management information system. The types of information in this system could include selected fiscal, manpower, and planning information, as well as comparable information on results and effectiveness of contractor activities.

The alternative of DDC acting as a responsible agent for a segment of an overall total system was explored and, though it was considered possible, it was concluded that an active major DDC role as a responsible agent is

not likely during most of the next five years. It, therefore, has not been treated as a formal alternative. However, such an alternative should be studied when more definitive plans of the responsible agent concept itself are known.

The five-year plan contains resource requirements for the three major alternatives above (see Vol. I).

F. FUTURE NEEDS

This section describes the system needs two to five years in the future.

1. EXTERNAL RELATIONS: NEEDS

a. Outputs Tailored to the Requirements of Users

Many different types of people use the services of DDC: scientists, engineers, managers, military men, etc. Each of these users imposes different requirements upon an information retrieval system. A manager, for instance, is likely to want summary information, whereas a technical man is more likely to want discrete items of information. Furthermore, the requirements of all users vary with the use to which the information is to be put. At least six different modes of information search can be distinguished, each of which corresponds to a major type of information requirement:

(1) To satisfy a unique point of information

(2) For an exhaustive search to identify all information relevant to a given topic.

(3) To browse for problem-solving purposes where the searcher has little certainty about the topical description that will yield appropriate information.

(4) For retrospective awareness of material in a topical area not ordinarily of concern to the searcher.

(5) For current awareness of material in a topical area not ordinarily of interest to the searcher.

(6) For current awareness of material in a topical area or range of topical areas (a standing need).

All the outputs of DDC's systems (announcements, bibliographies, information summaries, etc.) should be tailored both to the type of user and to the use to which the information is to be put. If necessary, new outputs should be generated to fulfill the needs of the users.

b. Control of Output for Security Purposes

As the outputs of DDC's systems become more varied and sophisticated, the problems of security and proprietary information control will become more difficult. On-line access to the data bank will produce further problems. Techniques will have to be developed to insure that the on-line user is indeed authorized to receive the information he requests, that he has a need-to-know, and that he is actually the person authorized to use the on-line terminal. One of the major reasons for DDC's continued existence in the face of many competitive retrieval systems is its ability to handle classified and proprietary information. Considerable thought and effort should be put into expanding and enhancing that ability.

c. Control of the Quality of Input to DDC

Since DDC is primarily a service agency it has little direct control over the quality of its input. However, DDC can exert considerable indirect control. DDC should make it a policy to

discuss with those users whose input is below standards the advantages accruing to those who meet the standards and the disadvantages of those who do not. DDC should also investigate the user's problems in generating the input and, where possible, assist the user in bringing his input up to standards. When these techniques fail, DDC should make the problem known clearly and specifically to those with authority over the input agency.

d. User-Specified New Uses of the System

In addition to its on-going survey of user satisfaction with the current system, DDC should periodically query its users about new uses for the system. Although the vast majority of users will have no suggestions to make, the few who do may create uses of wide applicability.

e. Compatibility With Other Information Retrieval Agencies

DDC should cooperate with other agencies in the generation and maintenance of information processing standards. DDC should also insure that its systems are compatible with the systems of other agencies. There is a definite trend toward the aggregation and standardization of information processing systems. DDC should be in the vanguard of that trend.

2. DOCUMENT INPUT PROCESSING: NEEDS

a. Automation of Input Processing

Automation of any process requires two steps: first, definition and standardization of the procedures used in the process; and,

second, reduction of the procedures to computer terms. The degree to which any given procedure should be automated is determined by the precision with which its processes can be defined and by the cost of computer performance vs. manual performance of the same processes. The factors of reliability, efficiency, and speed of processing as well as purely economic factors should be used in the determination of relative cost. The prospects for automation of document input processing are as follows:

(1) Descriptive Cataloging

The procedures involved in descriptive cataloging are well standardized but are not amenable to automation until some means, such as optical scanning, is available to input the title pages of a document. Until that time, automation of descriptive cataloging will be limited to checking the input for keyboard errors and inconsistencies and performing simple table look-ups for such items as "sponsoring agency" and "congressional district", etc.

