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RADC-TR- 68-339, Volume I
Final Report

DEVELOPMENT AND IMPLEMENTATION OF A RELIABILITY ANALYSIS CENTER

Volume I, Sections 1-7

G. T. Jacobi
H. A. Lauffenburger
P. A. Llewellen
et al
IIT Research Institute

TECHNICAL REPORT NO. RADC-TR-68-339
October 1968

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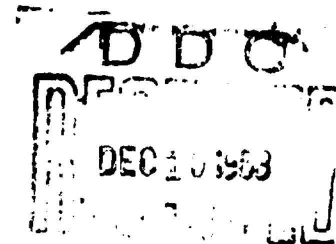

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Air Force Systems Command
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FOREWORD

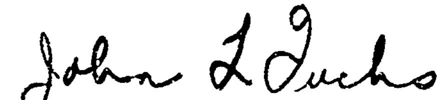
This Technical Report prepared by IIT Research Institute, 10 West 35th Street, Chicago, Illinois, on Contract AF 30 (602)-4265, Project 5519, for Rome Air Development Center, Griffiss Air Force Base, New York, relates to the work performed during the past thirteen months of the contract period, 20 June 1966 to 15 July 1968. A previous document has covered the period from 20 June 1966 to 15 June 1967. Description is given herein of the work performed from 15 June 1967 through 15 July 1968 under engineering change "A" of this contract. This report is identified by IIT Research Institute as IITRI FR-E6071.

Mr. John L. Fuchs, EMERR, monitored the program for Rome Air Development Center.

The following IITRI personnel contributed to this project: G.T. Jacobi, H.A. Lauffenburger, P.A. Llewellen, B. Kapchinski, H.C. Edfors, B.F. Lathan, T.R. Myers, F.R. Hand, J. Bereznak, and L.P. Kirchner.

Distribution of this report is restricted to protect critical technical know-how, under the provisions of the U.S. Mutual Security Acts of 1949.

This Technical Report has been reviewed and is approved.

Approved: 
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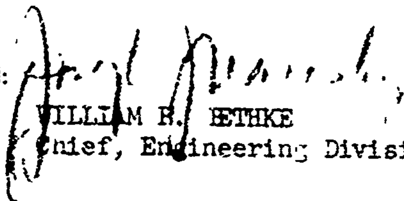
Approved: 
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FOR THE COMMANDER
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Chief, Advanced Studies Group

ABSTRACT

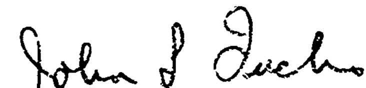
The Reliability Analysis Center is being established for the collection, analysis, and dissemination of technical information on microelectronic device reliability. Its objective is to establish a basis for correlating reliability factors with device material, design, fabrication, quality assurance and application factors. This report describes the development, implementation, and present status of a data collection and file entry effort supplemented by a Termatrex data retrieval system. Detailed operating procedures, periodic outputs, and user services from the Center are described in detail.

Future plans call for expansion of RAC into hybrid microelectronics and discrete semiconductors used in military weapons and communications systems.

EVALUATION

1. The objective of this effort was the development and implementation of a Reliability Analysis Center (RAC). The RAC will serve as the central Department of Defense activity for the collection, storage, reduction, organization, review, assessment, analysis, and dissemination of information and experience data bearing on the reliability of microelectronics and discrete semiconductor devices. The RAC is concentrating on the modes and mechanisms of failures encountered during fabrication, testing, and operation of such circuits and devices and the influence and contribution of part design, material, manufacturing techniques, processing, configuration, test practices, screening practices, and electrical and environmental stresses on the nature of failures. The objective of this effort was met. An initial, meaningful data base has been acquired on microelectronic devices through a concerted data collection effort directed at device vendors, equipment and system contractors, Government agencies, and other data exchange programs. The system elements, functions, and activities have been defined. Detailed operating procedures have been devised for each task which define task objectives, personnel qualifications and responsibilities, forms employed and detailed procedures for accomplishing the specified function. Included are necessary control functions to assure adequate administrative control over schedules and quality of operations. The system concepts were demonstrated by processing the accumulated information and data into files, performing retrieval and analysis operations and preparing an initial set of useful output products. A descriptive booklet was prepared and published. The booklet is intended to introduce prospective users to the RAC and describes its purpose, scope and available services and how to obtain these services and outputs.

2. The results of this effort will provide the users with timely high-quality data for their use in improving, selecting, evaluating, establishing reliability and quality assurance procedures for, and applying parts in the design, development, production and operation of reliable military systems and equipments. The system and procedures developed under this effort will be utilized in the continued operation, development and expansion of the RAC.



JOHN L. FUCHS
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1.0 PURPOSE AND SCOPE

1.1 Introduction

This technical report describes the work performed by IIT Research Institute under Engineering Change "A" of Contract AF 30(602)-4265 for the development and implementation of a Reliability Information and Analysis Central, effective 15 June 1967. This change modified the scope of the original contract in order to establish an early, viable operating system service providing a useful reliability and analysis service for micro-electronic devices. Accomplishments prior to Engineering Change "A" were fully documented in an earlier interim report.

A semimanual search and retrieval system has been developed and is employed in conjunction with relatively simple computer routines for analysis and merging of statistical data. The system is officially identified as the "Reliability Analysis Center;" the name or its acronym, RAC, will henceforth be used throughout this report and all other publications of the Center.

The contract change also requires an independent, coincident effort continuing development of a computerized data management system. It is envisaged that the Reliability Analysis Center will avail itself of this system when it becomes operational. Data and file structures developed under the present contract have been coordinated with the machine system requirements and are readily transferable.

1.2 Reliability Analysis Center Objectives

The Reliability Analysis Center has been established by the Department of Defense as a centralized activity for the collection, storage, reduction, organization, review, assessment, analysis and dissemination of information and experience data relating to reliability of microelectronics and discrete semi-conductor devices. It will concentrate on the modes and mechanisms of failure encountered during fabrication, testing and operation of such circuits and devices and the influence and contribution of part design, material, manufacturing techniques, processing, configuration, test practices, screening practices and electrical and environmental stresses on the nature of failures. The Center's objective is to provide a broader knowledge and a deeper understanding of the nature of device failures and their causes by analysis, review and evaluation of available information and its synthesis into a data file, publications, reliability prediction models, and techniques. Key users within the electronic Government-industry complex are thus provided timely,

high-quality data for their use in improving, selecting, evaluating, establishing reliability and quality assurance procedures for, and applying parts in the design, development, production and operation of reliable military systems and equipments.

1.3 Scope of the Reliability Analysis Center Operations

The Reliability Analysis Center will be established as a separate contractor operated function which will be administered and guided by the Rome Air Development Center, U.S. Air Force.

The Center will treat parts and devices which are expected to be used in future military equipments and which will be of most immediate significance to the electronic Government-industry complex. The operations of the Center will encompass microelectronic circuits and discrete semiconductor devices.

Microelectronic circuit coverage will include monolithic integrated circuits, metal oxide semiconductor integrated circuits, hybrid circuits, thin film circuits, and integrated arrays. Semiconductor diode coverage will include general purpose diodes, switching diodes, diode rectifiers, zener diodes, voltage reference diodes, control rectifier diodes, and tunnel diodes. Semiconductor transistor coverage (both unipolar and bipolar) will include general purpose transistors, power transistors, switching transistors, and special transistors. Organization of the Center's data base and the dissemination of its outputs to users will be accomplished by recognized generic classes and subclasses that are appropriate for each type of part and device covered.

The Center will concentrate on the acquisition of information which will lead to the establishment of a useful, high-quality long-lived data file. Collection efforts are being directed toward the acquisition of data generated by part and device manufacturers, equipment/system contractors, and Government exploratory development, specification, product acquisition activities and field operations. Of particular interest are programs that concern the following:

1. Identification of the individual failure modes, mechanisms, and quality defects which are predominant in electronic devices and contribute to catastrophic failure and time dependent degradation of typical parts and devices.

2. Determination of the influence and contribution of part design, material, manufacturing techniques, processing, configuration, testing practices, and electrical and environmental stresses on the predominant failure modes and mechanisms.

3. Development, assessment and specification of quality, reliability, screening and burn-in procedures and test methods for eliminating predominant failure modes and mechanisms and assuring the parts and devices conform to design, reliability and application requirements.

4. Determination of the reliability characteristics intrinsic to the various approaches to part and device design, fabrication, and processing and the extent to which these intrinsic reliability characteristics may be influenced by manufacturing, quality control, and screening practices.

The Center will attempt to provide the user with timely, valid information within reasonable economic restraints. The following outputs on generic classes and subclasses of parts and circuits are to be provided:

1. Identification and classification of the predominant failure modes and quality defects which are encountered in devices and the frequency and proportion in which they occur in failed devices.

2. Identification and classification of the failure mechanisms which contribute to the catastrophic failure and/or time dependent degradation of generic classes of devices.

3. Complete description of the design, materials, manufacturing techniques, processing, configuration, and environmental and electrical stresses imposed upon devices which have failed by identified failure modes and mechanisms.

4. Identification, complete description, and effectiveness of quality and reliability assurance procedures and screening practices that have been and are being used in culling out devices exhibiting known failure modes, failure mechanisms, and quality defects.

5. Textual and graphical information describing the influence and contribution of part design, materials, manufacturing techniques, processing, configuration, testing and screening practices, and environmental and electrical stresses on nature of failure modes and mechanisms.

6. Techniques and models for quantifying reliability determining factors of electronic and electro-mechanical parts and for predicting the reliability of such parts.

7. Identification and abstracts of significant published and unpublished literature, reports, specifications, quality and reliability assurance documents, and other information collected by the Center which cover previous work dealing with the identification of the mechanisms of failures or devices and factors influencing and contributing to these mechanisms.

8. Comparison of the occurrence of specific failure modes and mechanisms in different generic classes of the same types of parts and the results of analysis to account for differences in the frequency of occurrence of the failure modes and mechanisms.

Basic Center outputs will be in the form of regularly scheduled publications, periodically updated to purge obsolete data and incorporate the most recent. Additionally, it is to be responsive to individual user needs through establishment of a direct inquiry service.

The information storage and retrieval system to be used by the Center will be an economical, semimanual system which, rather than generating new methods for handling data, will emphasize the use of proven techniques to create a useful data base and to provide the means for quick and direct recall of data for analysis, for preparation of the Center's outputs, and for responding to queries. The information storage and retrieval system will offer considerably more than the ability to sort data. It will accept less-than-complete data, as it is offered; it will allow the programmed use of the data provided; and it will assist and greatly facilitate human analysis and weighing of the information in the data store, including less-than-complete data.

1.4 System Overview

In compliance with contractual requirements, an information and analysis system has been developed and implemented for the collection, reduction, storage, analysis, and dissemination of reliability data. The necessary methodology for these functions has been devised and documented into suitable specifications and operating and administrative procedures.

The data indexing, storing, and retrieving system established for the Reliability Analysis Center is based on an inverted-term-matrix concept denoted as Termatrex. With this system, a file record or Termatrex card is prepared for each concept or descriptor term of interest. This approach is versatile, utilizes convenient, inexpensive equipment and has ability to rapidly retrieve information according to Boolean combinations of concepts. Implementation of this system necessitated the preparation of a concept thesaurus containing appropriate terms to identify and classify the document and source, device properties, and the significant contents of the source documents processed into RAC files.

