AD640116

Technical Report

AD 640 116

MECHANIZATION STUDY OF THE RELIABILITY CENTRAL ROME AIR DEVELOPMENT CENTER, GRIFFISS AIR FORCE BASE, N.Y.

Submitted to

Defense Supply Agency
Defense Documentation Center
Cameron Station, Virginia

by

Booz, Allen Applied Research Inc.
4733 Bethesda Avenue
Bethesda, Maryland 20014

Under Contract No. DSA-7-15489

BAARINC Report No. 914-1-21

September 1966

BOOZ·ALLEN APPLIED RESEARCH INC.

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ABSTRACT

Computer mechanization of the Reliability Central (RC) at Rome Air Development Center (RADC) is currently being designed and partially implemented, by contractors. RC will be an information center but will not ordinarily distribute source documents. It will retain hard copy from which raw data on electronic parts have been obtained, and it will maintain the raw data in computer files and will manipulate and interpret these data to produce handbooks in various summary forms to be widely distributed throughout the scientific community. It will also entertain queries for information obtainable from the data base but not found in the handbooks. The program will be operated on the RC computer complex following the test operation planned for March 1967.

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I. SUMMARY

Computer mechanization of the Reliability Central (RC) at Rome Air Development Center (RADC) is being designed and partially implemented by contractors. The program will be operated on the RC computer complex following the test operation now planned for March 1967.

RC will be an information center but will not be a documentation center or repository in the usual sense. That is, it will not ordinarily distribute source documents. It will retain hard copy from which raw data have been obtained, and it will maintain raw and reduced data in computer files and will manipulate, interpret, and analyze these data to produce reliability handbooks in various summary forms to be widely distributed throughout the scientific community. In addition, it will entertain queries for information obtainable from the data base but not found in the handbooks.

The data base will contain a wide variety of information on components and devices, beginning with transistors and diodes. Specifically, the data will include electrical, physical, and environmental parameters; identification information; specifications; test results; and a wide range of reliability information.

Initially, the data are being collected under contract and will be extracted and analyzed for input to the computer system. When the Central becomes operational it is expected that component test reports, equipment test reports, and field operational reports will automatically be submitted to RC by Government agencies and their contractors. It is also expected that component vendors, equipment manufacturers, and similar sources will make voluntary contributions to the data base.

The majority of the source material for RC will be as follows: equipment and system contractors' equipment test reports; reliability demonstration test reports; component reliability program reports; component failure analysis reports; field operation failure reports; component manufacturers' qualification test, production test, reliability test, and failure analysis reports; Government agency component test reports and field operation failure reports. In addition, information from Interservice Data Exchange Program (IDEP), Failure Rate Data Program (FARADA), National Aeronautics and Space Administration (NASA) Reliability publications, Goddard Space Flight Center Semiconductor tape file, vendor publications, specifications, and standards will also serve as source material for RC.

Though Air Force funded, RC will provide service to the DoD community and NASA. While the most frequent users of the computer complex will be the employees of RC, the outputs and services of the RC will primarily be provided to Government agencies and their contractors responsible for the design, development, evaluation, production, logistic support, and operation of military systems and equipment.

At present the RC staff consists of nine people, with one person on loan. The staff will be augmented by a field team which will have data collection and validation as its main function. A parts engineering group will be responsible for the technical adequacy of the data base. A data analysis and processing group will be responsible for the data storage and analysis functions.

II. MECHANIZATION

1. CHRONOLOGY

Development of RC is proceeding with contractual support, under a five-year implementation plan (Figure 1) which began early in 1964.

Three major contractors are currently participating: Illinois Institute of Technology (IIT) Research Institute, Autonetics Division of North American Aviation, and Auerbach Corporation.

IIT has two contracts, one to develop the detailed operation and implementation plan ($37, 000) and the second to collect and reduce data from a variety of sources to serve as the initial data base for RC ($380, 000).

Auerbach completed the general design of the storage and retrieval system ($70, 000) and is accomplishing the detailed design for the test operation ($90, 000).

Autonetics has a contract ($419, 000) to collect, reduce, and supply Ballistic System Division (BSD) data from the Minuteman program. It also has available some 7094 programs relating to Minuteman data that will be modified for use at RC. This contract