(2) Abstracting

Currently there is little or no standardization of abstracting techniques. Abstracting standards should be developed even if no automation were planned. A list of questions that abstracts are designed to answer should be evolved, leading to a set of standard formats for abstracts. Although no

single format would be likely to suffice for all abstracts, a set of half a dozen or so formats should suffice to satisfy the abstracting requirements of most of the documents input to DDC. After standard formats have been developed, the computer can be used to check the consistency and completeness of the abstracts. Truly automatic abstracting (or rather extracting) would require full-text processing and extremely sophisticated manipulation techniques.

(3) Indexing

Current DDC indexing techniques, although not very well standardized, are based upon the descriptor principle. Techniques exist in the state-of-the-art for deriving descriptors from the full text, from abstracts, and from titles. None of these techniques are very satisfactory, probably because descriptors themselves are not very satisfactory (see Section 4.a below). More sophisticated indexing techniques would not be amenable to automation without full-text storage. However, the computer can be used as an assistant to the indexer by performing consistency checks and doing table look-up. The computer can also be of considerable assistance in the maintenance of the thesaurus used by the indexer.

b. Minimum Classification

DDC should encourage input agencies to put the lowest possible security clearance and proprietary limitation on documents sent to DDC in order to facilitate information dissemination.

3. MANAGEMENT INFORMATION INPUT PROCESSING: NEEDS

a. Reduction of Keyboarding

DDC should study and try to develop alternatives which will greatly reduce or eliminate keyboarding for the majority of the inputs to the management information system.

b. Cross-Check Inputs for Consistency and Completeness

If the management information data system grows to include new forms of inputs such as manpower data and fiscal data, it will become necessary to check the new forms of input against each other and against the data store for consistency and completeness. Inconsistencies will have to be traced back to the input agencies and corrected. Sources of inconsistency should be eliminated by direct consultation with the input agency where possible, and by appeal to higher authority when necessary.

4. INFORMATION SEARCH AND RETRIEVAL: NEEDS

a. Improved Indexing Methods

To improve consistency of indexing, DDC is strongly urged to install an automatic thesaurus. Since the quality and consistency of indexing by a person differs from day to day, means have to be

devised to achieve consistency through mechanical means. Guidelines should be given to the indexer which he may follow to assure that there always is a core of indexing terms which will be the same for each item of information and, in effect, will tie the various individual reports together. A requirement for adding the generic term to specific terms will assure retrieval at a more general level, especially for retrieval of information dealing with the state-of-the-art.

b. Improved Retrieval Techniques

Improved indexing and automatic input processing will make retrieval easier and more accurate by improving the quality of the data base. However, improvements can be made in the retrieval process itself. Potential for improvement exists in the following three areas:

(1) File Structure

The structure of the data file has considerable effect upon the speed and ease of retrieval. DDC's direct and inverted files are simple and allow rapid access when properly constructed and used. Since both the number of entries and the number of index terms per entry will increase, extremely large amounts of random access storage will be required for these files. It may be necessary to modify, supplement or replace the present files with other file structures such as trees or word-association maps. Hardware developments,

such as large-scale associative memories, may render the present file structures obsolete. DDC's file structures should be periodically re-examined in the light of retrieval need and available techniques.

(2) Search Techniques

DDC's present search techniques assume that the searcher knows exactly what he wants, is familiar with both the form and content of the files, and is reasonably certain of what the results of the search will be. These assumptions are not completely valid even today and will become less valid as the number of requests in the size of the data file increases and as less sophisticated users gain access to the files on-line. Future techniques should be fast, requiring no more than 10 seconds between the end of input and the beginning of output. Indicators of output content, such as number of items retrieved and data samples, should be given to the user before he requests full output. The retrieval programs should instruct the user in the techniques of retrieval as he uses the system.

(3) Output Checks

As long as the outputs of the system are simply printouts of the data in the files, no output checks are needed, since the user can check the quality of the data for himself. However, when the output is the result of summarization or

other computations, the user no longer has the data available to make his own quality checks, so that checks for data consistency and completeness must be made by the computer and the results of the checks given to the user.

c. Exchange of Data and Techniques Between Systems

Much of the information available in the document system (such as DD Form 1473 and progress reports) could usefully be added to the management information system. On the other hand, the management information system, with a small data base and few users, makes an excellent test bed for new techniques. Once these techniques have been developed and proven in the management information system, they should be applied to the document system.

d. Use of Document Content for Search and Retrieval

The document system cannot become a true information retrieval system until it is possible to retrieve the document contents as well as the complete document. It is doubtful that this goal will be reached within the next five years. Nevertheless, a start can be made by using the abstracts or the full-text of a selected subset of documents and by developing a question-answering program for use with this limited data base. Only in this way will the problems and prospects of document information processing become known in preparation for a full-scale attack on the problem during the 1970's.