Approximately 1100 terms appropriate for meaningful retrieval of stored microelectronic data and information are incorporated into the current thesaurus. It is necessarily open-ended to accommodate addition of new terms required for expansion to discrete semiconductor devices as well as advances in technology.

An initial, meaningful data base has been acquired on microelectronic devices through a concerted data collection effort directed at device vendors, equipment and system contractors, Government agencies and other data exchange programs. System concepts were demonstrated by processing the accumulated information and data into the files, performing retrieval and analysis operations and preparing an initial set of useful output products.

A descriptive booklet was prepared and published. It is intended to introduce prospective users to the Center and describes its purpose, scope, and available services. It also provides detailed instructions for making application for RAC outputs and services.

The basic RAC system elements are illustrated in Figure 1. This diagram is intended to provide an overview of the major elements, functions, and activities as they are unified into the total Center operations. Detailed operating procedures have been devised for each task. They define task objectives, personnel qualifications and responsibilities, forms employed and detailed procedures for accomplishing the specified function. Included are necessary control functions to assure adequate administrative control over schedules and quality of the operations.

Major elements of the RAC sy: em are briefly described in the following paragraphs. For more detailed treatment, the reader is referred to the appropriate Operating Procedure appearing in later sections of this report.

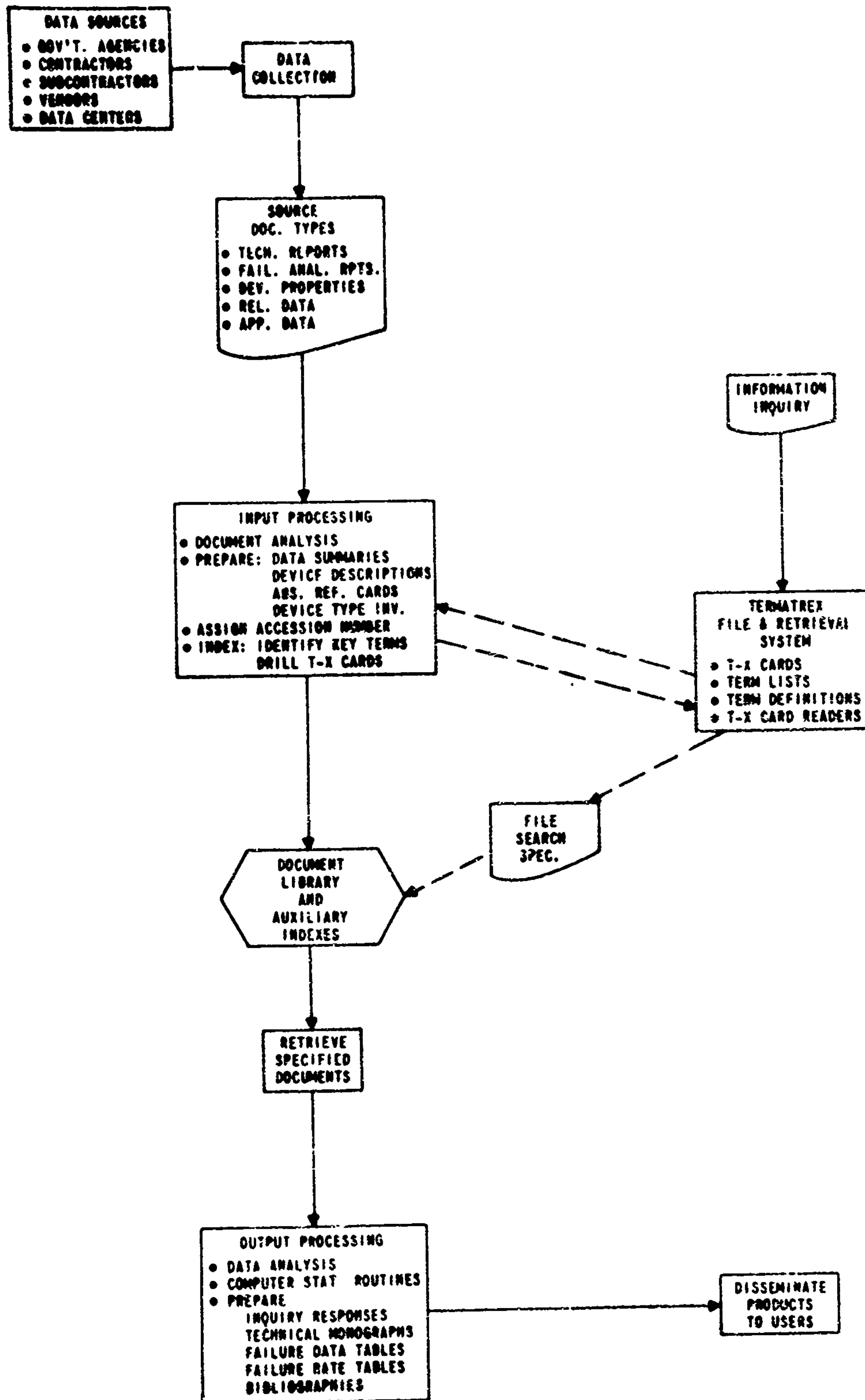


Figure 1. RELIABILITY ANALYSIS CENTER SYSTEM ELEMENTS

In order to remain responsive to the needs of its users, RAC must remain abreast of the rapid advances being made in the microelectronic and semiconductor technologies. This requires a concerted and continual data collection effort with full cooperation of the many sources that generate information and data as part of their own ongoing activities. These source types are listed in Figure 1, as are the document types that make up useful input intelligence. Arrangements are being made to incorporate RAC data requirements into an increasing number of development and hardware contracts. However, the greater portions of input must presently be acquired through direct solicitation and voluntary contributions.

Incoming documents are thoroughly reviewed for relevance, validity, accuracy, and completeness prior to acceptance into the files. Input processing includes preparation of a number of auxiliary items for cross reference and control purposes as well as to effect the necessary data reduction and correlation of information to device properties. The latter is accomplished through employment of DEVICE DESCRIPTIONS. Each Device Description is a detailed catalog of all material, design, process, screening, and quality assurance controls employed in the production of a single device or family represented by data in RAC files. Quantitative data is also reduced to summary form at this time to expedite subsequent processing and analysis.

The final steps of the input processing stage are assignment of accession numbers and indexing. Indexing is the task of identifying key words from the document's contents which are relevant for later search purposes. These key words are correlated to the system term thesaurus. Finally, the corresponding Termatrex cards are drilled with the proper accession number.

The RAC library contains the entire collection of Source Documents, Device Descriptions, Data Summaries and copies of RAC publications filed by accession number. It also contains a number of auxiliary indexes such as the Abstract Reference Cards and Device Type Inventory which are valuable internal cross reference and control aids.

Response to inquiries for information are initiated by formulating a suitable search specification which consists of selecting appropriate terms from the system thesaurus and determining the Boolean combination of descriptors for search purposes. Search is accomplished by viewing the selected cards in proper combinations and identifying corresponding accession numbers with the aid of a card reader.

Output processing is contingent upon the nature of the information required. For example, computation of failure rates calls for statistical manipulations of quantitative data values. Computer routines have been prepared and employed for performing certain homogeneity tests and data merges. On the other hand, requests for application assistance may require survey and analysis of textual material. Initially, the Center has devised a set of output publications that are updated at periodic intervals and disseminated to all users on its distribution roster. These products are:

> Failure Data Tabulation: This publication lists by generic device descriptors each reported microelectronic device failure for which the failure mode/mechanism is identified. Conditions of stress and other pertinent details are included.
>
> Failure Rate Tabulation: A listing of microelectronic circuit failure rate data merged according to generic device descriptors and equivalent stresses.
>
> Source Document Bibliography: A listing organized by broad subject categories and author of all active documents contained in the RAC library.
>
> Technical Monographs: Specific technical problem areas are treated, providing an authoritative introduction to the state-of-the-art and professional guidance.

A direct inquiry service is available to users desiring individual assistance on specific problems. Such requests are serviced within the scope of RAC operations, accumulated data base and reasonable economic considerations.

Although not shown on the diagram, users and data sources are essentially synonymous; thus the Center provides a vital element in the information feedback loop. Through judicious collection, reduction and analysis of accumulated experience, the quality of engineering data available during development of each new generation electronic systems is materially improved.

1.5 Organization of This Report

The remaining sections of this final technical report contain a more detailed treatment of the accomplishments of the current program, complete documentation of internal operating procedures, and a recommended five-year plan of Center operations. Internal operating procedures appear in the following sections:

System Configuration and Maintenance	Section 2.0
Procedural Guide for Data Collectors	Section 3.0
Document Input Processing	Section 4.0
Structured Term List	Section 8.0
Alphabetical Term List	Section 9.0
Term List Definitions	Section 10.0
File Search and Output Processing	Section 5.0

Each procedure is self contained and has been written for detailed guidance of operating personnel. Section 6.0 contains a review of program task progress and current status. It provides background material and rationale for the functions, operations, and analysis procedures employed by the Center. The computer statistical analysis program, developed for operation with a remote terminal online computer system, is also described.

The five-year plan is outlined in Section 7.0 . It develops a realistic implementation schedule for expansion into hybrid and discrete devices and extension of operations and services. It develops the staffing and organization needs appropriate to the task and the methods by which user's services will be rendered.

2.0 SYSTEM CONFIGURATION AND MAINTENANCE

This section provides an overview of the data system so that later procedures may be understood in their proper context. It describes briefly its major elements and outlines those procedures that are necessary to the integrated system. In particular, this includes certain system maintenance tasks such as Term List updating that are not applicable to any one specific process.

2.1 System Elements

The Reliability Analysis Center's operating system is designed around three basic elements, namely:

Source Documents

Internal Data Bank

Center Outputs

Of course, each basic element is made up of numerous subelements. For example, Center Outputs may be subdivided into 1) regularly scheduled outputs and 2) Ad Hoc Query response. These may be further separated, for example, into particular output product entities. Figure 2 depicts the major system elements, their principal subelements, and essential interfaces.

The RAC system employs the Termatrex (inverted term matrix) system for main file organization and information retrieval purposes. It is supported by a Term List (see Sections 5.0 and 6.0) and several other library items including Abstract Reference Cards and a Device Type Inventory which, in combination, provides for positive cataloging control over file contents for efficient retrieval and ultimate utilization of desired intelligence.

2.2 Description of File Documents

Information processed onto RAC files may be broadly classified into two categories, namely:

Source Documents

Internal Summaries

The former consists of all that information which is furnished from sources outside RAC. The latter are documents that are generated internally for the purpose of organizing certain source information into a more readily usable form.