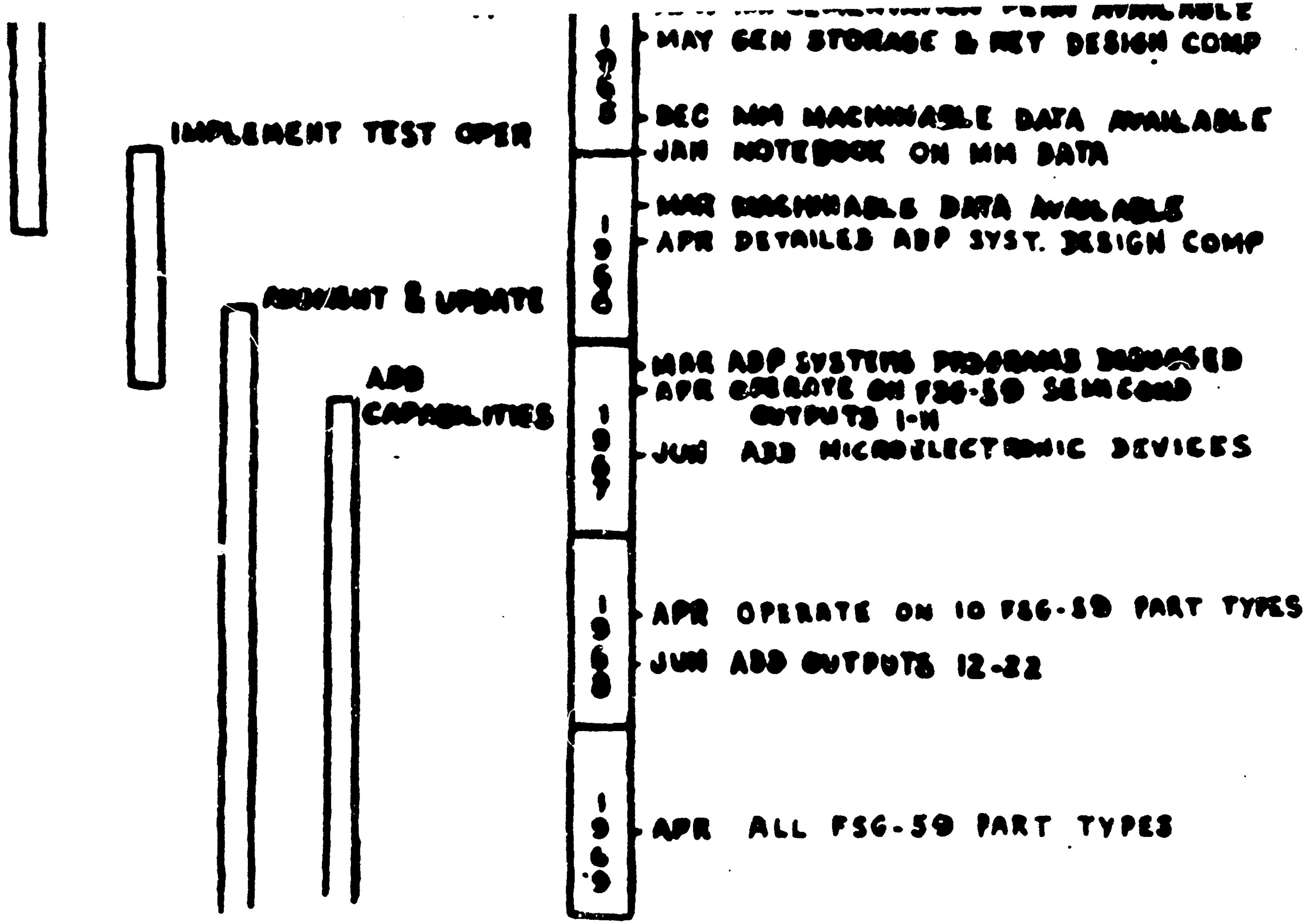

FIGURE 1
IMPLEMENTATION PLAN FOR RC

also calls for assistance to RADC on the management of a series of established reliability specifications.

Development of a pilot operation is now underway, and a preliminary test operation on approximately 200 million bits is scheduled for March 1967 to demonstrate the system. The data base will include information on transistors and diodes, and 11 of the proposed major outputs will be produced. At the conclusion of the test operation, RC will be capable of being expanded smoothly and rapidly into full-scale operation.

The output for the test operation will be implemented through a combination of manual and computer effort. As the analysis procedures are more clearly defined and experience with the data base is attained, more tasks can be turned over to the computer system.

2. DESCRIPTION OF PROCESSES

The RC will always remain more manually oriented than most computer systems because of the diversification of the data base.

Inventory printouts of all data will be available to the analyst. An audit trail will connect each datum in the data file to the originating documents. This will enable the analyst to interpret the formal output from the system by inspecting the source documents, which will be stored in accession number order.

When the original document either is classified or contains industrial proprietary data with restricted distribution rights, this information also will be carried into the file by separate information bits.

Any analysis, summarization, or printout which utilizes classified and/or proprietary data will become "contaminated" and will carry an appropriate symbol of its classification.

It is the responsibility of the analyst to determine whether a summarized printout partly based upon classified data is or is not classified. Obviously, this depends on the nature of the analysis in merging of classified and unclassified data and on the method of presentation.

Proprietary data, similarly, will contaminate all output for which it is used. In this case the analyst will have to determine whether the proprietary nature of the original data has been eliminated through deletion of corporate identification or merging of data.

It will be the responsibility of RC to use the data trail facilities built into the system to avoid release of classified and/or proprietary data to unauthorized recipients.

(1) Input Procedures

Figure 2 shows the classification of electronic parts, indicating their hierarchy and class delineation. This figure is useful for keeping in mind the several levels at which data are available for entry into the RC file. The part identification system that will be used will employ the same first three digits as IDEP, thus providing a measure of consistency with other reliability data services. The system is, however, not adequate to describe specific parts, so that additional digits must be added for full description within RC.

(2) Flow

To provide efficient storage and exchange of data for the test operation within the RADC complex, the RC data base will consist of three data banks for raw, reduced, and summary data. The raw data consist of detailed test results such as are exhibited in the entries of a matrix test. The reduced data may be failure rates, drift rates, or scatter diagrams calculated from the raw data. Summary data may be families of failure rate curves, distribution curves, or tabulated failure rates and failure modes obtained by merging and correlating reduced data.