5. REQUEST PROCESSING: NEEDS

a. Faster Response to Requests

The use of improved and automated retrieval techniques and more rapid means of transmission, such as teletype, will reduce request processing time to a few hours. However, for many applications, particularly in the management information system, a response time on the order of minutes or seconds is required. This kind of response time will require direct on-line user access to the data base and to the retrieval programs. Although demand for such rapid response is not strong at present, demand will increase as on-line systems become more prevalent and their advantages become more obvious. DDC should anticipate that demand by developing a user-oriented on-line system.

b. Better Focusing of Requests

Improvements in indexing techniques and retrieval techniques will make it possible to specify the information required with greater accuracy and in much more detail than presently. More detailed request forms and more specific instructions in the use of the forms should be produced to take advantage of these improvements in technique.

c. Feedback to the User

In the on-line system the feedback techniques developed for searching should be expanded and improved and made available to the on-line user in order to prevent the generation of massive amounts of useless output.

d. Individual User-Generated Search Techniques

Many system users need specific standard searches performed at frequent intervals. DDC should allow such users to generate search programs to perform these searches and to store them in DDC's computer. DDC should, of course, monitor such activity and advise the user when techniques are already available or when the user's techniques can be improved.

6. ADP OPERATIONS: NEEDS

a. Keep Up With the State-of-the-Art

The State-of-the-Art Study included in this document (Volume III) makes knowledgeable predictions about the hardware and software which will be available within the next five years. However, it is quite probable that progress in some areas will spurt ahead of the predictions and in other areas lag. Furthermore, breakthroughs may render any of the predictions obsolete or irrelevant. DDC should maintain a study group composed of both managerial and technical personnel which would meet at least once a year to consider the current and predicted state-of-the-art in both hardware and software with regard to possible applications to DDC's needs. Particular consideration should be given to larger, cheaper, random access memories, faster processing, advanced data storage and retrieval techniques and improved input/output techniques.

b. Plan for Expected Increases in Workload

Major changes to either hardware or software require considerable lead time to implement. When expected increases in workload require such changes, implementation should be begun well in advance of the expected date of increase.

c. Ability to Accommodate New Work

Not all increases in workload can be anticipated, particularly when such increases are the result of requirements imposed from above. However, most requirements have certain common features which can be anticipated in the design of the system, making the absorption of new requirements faster and easier. For example, most requirements will involve new or revised outputs and an enlarged data bank due either to the acquisition of new inputs or of a data bank already in existence. In hardware, these changes can be anticipated by maintaining an extra reserve of data storage capability and computing power. In addition, the hardware should be modular, so that memory storage unit, central processors and input/output units can be added without completely re-designing the hardware system. In software, the program system should also be modular so that programs can be added or changed without disrupting system operation. Similarly, the programs themselves should be designed so that the data base structure and output formats can be changed without completely rewriting the program.

d. Innovation in ADP

The development of management information systems (such as DDC's) will have a revolutionary impact on managerial techniques. The manager will have available to him more accurate and detailed information in much greater amounts than is currently possible. This will result in a demand for computation programs to reduce the amount of information presented to the manager without sacrificing the detail or accuracy. For instance, there is no reason why the manager should be presented with the cost of a program and the measures of its effectiveness when a computer program can generate a cost effectiveness ratio and present the manager with this single figure. Similarly, the detailed information available will increase the range of possibilities involved in a decision from two or three to hundreds or even thousands. This will result in a need for computer programs to reduce the range of possibilities to a manageable level, or in other words, to make routine and non-critical decisions.

Advances in document systems will result in the ability to directly access the information contained in the document or collection of documents rather than requesting the documents and obtaining the information manually. DDC should study and develop programs to perform business computations and routine decision-making and to analyze and synthesize the information content of documents.