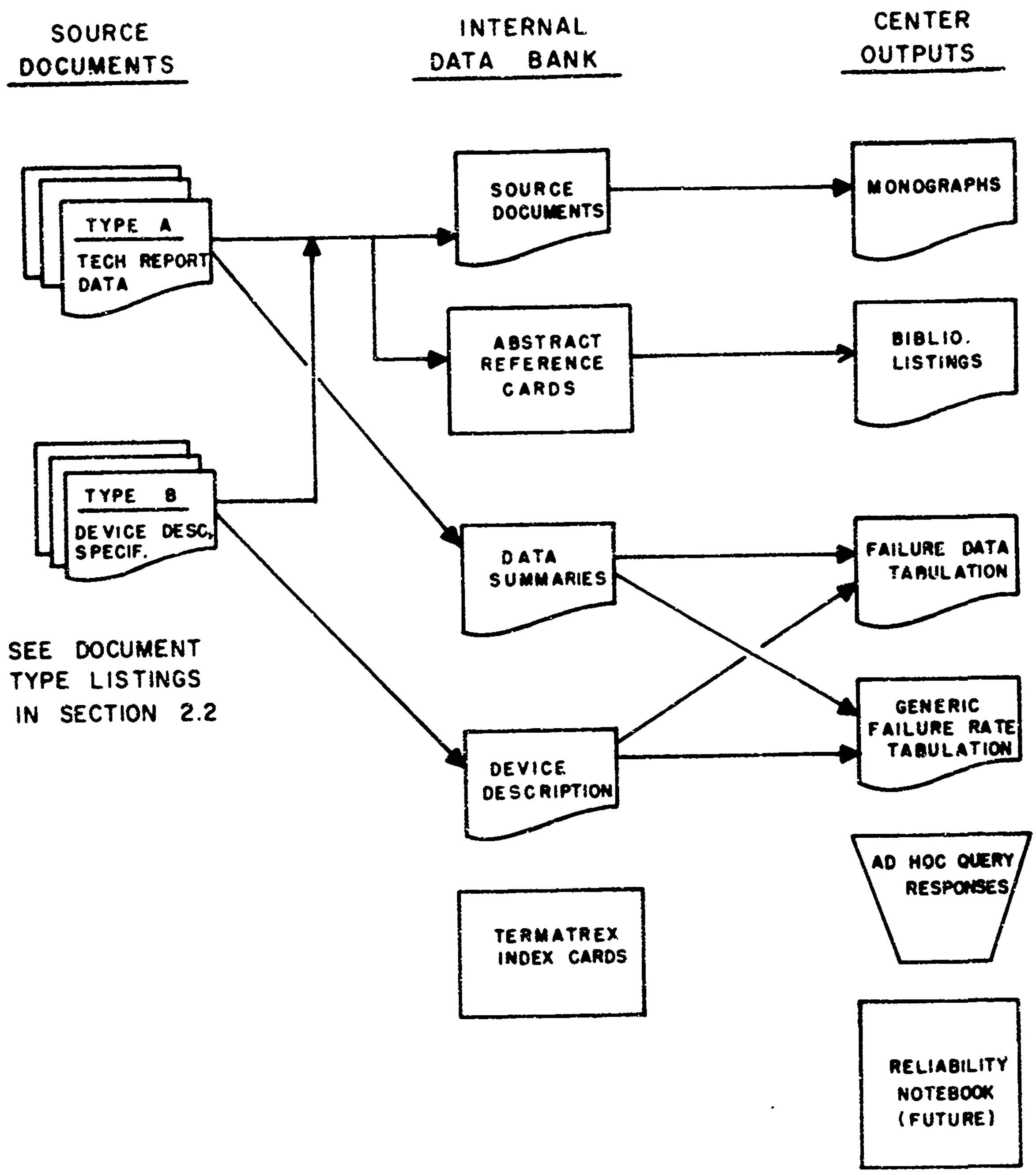


Figure 2. INFORMATION FLOW WITHIN RAC COMPLEX

Source documents are primarily in hard copy form, although other forms such as microfilm, punched cards, paper or magnetic tapes, etc., may be encountered. At present, Internal Summaries are exclusively hard copy documents.

2.2.1 Source Document Types

RAC collects and maintains on file technical information and data pertaining to microelectronic device reliability. Applicable information encompasses information which is generated during R&D studies, device processing, device testing, equipment assembly, equipment testing and field operations. The resulting documentation may be uniquely grouped as:

> Type A documents: descriptive accounts of events or actions.
>
> Type B documents: descriptive accounts of the devices and conditions surrounding events reported in Type A documents.

Specific documents of each type are:

Type A

1. Test Reports
2. Open Technical Literature
3. Vendor Analysis Reports
4. Contractor Analysis Reports
5. Field Analysis Reports
6. Government Agency Reports
7. IDEP Reports
8. FARADA Failure Analysis Reports
9. Other Data Center Reports
10. Independent Test Laboratory Reports
11. Burn-In Analysis Reports
12. Physics of Failure Reports

Type B

1. Vendor Catalogs
2. Vendor Specifications
3. Contractor Specifications
4. Government Specifications
5. Device Development Reports
6. Testing Specifications
7. Processing Specifications
8. Quality Assurance Specifications
9. Vendor Technical Information

Section 3.0, "Procedural Guide for Data Collectors" of the RAC Internal Operating Procedures should be consulted for a more comprehensive treatment of information being collected.

2.2.2 Internal Summaries

Five unique summaries are generated internally and maintained on file for subsequent use in preparing output products and answering user queries. They are:

Device Description

Data Summary

Abstract Reference Card

Device Type Inventory

Manufacturer's File Card

The Device Description contains detailed descriptions of the physical properties, processing, quality assurance screening, and burn-in procedures for each manufacturer's sales type on which pertinent Type A source documents have been acquired.

A Data Summary is prepared from source documents that contain data items needed for the tabular output products so as to minimize the effort required to prepare and update them. Essentially, applicable source documents are test reports and failure analysis reports.

An Abstract Reference Card, prepared for each source document on file, contains appropriate document and source descriptive information and an abstract of the document content.

The Device Type Inventory contains an alphanumerically organized listing of all manufacturer's families, device types, and package types represented.

The Manufacturer's File Card contains an accession number inventory of all catalogs or other brochures contained in the RAC files for that manufacturer.

Except for the Data Summary, the purpose and content of each internally prepared document is later discussed in greater detail in this section. The Data Summary consists simply of a formatted summary of the source document or parts thereof, and subsequently is treated in the document files as any other technical document, hence needs no further explanation at this point.

2.3 RAC Files

2.3.1 Main Document File

Document files are made up of source documents (obtained from outside research facilities, manufacturers, DDC, journal publications, etc.) and IITRI generated Data Summaries. For each document entering the RAC system, the following items are prepared.

(1) a document folder identified by a colored label (i.e.) red = vendor document - on this label is typed a brief document identification giving

Author (Research Facility) Acc. #

Sufficient title to identify the document - -

(2) an Abstract Reference on a 5 x 8 McBee punch card giving the following information:

Author (Research Facility) Acc. #

Title

Report No., Period covered, Total pages

Publishing date, Contract No.

AD or PB number, if applicable

Abstract Identifiers

(3) a reference plain white 5 x 8 card duplicating the above information except for the abstract and identifiers.

On both cards the accession number is typed on an appropriate color-coded label, i.e.:

Vendor = red label

The accession numbers are assigned in the number blocks set aside for the specific document type. See Table 1 for assignment blocks.

An accession number list is marked off as each accession number is used. This assures that documents cannot be assigned duplicate numbers.

Table 1

ACCESSION NUMBER BLOCKS

Accession Number	Folder	Document Type
1-1399	Red Label	Vendor
1400-2899	Blue Label	Journal Articles
2900-2999	Turquoise Label	Specs
3000-3399	Orange Label	Proceedings, Symposia Conferences
3400-3999	Coral Label	Bibliography, Surveys and Reviews, Handbook
4000-5599	Green Label	Technical Reports, R/D Reports, etc.
5600-7599	Yellow Label	Test Data
7600-8599	Brown Label	Summary
8600-9999	Brown Label	Device Description

The accession number list is kept by the library technician. Each page of the listing is identified by the color code assigned to the specific document type for which those numbers have been set aside. The document files are maintained in accession number order.

2.3.2 Device Description File

The Device Description file is independent of the main document files. It contains complete descriptive information on each microelectronic device type for which technical information or data is on file. The file entity is identified as the Device Description and is internally generated from various reference documents and direct communication with the manufacturer.

The Device Description consists of three separate items for describing the fabrication of the integrated circuit chip(s), packaging and bonding, and for describing the circuit configuration with its associated screening and testing. They are:

Family Fabrication Information (Form RAC 68-2 shown in Section 2.6): contains information on processing and fabrication which is pertinent to an entire family of integrated circuits. A family is a group of parts which come from the same production line or batch processing area and follow the same or nearly the same processing steps.

Packaging Information (Form RAC 68-3 shown in Section 2.6): contains information on packaging, die bonding and the electrical connections between the die and the package.

Individual Circuit Information (Form RAC 68-4 shown in Section 2.6): contains information on the circuit configuration, screening, and testing pertinent to a single microelectronic circuit.

Obviously, the information contained in the first two items are common to many part numbers, and it is necessary to obtain this information only once from the manufacturer for each family and package type. However, the information contained on Form RAC 68-4 is unique to a single part number and must be obtained each time a new part number enters the RAC system. A complete Device Description for a single device type then consists of a package containing one each of the above items. This is accomplished by reproducing the completed Family Fabrication and Packaging information forms and attaching one copy to the Individual Circuit information forms for each device type of interest from that family.

The Device Description file is organized alphabetically by manufacturer name and alphanumerically by part number under each manufacturer. At the front of each manufacturer's section are copies of Form RAC 68-2 for each of that manufacturer's families represented in the file, and copies of Form RAC 68-3 for each package type offered by the manufacturer. Behind these, in alphanumeric order according to part number, are copies of Form RAC 68-4 for each of the manufacturer's part numbers which has been identified in the RAC system. Attached to each of these forms are duplicates of Form RAC 68-2 for the family to which the part belongs, and Form RAC 68-3 for all packages in which the part is available.

2.3.3 Device Type Inventory

The Device Type Inventory is a card (5 in. x 8 in.) file of all device type numbers for which data or other technical information, exclusive of vendor catalogs, is on file.

The inventory consists of the following items on card types:

A) Separator Card - a colored card containing only the manufacturer's name.

B) Manufacturer's Card - a card which gives the manufacturer's name, a listing of all identified families, and available package configuration in a form such as:

Manufacturer XYZ

Identified Families	Package Types
Family A	Pkg. TO-X
Family B	Pkg. TO-Y
.	.
.	.
.	.
Family n	Pkg. TO-m
No Family Classification	

There will be one card of this type for each manufacturer.

C) Mfgr. Family Card - a card which identifies individual sales types belonging to a single family. Card form is:

Manufacturer XYZ

Family A

Pt # A-1

Pt # A-2

.

.

.

Pt # A-n

There is one Device Type ID card for each family represented.

D) Device Type Inventory Card - a card for each device type represented in the file. This card contains the following information:

Manufacturer's Name

Family Designation

Device Type Number

Device Description Accession Number

Termatrex Card Number(s)

Device Name

Generic Descriptors

Major Electrical Characteristics

Dates: Device Description Request initiated.
Device Description Request completed.

The inventory is organized alphabetically according to manufacturer. The first card in each manufacturer's section is the Separator Card followed by the Manufacturer's Card. The Mfgr. Family Cards are filed in alphanumeric order behind the Manufacturer's Card. Then the set of Device Type Inventory cards are filed in alphanumeric order behind their corresponding family card.

There are expected to be certain "one-of-a-kind" device types which do not belong to a larger family. These types are inventoried with the Device Type Inventory card but are not preceded by a regular Mfgr. Family card. Instead, they are filed behind a single No Family Classification card within the particular manufacturer's section.