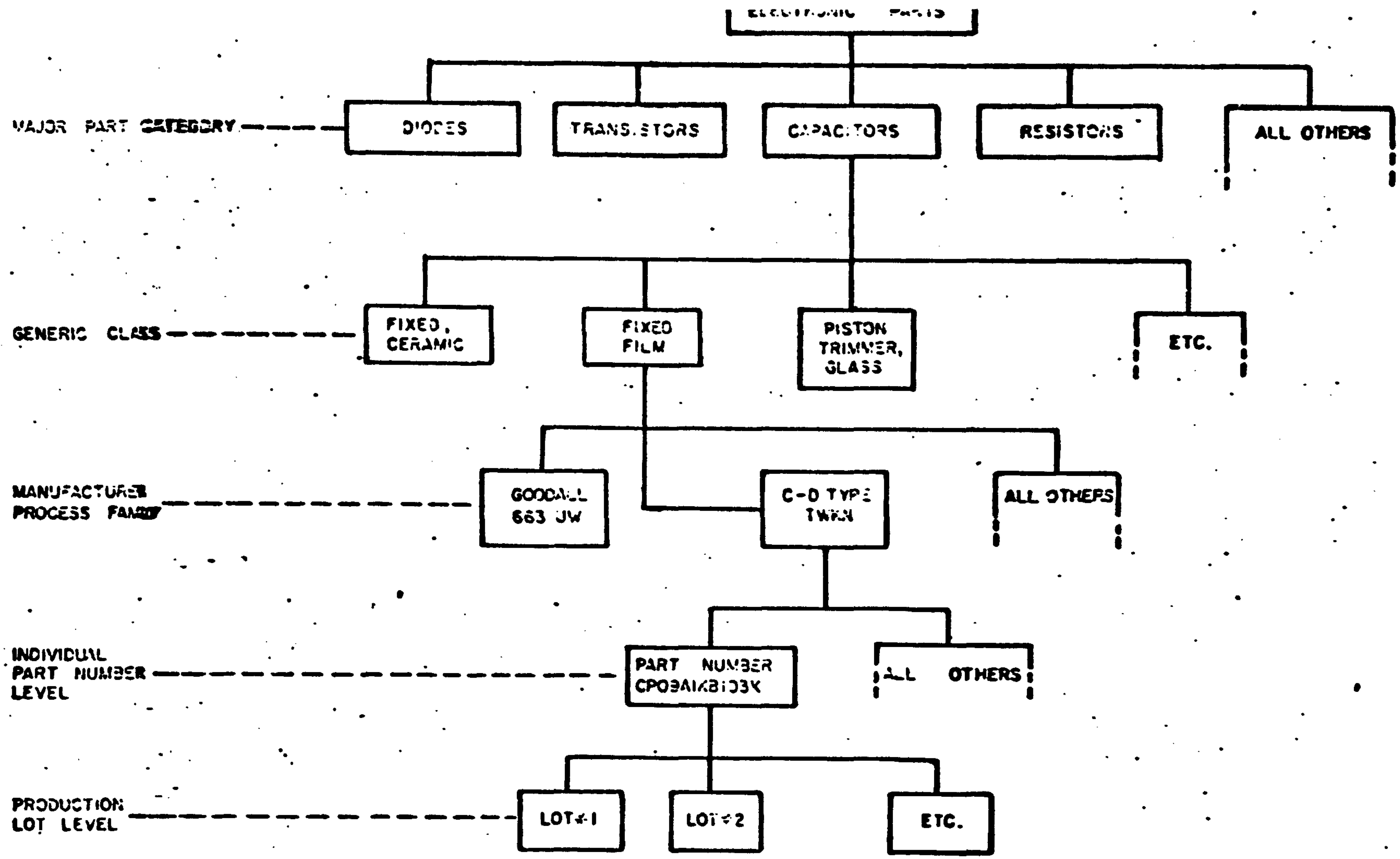

FIGURE 2
Hierarchy of Electronic Part and Class Delineation

The raw data bank will be stored on magnetic tapes with a minimum of access required. The reduced data bank will be stored on magnetic disks and random access magnetic cards, and will require heavy access. The summary data bank will contain the results of the various outputs, analyses, and calculations. During test operation, the summary bank will be on random access magnetic cards, and users may request selected results. When RC attains full operation with more users and an on-line, time-shared system, disk or fast access storage for the summary data bank can be justified, and more storage space will be required. The flow of data within RC is shown in Figure 3.