The Device Inventory Card is prepared as soon as a new device type is identified (see Section 4.0). At this time a complete Device Description will not be available. To signal the fact that a Device Description Request has been initiated but not completed, a colored metal tag is affixed to the top edge of such cards.

2.3.4 Abstract Reference Card File

The following card files will be utilized:

(1) Abstract Reference Cards. These cards are filed in in accession number order and serve as a rapid means of identifying documents located through the Termatrex search. Brief descriptive abstracts given on each card is useful in determining which documents warrant detailed study to assist in answering a search question. The major descriptors under which the document is indexed is also typed on this card. This will assist in determining why a certain document was identified in a specific search. The 5 x 8 McBee punch cards are used to allow future coding procedures should the need arise. An example of a punch card is shown on page 21.

(2) Reference Cards. These are prepared on plain white 5 x 8 cards. They will be filed alphabetically by personal or corporate author. This file will facilitate the identification of duplicate documents and prevent their being further processed. An example of a card entry is shown on page 22.

2.3.5 Manufacturer's Catalogs

Manufacturer's catalogs and other sales oriented literature are an important adjunct to the technical information files, yet are sufficiently unique to warrant separate handling and file procedures. In essence, documents in this class are incorporated into document folders and assigned accession numbers and filed accordingly as described in Subsection 2.3.1 above. However, they are not indexed into the Termatrex system. Rather, they are controlled and accessed as described in the following paragraphs.

2.3.5.1 Manufacturer's Card File. A card file has been set up in alphabetical order by manufacturer's name. Each card is identified by manufacturer name and manufacturer address. As soon as a document with an identified manufacturer is received and the accession number is assigned, this accession number and catalog title is recorded on the manufacturer's card. This file is proving very useful to the project engineers in identifying manufacturer information already in the file. The following example on page 23 illustrates the entries on a typical card.

Examples and format of the McBee punch card:

Anon. (AFSC, RADC)

Quality and reliability assurance procedures for monolithic microcircuits
RADC Specification 2867A, 15pp.,
Jan. 30, 1967
Superseding, RADC Specification 2867,
October 5, 1966

2900

This specification establishes the minimum quality and reliability assurance procedures for monolithic microcircuits (monolithic integrated circuits).

Identifiers
Specification
Unclassified
by Air Force
For RADC
Jan. 1967
RADC 2867A
Quality & Reliability
Assurance Procedures for
Monolithic Microcircuits
uses MIL-STD-202C

Example card entry:

Anon. (AFSC, RADC)

Quality and reliability assurance procedures 2900
for monolithic microcircuits
RADC Specification 2867A, 15pp., Jan. 30, 1967
Superseding, RADC Specification 2867, Oct. 5, 1966

Amelco Semiconductor
Box 1030
Mountain View, Calif. 94042
Attn: Sales Mgr. L. Solomon

9-22-67	7601	Procure. Spec. High Reliability Devices PACE II
9-22-67	5610	Reliability Rept Amelco 300 Series Molded package
9-22-67	012	Gen. Catalog Data Sheets & Price Lists
9-22-67	4078	Semiconductor Products Assurance Program
9-6-67	5606	Semiconductor TTL μ circuit reliability rept.
9-6-67	011	Semiconductor Condensed Catalog 1967
9-6-67	5603	Mech. & Envir. Test Data

2.3.5.2 Table of Contents for Vendor Catalogs. Figure 3 illustrates the form being completed and attached to vendor data received in loose leaf form. The information is grouped according to manufacturer. Each pamphlet is entered into the manufacturer packet as it is received. The table of contents is updated by the TIR technician when the item is received.

2.4 Termatrex Retrieval System

2.4.1 Description

The cards being used for the RAC system are Random Numeric (RN) cards, the most widely used Termatrex card. These cards contain document accession (identification) numbers in the form of holes. The cards have a capacity of 10,000 document accession number positions. They have the following characteristics:

A one-half inch color band across the top edge. (Available colors: black, blue, gray, green, orange, purple, red, sand, white, yellow)

A number scale (00-99) printed over the color band.

A small one-quarter inch tab protruding above the number scale. The tab is the same color as the band, and it has one digit from 0 through 9 printed on it.

The location of a tab in reference to the 00-99 number scale gives the identification code number for a card.

The right edge has twenty-give positions that can be notched in various combinations to assure that the card is in the proper cardholder. When one sights down the right edge of the card filed in a cardholder, all cards should be notched in the same position. If not, the improperly filed card can be easily identified and put in the correct cardholder. The side notch positions are used as follows:

The top five notch positions (1-5) indicate the section of a vocabulary (V) in which the cards are used. The ten color bands and 100 tab positions result in 1,000 unique card color number codes. These 1,000 cards would all be notched in position V = 1. If the vocabulary exceeds 1,000 cards, each group of 1,000 cards would be notched in a different position, V = 2, V = 3, etc.

CATALOG DATA SHEETS AND APPLICATION NOTES

American Micro-Systems, Inc.

Title	Part No.	No. Pages	Date
Introducing American Micro-Systems, Inc.		2	
Applied MOS Integrated-Circuits		20	
Hi Rel LSICs Start Here		1	1967
Ultra-DC 20-Bit Register	R1020	2	6-67
Ultra-DC Dual 20-Bit Register	R1040	2	6-67
Ultra-Logic 50-Bit Register	R2050	2	6-67
Ultra-Logic Dual 50-Bit Register	R2100	2	6-67
Ultra-Logic Dual 50-Bit Register	R2101	2	6-67
Ultra-Logic 20-Bit Register	R4020	2	6-67
Ultra-Logic Dual 20-Bit Register	R4040	2	6-67
Ultra-Logic Expandable Gate Array	L14GA	2	6-67
Ultra-Logic Gating and Storage Element	L22FF	2	5-67
Low-Power Logic Three-Input NOR-Gate	L203G	2	7-67
Low-Power Logic Three-Input NAND-Gate	L103G	2	7-67
Dual Matched MOS Transistor	DM050 DM100 DM150	2	6-67
Low-Power Logic Binary	B002E	2	6-67
MOS Low Power Logic - Application Note	AN-01	20	7-67
MOS Shift Registers - Application Note	AN-02	12	7-67

Figure 3. TYPICAL VENDOR DATA TABLE OF CONTENTS

The middle ten notch positions (0-9) indicate which document accession numbers are contained in a card. A notch in collection size (C) position 0 identifies those documents numbered between 0000 and 9999. A notch in C = 1 is used for documents numbered to 19,999.

The lower ten notch positions (1-10) identify the application (A) of the card.

The major features of this retrieval system are:

Random selection and rapid refiling of cards in any convenient place in the cardholder. This random selection process greatly increases the speed of data input.

Ability to store exact numerical values.

Flexibility in assigning cards to terms which are added to a vocabulary of an application because of random code number assignment.

If information contained in documents is classified, no vocabulary term need be printed on the card. By using RN code numbers exclusively, it is impossible to identify the vocabulary term a card represents. This eliminates the possibility of unauthorized personnel making meaningful searches.

Encoder can be used for indexing.

2.4.2 Guidelines for Handling Termatrex Cards

Labeling: Terms can be typed directly on the card. Sufficient space is available at the top of the card to allow for identification of generic and specific terms.

Corrections: Plastic correction fluid is available to "plug" holes in the cards.

Cleaning: Cards can be washed clean with soap and water.

Replacement of RN tabs: Improper handling of the cards may lead to damage of the RN tabs. Mylar tabs are available for replacement. Damage can be prevented by handling the cards from the side and not using the tab as a handle in filing the card. Pressure should never be placed on the RN tabs, as in resting documents on top of a set of cards or in reaching over the cards to extract one from the back of the holder.

Digit Coding: A technique known as digit coding allows many numerical values to be represented by a few cards. Normally, one card is required for each number. For example, 500 numbers would need 500 cards. However, when one uses the principles of digit coding, only 30 cards are needed. For example, if the range of numbers for a test was from 10 to 999, three separate sets of ten Termatrex cards would be assigned to each digit (0 through 9) to represent the units, tens and hundreds position of the numbers. The total number of cards in this case is 30. If the numerical value 642 is to be stored on Termatrex cards, the following cards would be selected:

"6" - Selected from the set of 10 Termatrex cards representing the hundreds position.

"4" - Selected from the set of 10 Termatrex cards representing the tens position.

"2" - Selected from the set of 10 Termatrex cards representing the units position.

These Termatrex cards are then superimposed and the pertinent document accession numbers are entered into them.

Digit coding can be used to store Manufacturer names, coded summary and device description document accession numbers, etc.

on cards. Table 2 illustrates the use of 30 cards in a three-digit coding scheme. The left-hand column illustrates how each card would be labeled. The right-hand column identifies the appropriate card code.

Using the table for an example, suppose digit coding is used to designate originating manufacturer sources of documents, and that in a directory of sources the Ajax Corporation has been assigned code number 147. Now if a searcher wanted to see all the documents from Ajax Corporation, he would reconstruct the code number 147 with the following cards:

1----	Red 01
-4--	14
--7-	27

When these cards were superimposed, documents from Ajax Corporation would be identified from coincident holes, those appearing in all three cards.

2.5 Termatrex Term List

The term list developed for use with the Termatrex retrieval system contains appropriate terms for indexing current literature on microelectronic device technology and reliability at a depth consistent with RAC service concepts. The list has been organized in two different forms to facilitate indexing and each is self-contained in a single section of the RAC Internal Operating Procedure. They are:

- Section 8.0 - Structured Term List - the terms are organized according to specific subject groupings.
- Section 9.0 - Alphabetical Term List - all terms are listed in alphabetical order.

A complete set of definitions which interprets every term, as it is employed on the RAC system, has been developed. This dictionary is contained in Section 10.0 and is a necessary adjunct to the term list itself for accurate and effective indexing.

Emphasis was given, during term list development, to anticipate near term future technology considerations. Concepts considered to gain broader interest were incorporated in an effort to extend the useful life of the present list. However,

Table 2

EXAMPLE OF THREE-DIGIT CODING

TX Card Label	RN Code	TX Card Label	RN Code	TX Card Label	RN Code
MANUFACTURER Hundreds Digit	Red	MANUFACTURER Tens Digit	Red	MANUFACTURER Units Digit	Red
0--	00	-0-	10	--0	20
1--	01	-1-	11	--1	21
2--	02	-2-	12	--2	22
3--	03	-3-	13	--3	23
4--	04	-4-	14	--4	24
5--	05	-5-	15	--5	25
6--	06	-6-	16	--6	26
7--	07	-7-	17	--7	27
8--	08	-8-	18	--8	28
9--	09	-9-	19	--9	29

it was recognized that future technology trends cannot always be predicted with accuracy. Hence, the list must be considered a dynamic entity amenable to updating to reflect changes that are expected to occur.

2.5.1 Updating Procedures

Updating procedures have been devised that make use of a review committee to act on both addition of new concept terms and deletion of obsolete terms. This will give positive assurance that the Term List and data files are consistent at all times with the objectives of the system and its users.

2.5.1.1 Addition of New Concept Terms. New terms located during the indexing procedure are recorded on 3 x 5 cards along with the document accession numbers where the term was located. At a predetermined time (every six months), these terms are reviewed by a committee made up of cognizant project engineers and information scientists. Decisions are made as to whether these terms should become a permanent part of the system. If the term is to be entered into the system, it is recorded in its appropriate place(s) in the structured and alphabetical listings, and a termatrex coding number assigned. The termatrex card is typed and the document accession number drilled. The 3 x 5 card for this term is now discarded. Terms not incorporated into the system are maintained on 3 x 5 cards for future review.