(3) Outputs

The initial phase in the realization of RC is the test operation. The test operation consists of 11 basic outputs, as follows:

1. Computation and Publication of Part Failure Rates
2. Part Failure Distribution Analysis
3. Part Parameter Drift and Stability Characteristics Versus Stress and Time
4. Part Failure Mode Summary

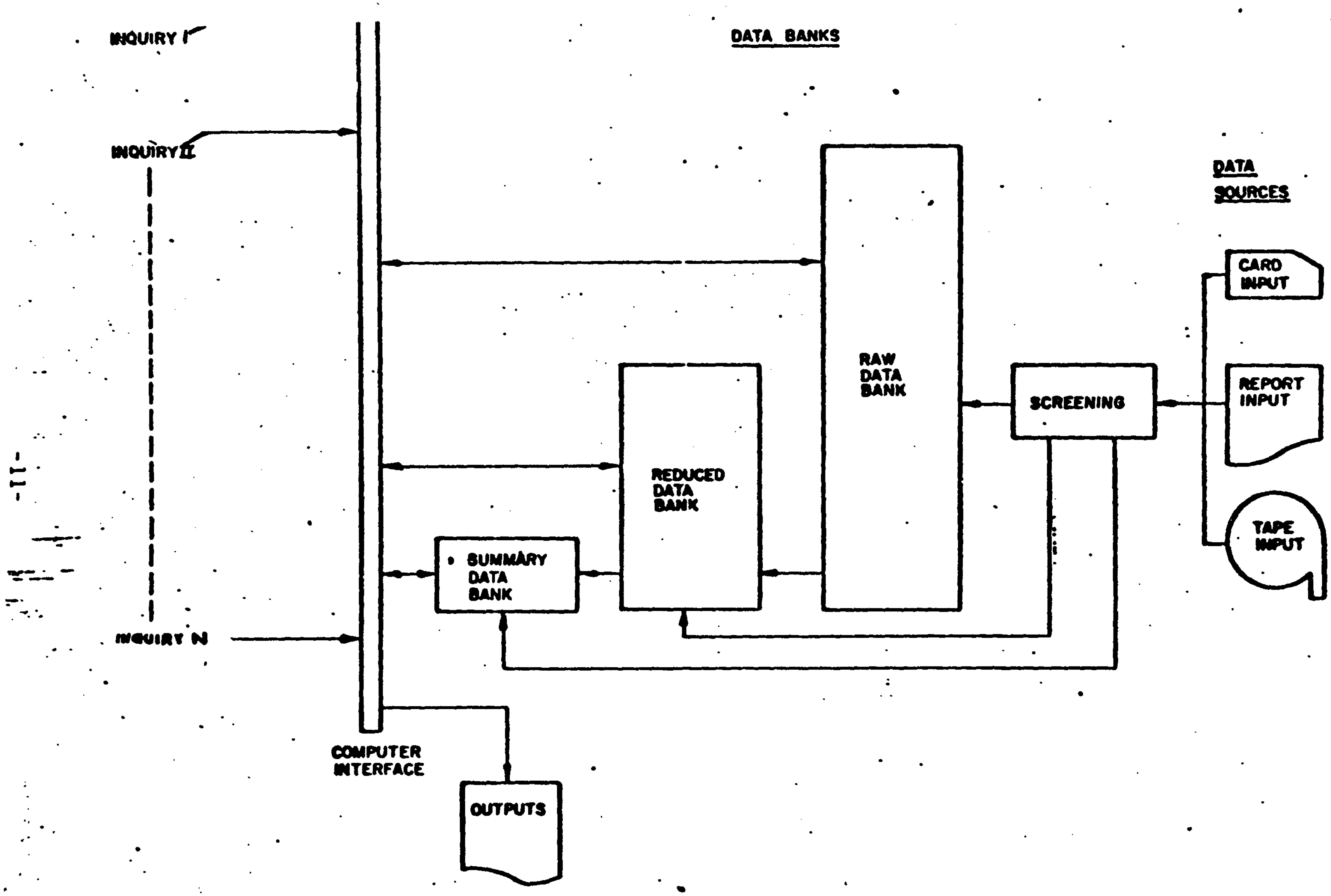

FIGURE 3
Data Flow Within Reliability Central

5. Preparation of Documented Reliability Parts List

6. Comparison of Reliability Obtained Under Field Operation with Laboratory and Qualification* Test

7. Preparation of Part Application Data Summaries

8. Analysis of Part Manufacturer's Qualification and Production Test Data Against Specification Requirements.

9. Part Reliability Improvement Rate Report

10. Preparation of Summaries of Test Programs Planned and Under Way.

11. Specification Review for Cancellation, Consolidation, and Updating

These outputs are to be implemented in such a manner that the test operation serves as a springboard for the full operation of RC. During full operation, the outputs of the test operation will be expanded, and additional outputs will be added to obtain optimum operation.

Although the 11 outputs are listed separately, they are by no means independent. Not only will they share specific subroutines, but some outputs will require summary information which will be provided by other outputs. Flexibility will be provided in the test operation outputs by the query procedure, which will enable one to specify parameters which control the output options and data items to be processed. Boolean expressions will be allowed for item definition. During full RC operation, a powerful query language will be implemented and used with one or more inquiry consoles for on-line usage of the RC data base and an eventual time-sharing system.

It is anticipated that, initially, outputs will be produced on high-speed printers or plotters and an on-line query console with visual display. Other display devices will be considered as the need arises.

3. MAJOR PROBLEMS

The data analysis procedures specified make extensive use of statistical models and tests. As will become clearly evident from RC functional specifications, the prime objective of each output is consolidation of large masses of test data into, hopefully, a homogeneous grouping for analysis and formulation of conclusions. Statistical methods provide the techniques by which these processes may be accomplished. They further permit statements of uncertainty about conclusions drawn.

It has not been an objective of the implementation study to develop new, or to extend application of, statistical techniques, but rather to employ those that have proved successful in reliability analysis. The problem of greatest concern is selection of the most efficient methods that will provide a valid quantitative statement of the observed behavior. Merging of data from a large number of individual tests (experiments) complicates the problem. Each testing agency has its own peculiar set of variables, or uncontrolled parameters, in addition to the specified conditions. In combination with data from other testing agencies, the dispersion can become quite broad and must be compensated for during analysis.

Parametric techniques have been chosen wherever practicable in preference to distribution-free methods. The former have been more fully developed, resulting in availability of practical techniques for most reliability analysis situations. Also, they have an inherent advantage in efficiency of parameter estimators and hypothesis tests. Certain distribution-free methods may become necessary if it is later found that portions of the collected data do not meet the qualifying assumptions for parametric modeling.

III. PROGRAM SYSTEM DATA

The Reliability Central Data Processing System is designed to operate within the RADC computer complex (Figure 4). RC will operate by means of stored programs in the Univac 1218 under the control of the RC executive program which will also be stored in the 1218. Access to data and input/output devices will be via a RW 400 switch with a RW 400 computer module for switching control and buffer module for information exchange.

Communications between RC and the computer complex will be performed by a master executive control system (ECS) stored in the CDC 160A computer. Communication with the satellite 1218 central processing unit (CPU) will be through a local control program (LCP) stored in the CPU. The LCP will be the intermediary between the RC's executive (supervisor) program and the external environment (Figure 5).

All data will be stored in a common storage pool under control of the master ECS. Data requests from RC will be processed via the 1218's LCP, the 160A's ECS, and the RW 400 switch. Conversion of the storage pool format (512-word blocks, 12 bits/word) to 1218 format (512-word blocks, 18 bits/word) will be automatically performed by electronic adapters. The auxiliary magnetic core,