2.5.1.2 Synonyms. Synonyms identified during the indexing procedure and recorded by the indexer should also be incorporated into the termatrex term lists at each updating period.

2.5.1.3 Deletion of Terms. After a predetermined time (12 months), the termatrex cards should be reviewed to determine the use or nonuse of certain terms. A decision should be made by the reviewing committee as to whether infrequently used terms might be removed from the system or whether certain of these terms might be combined on one termatrex card. Terms removed from the system are to be maintained in the 3 x 5 card file for possible future use in the system. Terms combined on a single termatrex card shall be assigned an identifying number recorded at the top of the card. Whenever any of these terms are used as an index entry, the document accession number is drilled into the card and the identifying term number recorded beside the hole.

2.6 Referenced Forms

The following referenced forms are herewith included:

RAC 68-2	Family Fabrication Information
RAC 68-3	Packaging Information
RAC 68-4	Individual Circuit Information

Form RAC 68-2

Accession No:___
Page: 1 of 5
Date:______

RELIABILITY ANALYSIS CENTER
MICROELECTRONIC DEVICE DESCRIPTION
FAMILY FABRICATION INFORMATION

1.0 FAMILY IDENTIFICATION

Manufacturer:______
Family Designation:______
Applicable Part Numbers:______
______
______

2.0 SUBSTRATE MATERIAL

_____Silicon Resistivity:______
_____Germanium Dopant:______
Original Wafer Size:______
Die Size:______

3.0 ISOLATION METHOD

_____Junction
_____Resistive
_____Dielectric
___Air
___Oxide
___Nitride
___Carbide
___Ceramic
___Glass

4.0 BURIED LAYER USED

_____No
_____Yes
Sheet Resistance:______
Dopant:______

5.0 EPITAXIAL LAYER USED

_____No
_____Yes
Thickness:______
Dopant:______
Resistivity:______
Isolation Diffusion Dopant:______

6.0 COLLECTOR DIFFUSION USED

___No
___Yes
Sheet Resistance:_______________
Dopant:_______________
Final Diffusion Depth:_______________

7.0 BASE DIFFUSION

Sheet Resistance:_______________
Dopant:_______________
Final Diffusion Depth:_______________

8.0 EMITTER DIFFUSION

Sheet Resistance:_______________
Dopant:_______________
Final Diffusion Depth:_______________

9.0 MOS/MNS DEVICES

9.1 Dielectric Type
___Oxide
___Nitride

9.2 TRANSISTORS (IGFETS)

9.2.1 Operational Mode
___Enhancement
___Depletion
Channel Size:__________
Channel Dopant:__________
Channel Sheet Resistance:__________

9.2.2 Channel Type
___P-Channel
___N-Channel

9.2.3 Source & Drain Diffusion
Sheet Resistance:_______________
Dopant:_______________
Final Diffusion Depth:_______________

TRANSISTORS (IGFETS) (cont d)

9.2.4 Dielectric Thickness:______________

9.3 MOS/MNS CAPACITORS

9.3.1 Lower Plate Diffusion
Sheet Resistance:______________
Dopant:______________
Final Diffusion Depth:______________

9.3.2 Dielectric Thickness:______________

10.0 SURFACE PASSIVATION
Type
___Oxide
___Nitride
___Other:______________

Thickness (Minimum):______________
Additional Passivation Processes & Materials:
____
____

11.0 INTERCONNECTION METALLIZATION (Bipolar & MOS/MNS Devices)

11.1 Metal(s) Used
Primary Metal
___Aluminum - Thickness:______________
___Gold - Thickness:______________
___Other:__________Thickness__________

Deposition Method
___Vacuum Deposition
___Cathode Sputtering
___Vapor Plating

Secondary Metal(s) Used (wetting agents, etc.)
Specify Metal, Thickness and Deposition
Method______________________________
____
____

12.0 FILM DEVICES

12.1 Conductors

Material:_______________

Thickness:_______________

Sheet Resistance:_______________

Deposition Method:_______________

12.2 Resistive Elements

Material:_______________

Thickness:_______________

Sheet Resistance:_______________

Deposition Method:_______________

12.3 Dielectric

Material:_______________

Thickness:_______________

Deposition Method:_______________

13.0 QUALITY CONTROL CHECKS - Specify method or procedure used to check and/or control the following parameters before sealing the package. (i.e.-Electrical Function: Probing)

13.1 Sheet Resistance:

13.2 Junction Profiles:

13.3 Passivation Thickness:

13.4 Passivation Quality:

QUALITY CONTROL CHECKS (cont'd)

13.5 Device Geometry:

13.6 Ohmic Contacts:

13.7 Electrical Function:

13.8 Metallization Adherence:

13.9 Metallization Thickness:

13.10 Bond Strength:

Form RAC 68-3

Accession No:______
Page: 1 of 2
Date:______

RELIABILITY ANALYSIS CENTER
MICROELECTRONIC DEVICE DESCRIPTION
PACKAGING INFORMATION

1.0 IDENTIFICATION

Manufacturer:____________________
Package Configuration
___Can - Hermetically Sealed
___Flat Pack - Glass
___Flat Pack - Ceramic
___Plastic Encapsulated (other than DIP)
___Dual In Line - Hermetically Sealed
___Dual In Line - Plastic
___Module
Manufacturer's Package Designation:______________
JEDEC Package Designation:______________

2.0 DIE BONDING METHOD

2.1 ___Eutectic Alloy Braze
2.2 ___Glass Frit
2.3 ___Solder
2.4 ___Direct
2.4.1 ___Beam Lead
2.4.2 ___Flip Chip
2.4.3 ___Ultrasonic Flip Chip
2.4.4 ___LID
2.5 ___Other:____________________

2.6 Direct Bonding Techniques (if used)

2.6.1 Metallization Material (if metallization is used to connect die to package leads)
___Gold
___Aluminum
___Other:____________________

2.6.2 Direct Bonding Method
___Thermocompression
___Ultrasonic
___Solder Balls

3.0 WIRE BONDING (if used)

3.1 Wire Material
- ___Gold
- ___Aluminum
- ___Other:______________

3.2 Wire Diameter:______________

3.3 Maximum Length Wire Used:______________

3.4 Bonding Method
- ___Ball - Thermocompression
- ___Wedge - Thermocompression
- ___Stitch - Thermocompression
- ___Ultrasonic

4.0 SUBSTRATE BONDING (If an insulating substrate is used such as with thin film, multichip, flip chip and beam lead construction, specify method of bonding substrate to package.)

Form RAC 68-4

Accession No: ______
Page: 1 of 2
Date: ______

RELIABILITY ANALYSIS CENTER
MICROELECTRONIC DEVICE DESCRIPTION
INDIVIDUAL CIRCUIT INFORMATION

1.0 IDENTIFICATION

Manufacturer: ____________________
Part Number: ____________________
Part Name: ____________________
User Name & Part Number: ____________________

2.0 FUNCTIONAL PROPERTIES

2.1 Circuit Configuration - (Attach schematics showing ALL circuit components including isolation diodes or isolation regions, zener diodes on IGFET gates, and method of connecting transistors as diodes.)

2.2 Chip Topography - (Attach photograph or scale drawing of top surface of chip showing device layout, interconnection pattern, and bonded wire layout.)

3.0 PROCESSING DETAILS

3.1 Processing Flow Chart (Attach copy of Flow Chart)

(Attach specs and/or details of photolithographic, washing, cleaning, epitaxy, diffusion, metallization and thin/thick film processing steps.)

(Detail Special, Non Standard, processing steps required by user - give user spec number if applicable.)

4.0 POST PRODUCTION SCREENING PROCEDURES

4.1 Test Specification Source: ____________________

4.2 Test Specification Number: ____________________

Provide either a copy of the specifications (preferable) or detailed conditions of each screening measure used. (i.e., electrical burn in, temperature aging, hermeticity, etc.)

5.0 DESTRUCTIVE TESTS - Indicate any limit or other destructive tests (i.e., Step Stress) that are conducted on each lot as part of Lot Acceptance procedure. State stress type and conditions and whether test vehicles are marketable items, non-functional items, or special test patterns.

6.0 DEVIATIONS FROM STANDARD FAMILY PROCESSING: Specify any deviations from standard family processing (as described in Form RC 68-2) peculiar to this part number, and not otherwise specified.

3.0 PROCEDURAL GUIDE FOR DATA COLLECTORS

3.1 Guideline Objectives

3.1.1 Principal Objectives

Among the principal objectives of the data collection guidelines are the following points:

1. Provisions contained herein are for obtaining a single submission of data from the sources contacted and receiving what is presently available. However, some negotiations must be made to determine the procedures needed for automatic data submission.

2. Information concerning the types of communication necessary prior to the data collection visit so that a uniform collection procedure is carried out.

3. Proper guidance on the conduct of the actual collection visit so that all important aspects are covered.

4. Documentation requirements so that the proper forms and controls may help to keep track of the data collection system.

3.1.2 Overall Chart

Figure 4 contains a flow chart representing the steps needed to achieve the objectives stated above.

3.2 Source Selection

3.2.1 Selection of Vendors

Source vendors have been selected from the 1967 Semiconductor Annual of EDN magazine.

3.2.1.1 Selection Criteria. From the entire list of qualified military specification producers, sources are selected by using the following criteria as selection factors:

1. Production volume of microcircuits.

2. Reputation as a reliable source.

3. Relative usage of device types in Government equipment.

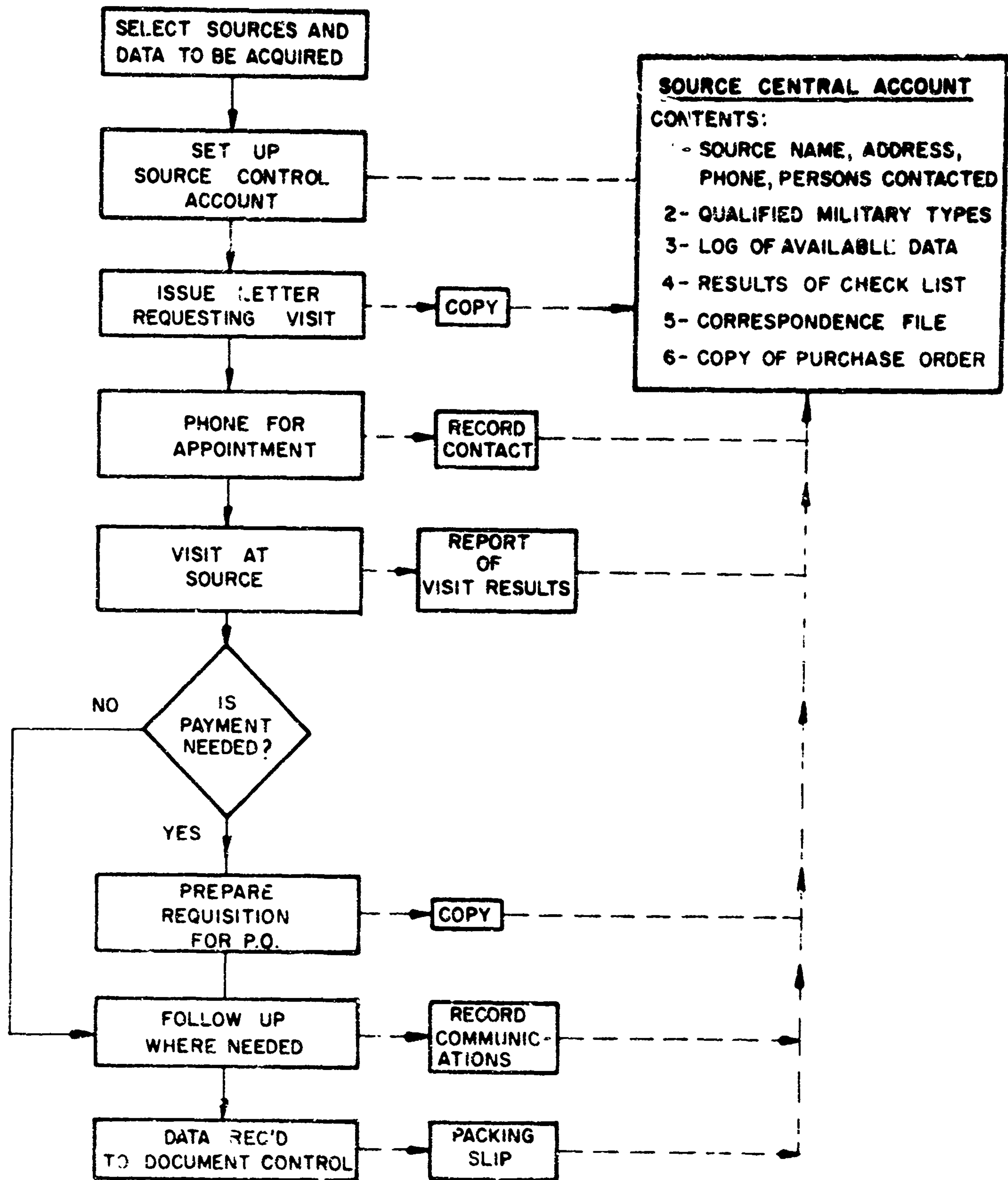


Figure 4. FLOW CHART OF DATA COLLECTION PROCEDURES

4. Geographical location relative to other qualified producers.

5. Expected usage in future equipments.

3.2.1.2 Data Source Classification. Potential sources are classified according to the above criteria into three classes as:

1. Major producers who are expected to have sizable data accumulations.

2. Smaller producers who are expected to have some useful reliability data.

3. Manufacturers who are expected to have little or no useful reliability data due to their size, specialization, reputation, etc.

Those in the first category are prime candidates for personal visitation and will be included in the initial trip schedules. Manufacturers falling into this second group will be solicited by letter/questionnaire to ascertain nature, quality, and utility of available data. Manufacturers in the third group are dropped from further consideration as a data source.

Depending upon success realized in obtaining good representation of data in all device types covered by the collection activity from the first selection analysis, a further review of potential sources may be made.

3.2.1.3 Vendor Visitation Schedules. Visitation schedules shall be determined by consideration of data sources concentration and available manpower schedules. Those areas such as Southern California, New York City, and New England, having a large number of prominent part manufacturers within a closely spaced geographical area, should receive top priority. Areas with a smaller number, but major part producers, are to receive second priority. Remaining geographically scattered sources are to be scheduled as time permits.

To some extent vendor visits should be planned in conjunction with visits to equipment manufacturing plants in the same locality. However, since the data generated by the two source types differ quite markedly, it is necessary to prepare differently in requesting data.

Trip schedules must take into consideration associated tasks of the program as well as commitments on other programs, vacation schedules, etc. To properly plan, prepare and follow up on trips, it is recommended that collection personnel are not scheduled for out-of-town trips during two successive weeks.

Local vendors within easy access to IITRI's location in Chicago will be visited between trips of longer duration to more distant points.

Subsequent trips may be required to those firms not initially included in the travel schedule (those in second group of Paragraph 3.2.1.2) and those unable to receive us as planned. Such trips will have to be scheduled as the need becomes evident.

3.2.2 Equipment Manufacturers and System Contractors

Data on parts generated during application usage phases is to be obtained from the prime Air Force Systems contractors, their subcontractors and Government Furnished Equipment (GFE) manufacturers. Applicable systems and their prime contractors must be identified by contacts through our contract monitor and with the various Systems Program Offices (SPO's) at the four Air Force Systems Divisions.

Data on these systems may be obtainable directly from the prime contractor or from the equipment manufacturers that supply the hardware items comprising the systems. The prime contractors shall be contacted initially. From these, the identity and expected data content of subsidiary sources (subcontractors, GFE manufacturers, etc.) will be established.

3.3 Contacts

3.3.1 Form Letters

3.3.1.1 Vendors. Two form letters will be used to solicit vendor cooperation. One letter will be written to request a visit at certain major vendors' plants. The other letter will contain a questionnaire to be answered and returned by those vendors being requested for catalog information.

Those vendors to be visited by IITRI personnel will receive an individually typed letter following the form shown in Exhibit I, stating the objectives of the Reliability Analysis Center. In addition, the letters will state that a staff member will call the vendor to arrange for an early appointment.

Individually typed letters shall be sent to all known microelectronic vendors. The contents of this letter is shown in Exhibit II. Also, a questionnaire (RAC 68-14) attached to Exhibit II shall be enclosed in each letter. This letter is intended primarily to obtain catalogs, device specifications, application notes and published reliability data.

After a manufacturer's catalogs have been received at IITRI, another form letter, as shown in Exhibit III, shall be sent out. This letter serves as an acknowledgment of the information currently received. In addition, it serves as a reminder that we wish to be placed on the manufacturer's permanent mailing list. All correspondence, of course, shall be individually typed and signed.

3.3.1.2 Equipment Manufacturers. Equipment manufacturers and subcontractors will be contacted initially with the form letter shown in Section 3.7. This letter requests that the manufacturer fill out a questionnaire entitled "Device/Count Application Stress Summary". Its purpose is to define device types, quantities and stress ratings of integrated circuits used in various military systems and subsystems.

The questionnaire attached to the form letter is assigned number RAC 68-6. Instructions will also accompany each questionnaire.

3.3.2 Phone Appointments

Sometime within one to two weeks after sending the letter requesting a visit, a phone call will be made to establish an appointment. The appointment should include the data and time, together with the name of the person or persons to be contacted. Experience tells us that one full day should be allowed for visits to microelectronic manufacturers. Equipment manufacturers also require at least one full day for a visit.

EXHIBIT I

FORM LETTER REQUESTING VISIT TO VENDOR

Gentlemen:

The Rome Air Development Center (RADC), Rome, New York, has contracted with IIT Research Institute (Contract AF 30(602)-4265) to establish a Reliability Analysis Center (RAC) for microelectronic devices. Its mission is to collect, consolidate, and disseminate technical, application and reliability information on devices designed and produced for military and space applications.

Your cooperation is being enlisted for building a complete and current file of technical, application and reliability information on your microelectronic devices. Among the chief items of interest to us are the following:

1) Reliability data including test description, number of parts on test, number of failures, total operating time, time to device failure and failure definitions.

2) Failure modes and analysis of causes

3) Qualification test results

4) Screening or burn in specifications and data.

A member of our staff will contact you by telephone within the coming week to arrange a visit at your plant. In this way we hope to determine what data is immediately available for acquisition and to initiate communications to effect automatic submission of future data outputs as they become available.

Thank you in advance for your cooperation in this matter.

Very truly yours,

H. C. Edfors
Reliability Analysis Center

EXHIBIT II

PROPOSED FORM LETTER FOR VENDOR CATALOG REQUEST

Gentlemen: (Dear Mr.)

The Rome Air Development Center (RADC), Rome, New York, has contracted with IIT Research Institute (Contract AF 30(602)-4265) to establish a Reliability Analysis Center (RAC) for microelectronic devices. Its mission is to collect, consolidate and disseminate technical, application and reliability information on devices designed and produced for military and space applications.

Your cooperation is being enlisted for building a complete and current file of published vendor information on microelectronic devices. To ensure that your company is properly represented, please place our name on your permanent, active mailing list for current catalog specifications, application notes, and related technical information on all active microelectronic devices produced by your firm.

RAC services are being made available to all Air Force systems and equipment contractors to aid them in device selection, application and procurement. Therefore, it is vital that we continue to receive notices and data sheets on all new device releases as they occur.

Would you kindly complete and return the attached short questionnaire to assist us in correctly cataloging your company and products? A self-addressed stamped envelope is enclosed for your convenience. Your cooperation in this important program will be much appreciated.

Sincerely yours,

H. C. Edfors
Reliability Analysis Center

RAC 68-14

MICROELECTRONIC INFORMATION
COMPANY SURVEY QUESTIONNAIRE

Please complete the following information items pertaining to Microelectronic Devices manufactured by your company.

1. COMPANY NAME ____________ PREFERRED ABBREV: ________
   DIV. ________ SR. OFFICER ____________ TITLE ________

2. ADDRESSES: Please supply street address, city, state and zip code.
   R & D FACILITY ____________
   MAIN MFGR. FACILITY ____________
   OTHER MFR. FACILITIES ____________

3. Please place check (✓) in cells corresponding to the device classes now being marketed and place an (X) in cells to indicate classes to be marketed in near future.

	MONOLITHIC	THIN FILM	THICK FILM	HYBRID	COMPATIBLE	OTHER
Digital						
Analog						

4. What Digital circuit configuration are marketed?
   ___RTL ___DTL ___TTL ___ECL ___CML ___OTHER: ________

5. Please check the information that is periodically published and can be furnished as it becomes available.
   ___ catalogs and brochures
   ___ complete spec. sheets
   ___ new release notices
   ___ device application notes
   ___ Failure Rate Summaries
   ___ Other Reliability Data
   ___ Other: ____________

6. Person to contact for future inquiries for sales publication
   NAME: ____________ PHONE: ________ EXT. ____

7. Technical individual to whom we may direct inquiries for laboratory technical and reliability test data.
   NAME: ____________ PHONE: ________ EXT. ____
   TITLE: ____________

8. REMARKS (optional) ____________

SIGNATURE: ____________
TITLE: ____________

EXHIBIT III

FORM LETTER OF THANKS FOR VENDOR CATALOGS

Gentlemen:

Thank you for furnishing us with your most recent catalogs, specification sheets, application notes and reliability data. We trust that you will continue to keep us on your mailing list for new release notices and other supplements and replacements for the information already sent to us.

Your continued, fine cooperation is much appreciated.

Yours very truly,
H.C. Edfors

H. C. Edfors
Reliability Analysis Center

Q-1 What is going to be done with our data?

A-1 It is to be analyzed and entered into a Parts Reliability Handbook and also stored in a Data Bank for use by Air Force system designers. This will be a long-term program designed for continuing operation by the Air Force.

Q-2 Why should we participate in this program?

A-2 It will provide a central point of inquiry for reliability users and make the users aware of your product. In addition, it should improve and standardize reliability test and report procedures, improve specifications, and identify part and data gaps with recommendations for corrective action.

Q-3 How is our proprietary information protected?

A-3 Proprietary information will be coded as such in the RAC data base and will not be released, except to Government personnel in identifiable form, without explicit prior consent of the originator. Proprietary data will be used in analyses which combine data from numerous sources for arriving at generic reliability statements. In such cases the original identity of data and source is completely masked.