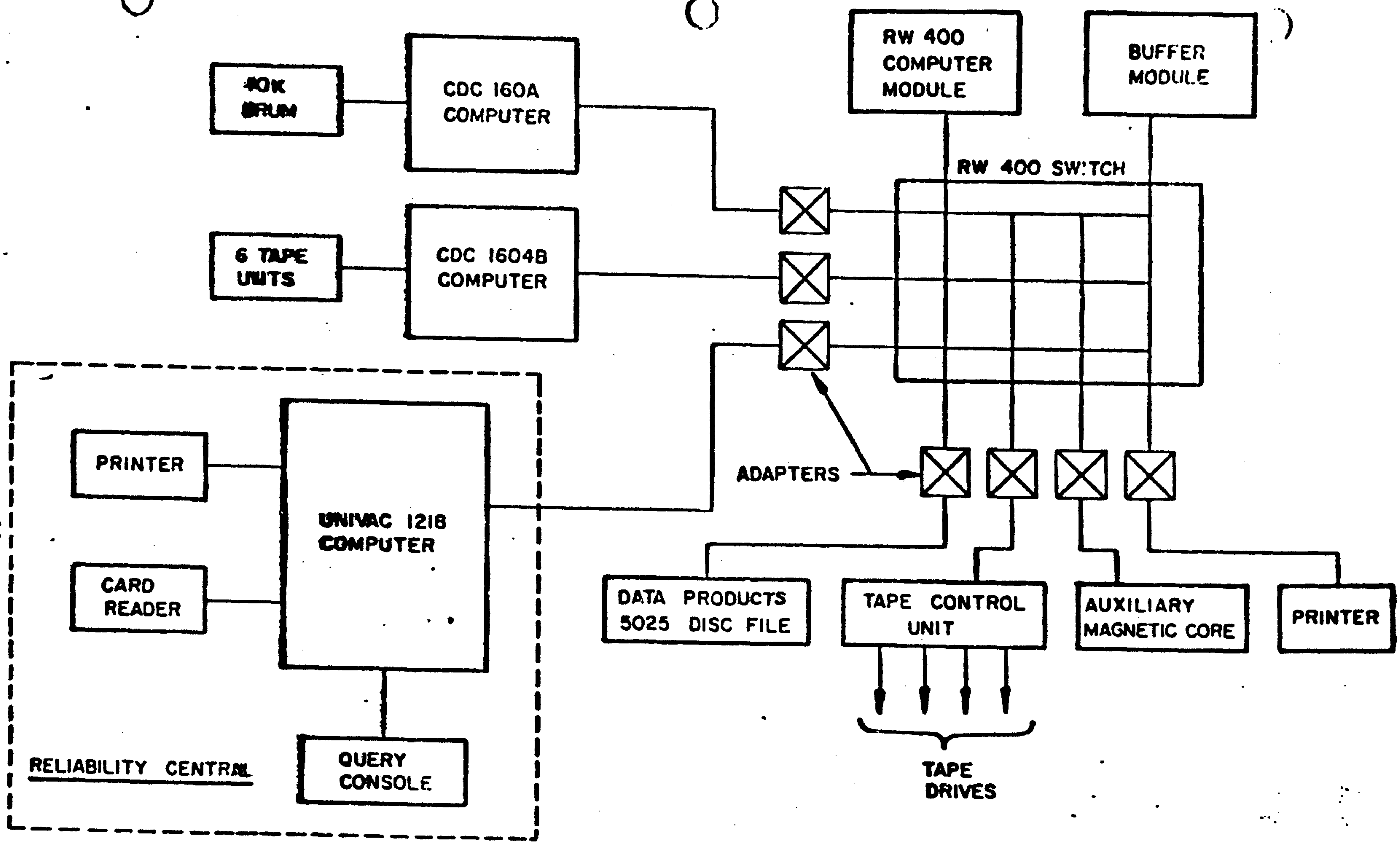

FIGURE 4
Reliability Central Within RADC Computer Complex

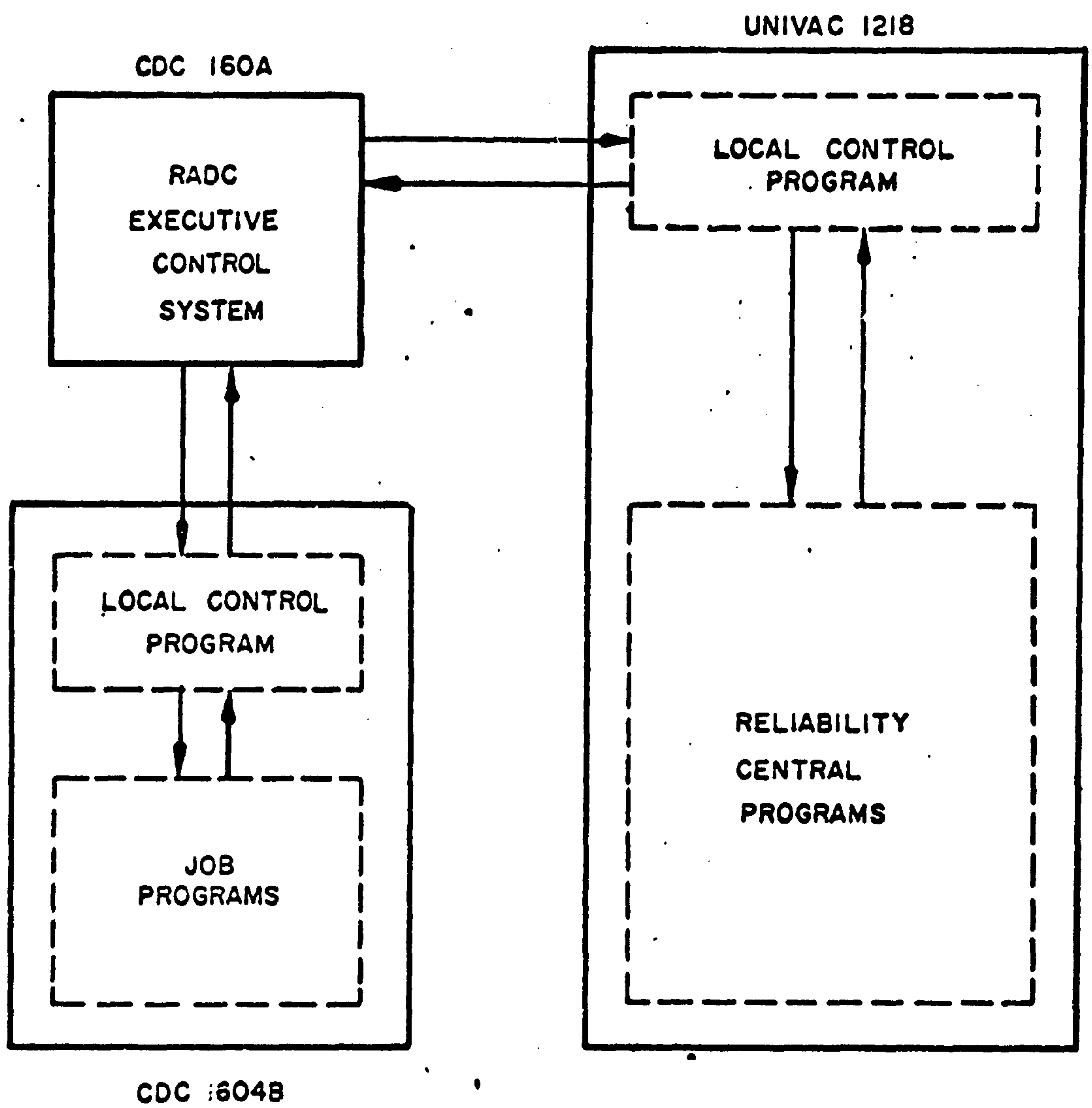

FIGURE 5
Program Systems

available through the switch, will help to reduce transfer time of directory tables and data between the disk file and the 1218 CPU.

The system has been designed as an information system for the acquisition, analysis, and storage of reliability data. It will include five basic program areas:

1. Common data base
2. Request language
3. Directories
4. System programs
5. Supervisor program

The system is based upon the principle of divorcing the physical location of data items from their logical names and relationships. The principle permits the names to be manipulated without reference to the data items themselves, and permits the items to be transferred in storage without altering the logical names or relationships.

The flexibility of the RADC computer complex is assured by the modularity of hardware and the logical structure of its programs. To ensure the viability of the RC as an independent entity within the framework of computer sharing in the initial stage of development, the following guidelines have been followed:

- The RC ADP system should be a machine-independent system (subject to compiler constraints), and both general design and specific programming should be oriented in this direction.

- The interface between the RC supervisor program and the RADC computer complex should be confined, as much as possible, to the LCP. Operation of RC in another environment would entail incorporation of selected LCP management within the Supervisor Program without major revision of other RC programs.