Q-4 What makes the Reliability Analysis Center different from FARADA, PRINCE, etc.?

A-4 The other systems are passive; that is, they redistribute reliability reports and information without performing any analyses or data validation. On the other hand, RAC will do various types of analyses, merging of raw data, and validation coding so that valid reliability comparisons can be made among various similar device types.

Figure 5. POSSIBLE QUESTIONS RAISED BY THE VENDOR OR EQUIPMENT MANUFACTURER

3.3.3 Contacts Via Air Force

Contacts with prime contractors and certain other sources must be made through the Air Force contract monitor. IITRI personnel shall determine tentative schedule dates for these visits and notify J. Fuchs (EMERR) at RADC sufficiently in advance of the comtemplated visit such that adequate calendar time is allowed to complete arrangements. To expedite the communication, extensive use of the telephone is recommended although follow-up letters of confirmation are suggested to ensure correct transmittal of detail. These contacts are arranged by our contract monitor through the cognizant SPO. At the time he must advise the names of individuals scheduled to make the visit, details of their clearance, and data of visit. We will be notified when the arrangements have been completed and advised of actual appointment date and personnel to be contacted.

The contact should be confirmed by telephoning the person (or main contact when more than one name is supplied) to be visited a day or so in advance. It is advisable at this time to reiterate briefly our objective to assist the contact in preparing for our visit.

3.4 Staff Visits to Data Sources

The following paragraphs describe the procedures to be followed in contacting all data sources requiring a visit. Figure 5 contains a typical list of possible questions that might be raised by those persons contacted.

3.4.1 Visits to Vendors

3.4.1.1 General Preparation. When a staff visit is made to a vendor, the first consideration is for adequate preparation prior to the trip. Some of the factors which have importance before and during the trip are mentioned in the following discussion.

Vendor's catalogs and technical data sheets will be available for reference. This information reveals the number and kinds of military and commercial part types being produced. It also indicates the microelectronic processes used and the possible availability of summarized reliability data.

3.4.1.2 Acceptable Data Content. Vendor requirements are defined in the "Data Input Specification for Microelectronic Device Manufacturers," SP-ID-01, found in Section 3.8.

EXHIBIT IV

Reliability Analysis Center

DATA COLLECTION REPORT

Data:

Company Name:	Type of Contact:
Address:	Phone:_______
Phone:	Visit:_______
Names of Persons Contacted:	Letter:_______

IITRI Personnel:

Input Data Available
From Requirements of SP-ID-01

EXHIBIT V

Reliability Analysis Center

CHECK LIST FOR SINGLE DATA SUBMISSION

1. Our chief interest in the Microelectronic Technology Family Tree is in the area of monolithic I.C.'s. However, we will also accept data on thick and thin film hybrids plus compatible I.C.'s.

2. What types of data can be provided to us from the attached list of desired information in Data Input Guidelines SP-ID-01?

3. How may we group your device types into families for reliability purposes?

4. For that data which is presently available to us, what is the volume in sheets of paper for each part family?

5. Can you indicate which particular parts have the highest sales demand for use in military programs? We are primarily interested in aerospace and Air Force items but will accept other military items.

6. Can you name certain prominent aerospace and military programs which have used your device?

7. Can you make reference to any user (military or defense contractor) which may have run tests on your devices?

8. How are the results of acceptance tests, life tests, etc., reduced or summarized? Do you have an in-house reliability reporting system?

9. How is your test data validated?

10. Can device test data be identified by part number, lot number, and date of manufacture?

11. Are facilities available for duplicating selected portions of your data for our use?

12. In what form is your data available?

    Reports Listings Cards Magnetic tape Other

13. Comments:

EXHIBIT VI

Reliability Analysis Center

CHECK LIST - AUTOMATIC DATA SUBMISSION

1. What is the volume of data generated on a weekly (or monthly) basis for each military device family? (Refer to Data Input Guidelines for Relevant types of data.)

2. What is the best or your most convenient form in submitting data of the type in SP-ID-01 to us?

3. Can we suggest formats for raw and summarized types of data? It might be desirable for us to have raw data from computer printouts according to a standard format.

4. Can you release product specifications and other technical details on your new product developments on an automatic basis?

5. What special problems, if any, do you envision by participating in automatic data submission?

6. Is it possible to have your military device qualification and lot acceptance data shipped to us on a regular basis? (DESC receives this information on mil. spec. semiconductors and other components.)

7. In regard to reliability data, it is necessary for us to have variables parameter data on device families as well as failure rate and test report summaries. Raw parameter readings allow us to show histograms, correlation plots, drift and stability trends. Can this be made available to us on some periodic basis?

3.4.1.3 Collection Report and Check List. Exhibit IV is the Data Collection Report which is to be completed during the visit to the vendor, using the check list in Exhibit V as a guide. In conjunction with the check list, Data Input Guidelines (SP-ID-01) are the basis for the first question. It is desirable to cover the data needs of RAC, stated in SP-ID-01, with the vendor's representative and write any comments that he has in the Data Collection Report. Of course, it may be impossible to obtain items which the vendor considers proprietary such as detailed fabrication specifications. However, information at a more general level (such as an illustrated flow chart of the IC processing steps) would be helpful. This approach should be followed for each item of SP-ID-01. Where detailed requirements for some reason are not available to RAC, try to determine items that would be made available at a more general level. Other items on the check list are rather self-explanatory and can serve as a guide for the interview with the vendor's representative.

3.4.1.4 Single Data Submission. It is expected that the interview at the vendor's site will result in an understanding of the immediate data requirements for RAC. Further phone and letter communications may be needed to culminate in an agreement and terms for the vendor to deliver a specified set of data to IITRI. Among the further facts to be determined over the deliverable set of information are the following:

1) What is the cost, if any, for reproduction?

2) When will IITRI receive the data?

3) Letter of quotation from the vendor is needed to reimburse expenses.

3.4.1.5 Automatic Data Submissions. A secondary purpose of the data collection visit is to determine the vendor's willingness to volunteer certain types of data on a continuing basis. Discussions are to be on a purely fact gathering basis, with no immediate action required on the vendor's part. It is expected that RAC will be a permanent data center with future data input needs and requirements which parallel SP-ID-01. The check list of questions to be answered on this subject may be found in Exhibit VI.

3.4.2 Prime Contractors and Equipment Manufacturers

3.4.2.1 General. Interviews with contractors and equipment suppliers generally will follow the same tack as described for part vendors. Differences are to be expected in several respects, however:

1. For the most part, equipment and system contractors are large firms; therefore, the interviews are likely to be attended by a large number of individuals and will be more formalized.

2. Data desired from these sources are generated mostly during testing and/or operation of completed equipments rather than during laboratory testing of the parts themselves.

3. Data will not be made available to us directly. Instead it will be obtained through the SPO via our contract monitor.

By recognizing these differences the collector should prepare himself to complete the interview with dispatch and acquire the required information. Organized data from equipment tests is almost exclusively in the form of malfunction reports, which are frequently prepared by electronic data processing equipment. To make effective use of this data, much additional information is required. Subsection 3.4.2.2 of this Guideline describes the nature and content of the required data in greater detail.

The interview must identify by report designation, description, authors, dates, etc., of all pertinent material that should comprise our collection such that it can be correctly described to our contract monitor for acquisition.

3.4.2.2 Data Input Content. Details on Data Input Specification for Contractor and Equipment Manufacturers may be found in SP-ID-02, Section 3.9.

3.4.3 Documentation

3.4.3.1 Source Control Account. Source Control Documents I and II are to be used for each data source solicited with the purpose of keeping an account of data as it is received and additional data expected to be submitted to the Center. Document I will be used only for data which has been brought into RAC. The date the data is received will be noted plus some description of the amount and type of data received.

Documen' II will be used as a log for keeping track of requests for submittal of data which has been promised by the particular source.* Any member of the staff contacting a source about data will place his initials, the date, and the type of contract (such as by phone, letter, etc.).

Where a source has physically separate plants or divisions being visited, each plant will be treated as a separate company and have its own Source Control File for follow-up.

3.4.3.2 Data Collection Report. This report basically consists of the forms shown in Exhibits IV and V which were mentioned in Subsection 3.4.1.3. Immediately following the interview, this form should be filled out as completely as possible. Any notes taken during the interview should be put on these forms. This consolidates all note taking onto one report form. Attachment of the Data Collection Report to the Source Control Documents and any other papers and letters pertaining to a particular vendor forms a file. Files on the various vendors will be stored in a cabinet for reference and follow-up.

3.5 Data Collection Follow-up

3.5.1 Price Quotation

If possible, it is desirable to get a verbal price quotation on reproduction of data at the time a plant visit is made. However, it will still be necessary to have the manufacturer write a letter to IITRI stating the costs of reproduction and schedule for delivery. The written quotation may then be used as the basis of a purchase requisition.

3.5.2 Purchase Requisition

As soon as the written price quotation has been received, the purchase requisition sould be filled out and submitted for approval. A copy of the purchase requisition should be made for the file and a copy of the written price quotation should be attached to the requisition sent to the purchasing department.

---

*Data from system contractors or equipment manufacturers will almost exclusively be obtained through our Air Force contract monitor. Where this occurs, the source control log must indicate such.

RELIABILITY ANALYSIS CENTER

SOURCE CONTROL DOCUMENT - I

COMPANY NAME:

ADDRESS:

PHONE:

NAMES OF PERSONS CONTACTED:

QUALIFIED MILITARY PRODUCTS:

DOCUMENT LOG

DATE	ACCESSION NUMBER

RELIABILITY ANALYSIS CENTER

SOURCE CONTROL DOCUMENT - II

DATE	IITRI PERSONNEL	TYPE OF COMMUNICATION & COMMENTS

3.5.3 Periodic Follow-up of Requisitions

One member of the staff will be assigned the responsibility of checking the status of purchase orders. Each purchase order will contain a requested delivery date. After one week has passed beyond the time of requested delivery, a phone call shall be made to determine the status of the order. Sound judgment and courteous manners shall be employed during all such follow-up inquiries.

3.6 Device Description Requests

3.6.1 Request Letter

Letters will be sent to vendors on those device types of greatest interest because of accumulated data on file. Three types of forms will accompany a letter for complete identification of each microelectronic device. An example of this letter is found in Section 3.10 under RAC 68-8.

3.6.2 Family Fabrication Information

This form pertains to an unpackaged chip with a request for processing details covering a family or series of microelectronic devices. This form may be found in Section 3.10 under RAC 68-2.

3.6.3 Packaging Information

Package details including wire bonding, die bonding, and configurations are included in this form. It is found in Section 3.10 under RAC 68-3.

3.6.4 Individual Circuit Information

Pertinent details on individual circuit devices include functional properties, processing, screening and destructive tests. This form is shown in Section 3.10 under RAC 68-4.

3.7 Device/Count Application Stress Summary

ATTENTION:

SUBJECT:

Dear Mr. ________________________:

The Rome Air Development Center (RADC), Rome, New York, has contracted with IIT Research Institute to establish an Air Force Reliability Analysis Center (RAC) for microelectronic devices. Its mission is to collect, consolidate and disseminate technical, application and reliability information on devices designed and produced for military and space applications. Primary recipients of this information will include component and design engineers at military equipment contractor facilities. Enclosed is a letter from Mr. D. F. Barber of RADC authorizing us to contact military contractors, subcontractors and microelectronic manufacturers.