- Data management should be implemented from the point of view of RC. Compromises between flexibility of structure and search time as well as between general-purpose programs and special-purpose programs should be RC-oriented to provide a realistic basis for time and cost evaluation of an operational RC.

- Although data storage will be shared with other users of the RADC computer complex, RC programming should proceed as if it possessed its own storage facilities associated with its own computer.

- Interrupt and time-sharing demands made possible by the switch should be confined to the LCP and should not be reflected in the internal programs of RC.

- The specifications for a detailed query language which incorporates on-line access to RC, possibly through remote control, should be made only after operating experience has been gained and evaluated.

1. FILES

A multilevel list structure is utilized to retain data in a flexible and readily accessible form. An arbitrary number of files can be described, containing an arbitrary number of records.

Within records, other files may be embedded recursively. Fields may be of fixed or variable lengths.

The three data levels, raw, reduced, and summary, will be incorporated into the logical structure of the data base in accordance with their frequency of utilization. Infrequently used raw data, for example, may be stored on magnetic tape, while frequently used reduced data may be stored on the disk file. An audit trail will link the three data levels, thus associating the summary data with its input documents.

The data for the RC files will be structured logically in the form of a rooted tree independent of its physical location. Branches will emanate from the root with diverging branches emanating from the next lower level of nodes. Each node will correspond to named data items, and the subtree emanating from that node will represent the structure of the item. The logical address of a data item will define the relative position of the item within the tree and will be coded so that a unique code is created for each item in the data base.

The major data items assigned to the tree for the raw data bank are given in Figure 6. The names for the reduced and summary data banks must also be developed; however, the identification data and hierarchy of these banks will be similar to those of the raw data bank.

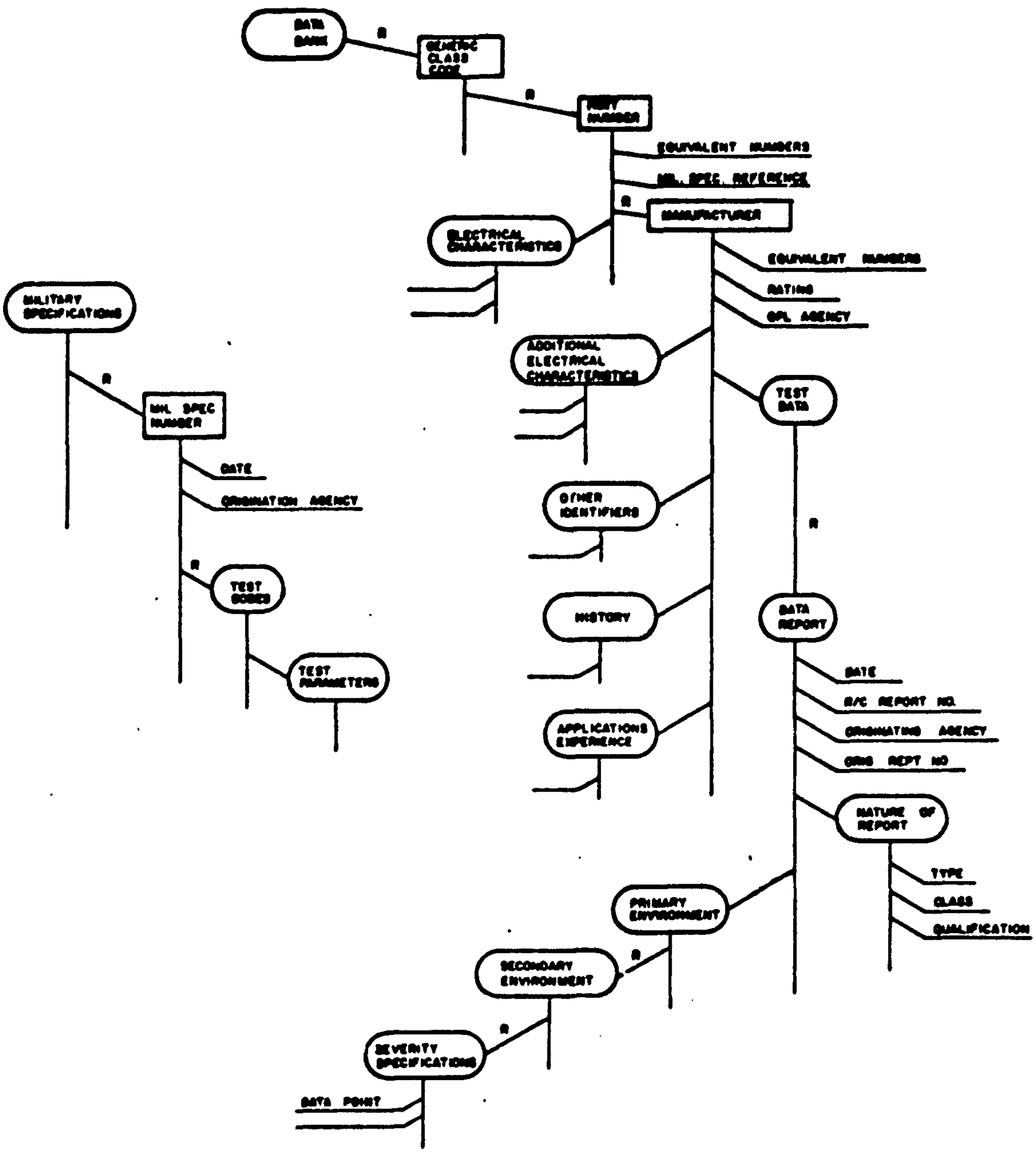

FIGURE 6
Tree Structure of Raw Data Bank

2. ROUTINES

System programs are linked in a macro structure which permits hierarchies of closed-end routines to be called upon by statements composed of the program name and program parameters. A user request language is being designed to express the following types of jobs: item definition, data entry, program entry, job entry, and job run.

Reliability data will be retrieved through directory search. The directories will translate the names of items into logical codes and will then determine the physical location where the item with a designated code will be stored. Retrieval will be accomplished through the RC's LCP communicating with the pooled data storage via the RADC's ECS.

File management and data analysis will be accomplished by the job run request routine which will specify the processing task to be performed. This routine can call for a linking of subroutines designated by a job entry request routine and containing independent programs defined by a program entry request routine.

The syntax of the formal language is described in an ALGOL-like metalanguage.*

The programming language for the RADC computer complex and RC is JOVIAL, an ALGOL-like language. The Univac 1218 will be provided with a TRIM assembler and a JOVIAL compiler.

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* Design specifications for the RC ADP System are contained in:

"Design of Reliability Central Data Management Subsystem," July 1965, Technical Report No. RADC-TR-65-189.

"System Language Specification," Dec. 15, 1964, Auerbach Corp., 1193-TR-1.

"Description of Reliability Central Data Processing Subsystem," Dec. 22, 1964, Auerbach Corp., 1193-TR-2.

IV. EQUIPMENT AND COSTS

1. EQUIPMENT

JOVIAL-MW*	1218 language of the Reliability Central Data Management Systems (RCDMS) operational programs
JOVIAL	disk-oriented 1604 language developed by System Development Corporation (SDC)
CS1-MW*	1218 compiler
TRIM-MW*	1218 assembly language
RADCAP	assembly language for 160A, developed by Auerbach, featuring segmented object code
ECS	master executive program for 160A, developed by Informatics one year ago

RADC owns all the following hardware:

<u>CDC 1604B</u> This computer supports most of the scientific computations for RADC. RC uses about 2 hours per day for the various data conversions. The system runs two shifts now and may soon extend to weekends. Most operating programs are written in FORTRAN. RC programs are in JOVIAL. Formatting and peripheral processing required for RCDMS will be performed by this computer.

	1604B	featuring memory protect in blocks of 512 words
6	CDC 606	tape units
	407	card reader
	1612	line printer
	828	drum

---

* MW indicates a modification for blocking object code into 512-word patches.

Univac M1218	This time-sharing computer will be used primarily for RCDMS programs. RC financed the computer and half the memory; the computing center owns half the memory.
M 1218	64K memory in eight banks; features memory protect and read-only designators
CDC 160A	These two computers serve as controllers of communications between peripheral devices, local computers, and mass storage devices.
2 CDC 160A	8K and 32K memory Selectric typewriter On-line typewriter
RW 400	This computer, under the direction of the Master Control Program, supervises the transfer of data between mass storage devices, computers, and external devices.

Peripheral Devices

RW switch (CX-400)
Datacom 408 console
Datacom 415 console
Data Products 5025 disk file (200 million bits)
RCA 3488 magnetic card mass memory (340 million characters)
2 RCA 582 tape units
2 Univac Uniservo IIA tape units
1 RW tape unit
EAI tape-driven plotter
RW-85 display console
RCA 6320 display console
Stromberg Carlson 3000 printer
Goodyear associative memory--2,000 words (under development--to be delivered in spring 1966)

2. COSTS

In addition to the costs shown on page 4, the development and implementation cost to the end of the test operation will approach $800,000. The following equipment costs were also incurred:

Univac 1218	$450,000
Adaptor matching 12-bit and 18-bit words	88,000
RCA 3488	170,000

B I B L I O G R A P H Y

"Air Force Reliability Analysis Central Concept, Purpose, Approach, Status," 13 August 1965, an internal publication of Reliability Central, Rome Air Development Center, Griffiss Air Force Base, New York.

"Design of Reliability Central Data Management Subsystem", Technical Report No. RADC-TR-65-189, December 15, 1964, RADC, Griffiss Air Force Base, New York.

"System Language Specification", by the Auerbach Corporation, Report 1193-TR-1, December 15, 1964, Rome Air Development Center, Griffiss Air Force Base, New York.

"Description of Reliability Central Data Processing Subsystem", by the Auerbach Corporation, Report 1193-TR-2, December 22, 1964, Rome Air Development Center, Griffiss Air Force Base, New York.

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DOCUMENT CONTROL DATA - R&D

BOOZ · ALLEN APPLIED RESEARCH, INC. 4733 Bethesda Avenue Bethesda, Maryland 20014	Unclassified

Mechanization Study of the Reliability Central, Rome Air Development Center, Griffiss Air Force Base, New York

Final Report of on-site survey

G. A. Kershaw, D. Crowder, J. E. Davis, E. G. Loges, E. Merendini, S. M. Thomas

September, 1966	35	4

DSA-7-15489	914-1-21
	AD 640 116

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14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
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Analysis						
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