We have been advised by a microelectronics manufacturer that they are supplying ___________________________ integrated circuit devices in the __________________ program which contain electronic systems produced by your company. Since equipment test and field reliability data on microelectronic devices is vitally needed information, we are asking you as a defense contractor to cooperate by filling out the attached questionnaire entitled Device/Count Application Stress Summary. This information will be used to identify and evaluate field use experience with different types of microelectronic circuit configurations, packages and processes. You will find three (3) copies of the questionnaire enclosed for possible use in describing more than one equipment or assembly. A set of instructions for completing the form is also enclosed.

We will ultimately want to determine usage failure rates (test and full operation) for the various microelectronic devices made by the major microelectronic manufacturers.

Consequently, we will appreciate an opportunity to visit your facility to discuss how this information can be retrieved. Screening and procurement specifications and data are also of interest to us.

We trust that either you or some members of your organization will be able to provide the requested information. Success of the program is contingent upon the cooperative efforts of the many device manufacturers and military contractors as contributors of technical information and data. Participation will prove most beneficial as this is a comprehensive central agency which is cooperating with other data banks and Government agencies in a continuing effort to consolidate and disseminate microelectronic application, experience and reliability data.

Thank you in advance for your cooperation. If there are any security questions or need-to-know problems, please advise us. Also, if any further questions come to mind, feel free to call me or Mr. B. F. Lathan collect at (312) 225-9630, extension 4041. We look forward to your early reply.

Yours very truly,

Hugh C. Edfors
IIT Research Institute
Reliability Analysis Center

HCE/pmp

Encls.

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS ROME AIR DEVELOPMENT CENTER (AFSC)
GRIFFISS AIR FORCE BASE, NEW YORK 13440

REPLY TO ATTN OF: EMERR/J. Fuchs/330-4064 10 Oct 67

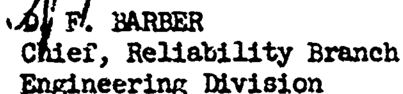
SUBJECT: Microelectronic Data for Use in the Reliability Analysis Central

TO: IIT Research Institute
10 West 35th Street
Chicago IL 60616

1. The success of the Reliability Analysis Central and the speed at which it is implemented will depend on the immediate availability of reliability information which has been generated by system contractors and microelectronic vendors. To speed the acquisition of the desired information RADC has awarded Contract AF30(602)-4265 for the collection, reduction and analysis of microelectronic reliability data.

2. Since the bulk of the required data has been generated by system contractors and microelectronic vendors, it is requested that you contact as many of these sources as possible. To each source being solicited, you should supply details on the information required. If the source has good raw or reduced data you should request their authorization to access and use this information, expressing the gratitude of the Air Force for their cooperation in this effort.

3. This letter will not be construed as a written order within the purview of the existing contract. It is intended only to furnish information. Changes which: (1) involve increase or decrease in price, (2) involve delivery, or (3) may result in forming the basis of future claims against the Government, etc., will be covered by appropriate written instructions provided by applicable existing regulations and the contract.



D. F. BARBER
Chief, Reliability Branch
Engineering Division

RAC 68-6

DEVICE/COUNT APPLICATION STRESS SUMMARY

page of

originator/contractor	contract num	report num	date
	equipment/assembly name	nomenclature	
prime contractor	primary function	type application	
cognizant system project office	ENVIRONMENTAL PROTECTION		
	TEMP CONTROL: heated / refrig / forced; temp	duty	other
system/subsystem used on	VOLTAGE/CURRENT PROTECTION: surge; volt; current	shock/vibr mounts	

DEVICE NUMBER	DEVICE NAME	MANUFACTURER	NUMBER USED	% VOLT RATING	% PWR RATING	DEVICE TEMP*

* At 25°C ambient outside housing | Prepared by-Signature | Title

COMPLETION INSTRUCTIONS FOR DEVICE COUNT/APPLICATION STRESS SUMMARY FORM

Purpose: The "Device Count/Application Stress Summary" form is intended to provide the Reliability Analysis Center (RAC) with quantitative information concerning the application environment surrounding microelectronic devices employed in Military weapons and support equipment and systems. Only information concerning microelectronic device usage is to be reported on this form.

General: A separate form shall be completed for each unique equipment/assembly entity. Should a complete functional unit be comprised of several separate physical compartments or housings having differing electrical stresses or environment control, a separate form should be completed for each to reflect the differences. Multiple pages should be used where necessary to accommodate the complete device type complement employed in a given unit. Common information at the top of the form need not be repeated on each page.

Detail Entries: The following paragraphs describe the information content to be entered for each detail item.

ORIGINATOR/CONTRACTOR: Enter the company name, division and address of the organization completing the form. This should be the same organization that has developed or is producing the equipment or assembly.

PRIME CONTRACTOR: Enter the name and division of the prime contractor if this equipment/assembly has been developed or produced under subcontract.

COGNIZANT SYSTEM PROJECT OFFICE: This is the government organization that has contracted for and is monitoring the procurement.

<u>SYSTEM/SUBSYSTEM USED ON</u>: Enter the name or designation of the program or system on which the equipment/assembly is to be used if such an entity is identifiable.

<u>CONTRACT NUMBER</u>: Enter contract number of this procurement.

<u>REPORT NUMBER</u>: This item is optional and may be filled in if the respondent desires to assign an identification number for control purposes.

<u>DATE</u>: Enter current date.

<u>EQUIPMENT/ASSEMBLY NAME</u>: Enter the name or designation used for identification of the unit.

<u>NOMENCLATURE</u>: Enter the assigned model number or other alphanumeric identifier.

<u>PRIMARY FUNCTION</u>: Refers to the intended function to be performed by the unit.

<u>TYPE APPLICATION</u>: Enter the intended end use deployment; terms such as ground-fixed, ground-mobile, airborne, missile launch, etc. are applicable.

<u>ENVIRONMENTAL PROTECTION</u>:

<u>TEMPERATURE CONTROL</u>: Check whether internal temperature of the unit is controlled by heating, refrigeration or forced air circulation.

<u>TEMPERATURE</u>: Indicate the design-center internal temperature if temperature control is employed.

<u>DUTY √</u>: Indicate the approximate on-off ratio of the functional unit in %. Do not attempt to indicate duty cycle of individual circuits or subassemblies.

<u>VOLTAGE/CURRENT PROTECTION</u>: Indicate with check in proper spaces whether surge, voltage or current regulation or other protective devices are employed.

<u>SHOCK/VIBRATION MOUNTS</u>: State whether special mountings or other provisions are incorporated to reduce effects of mechanical stresses.

<u>OTHER</u>: Indicate here what other, if any, precautions are taken to protect the unit from anticipated hostile environments, i.e. radiation, low pressure, etc.

<u>TABULAR ENTRIES</u>:

<u>DEVICE NUMBER</u>: Enter in this column the identification number of each <u>microelectronic</u> device employed. This may either be the manufacturer's number or your procurement control number. It is desired that each unique device be entered separately although it is recognized that in certain situations it is more appropriate to identify an entire family of devices as a single entry.

<u>DEVICE NAME</u>: Self explanatory.

<u>MANUFACTURER</u>: Self explanatory - list all vendors if more than one.

<u>NUMBER USED</u>: Enter the quantity of devices of that type number used per equipment or assembly.

<u>% VOLT RATING</u> and <u>% PWR RATING</u>: Enter in these columns the design center or derating philosophy employed for supply voltage and/or device dissipation.

<u>DEVICE TEMPERATURE</u>: If possible denote the approximate expected package surface temperature in °C with the unit operating in a 25°C external ambient.

<u>Authentication</u>: The person completing the form should affix his signature and title in the spaces provided at the bottom of the form. Succeeding pages may be initialed.

3.8 Data Input Guidelines for Microelectronic Device Manufacturers

SP-ID-01
8/1/67 (3)

Data Input Guidelines For Microelectronic Device Manufacturers

1.0 Purpose and Scope: The Reliability Analysis Center (RAC) at Rome Air Development Center will serve as the central Air Force activity for the collection, reduction, analysis and dissemination of reliability data, technical data, application data and procurement information on microelectronic devices. As partial fulfillment of the data input requirements, information generated by microelectronic device manufacturers during both development and production, will be utilized. These guidelines provide details on the type and nature of the data that are desired.

1.1 Proprietary Data -- All furnished data items of a proprietary nature shall be positively identified as such by the source. These items will receive appropriate restrictions in the dissemination to users of RAC.

1.2 Formats -- RAC shall accept source data in the formats in which they are presently available. Primary concern is that furnished data and information contain positive identification and descriptive items as defined in appropriate paragraphs below. This is to insure correct classification within RAC.

1.3 Certification: To enhance credibility, data of the types described herein and furnished to RAC shall contain the signature of an appropriate company officer certifying to its factual completeness and accuracy.

2.0 Sources of Information: There are four major sources of input data of interest to RAC. These include developmental data, fabrication specifications, quality assurance data and performance data.

2.1 Developmental Data -- This source comes from the efforts of research and engineering which results in new designs, technical changes and design improvements. Among the types of technical development reports which are found in this category are the following:

2.1.1 New product developments

2.1.2 Processing improvements

2.1.3 Product changes and improvements

2.1.4 Physics of failure studies and failure acceleration studies.

2.2 Fabrication Specifications -- Among those specifications sought are the following:

2.2.1 Screening Specifications

2.2.2 Processing Specifications

2.2.3 Product Design Specifications

2.2.4 Material Control Specifications

2.2.5 Quality Assurance and Control Specifications

2.3 Performance Data -- This type of data is normally found in highly summarized form in manufacturer's catalogs and application sheets. Suitable input for RAC consists of the detailed graphs, tables and charts which fully describe the capabilities of a device.

2.4 Quality Assurance Data -- Included are data which are generated during quality and reliability evaluations of new product releases and/or as part of the normal company Quality assurance program. It also includes performance studies and special reliability studies to user procurement specifications. Among those items emanating from this source are the following:

2.4.1 Qualification test results

2.4.2 Lot acceptance test results

2.4.3 Failure analysis results, i.e., failure modes and mechanisms.

2.4.4 Screening test results

2.4.5 Reliability data from the following types of tests:

2.4.5.1 Operating high temperature life tests

2.4.5.2 High temperature life storage tests

2.4.5.3 Operating and storage step-stress tests

2.4.6 Environmental test results from the following environmental stresses:

2.4.6.1	Thermal shock
2.4.6.2	Temperature cycling
2.4.6.3	Mechanical Shock
2.4.6.4	Vibration variable frequency
2.4.6.5	Vibration fatigue
2.4.6.6	Constant acceleration
2.4.6.7	Moisture resistance
2.4.6.8	Salt atmosphere/salt spray
2.4.6.9	Humidity
2.4.6.10	Immersion
2.4.6.11	Radiation resistance
2.4.6.12	R. F. Interference
2.4.6.13	Acoustic noise
2.4.6.14	Soldering heat
2.4.6.15	Terminal or lead strength

3.0 Detailed Data Requirements: The desired specific information items for each of the four major sources of input data are described in the following paragraphs.

3.1 Developmental Data Requirements -- Engineering change reports, product evaluation reports and technical directives and other items which document product and process improvements. Information of this nature is important to RAC to help in determining reasons for performance and characteristic changes in a manufacturer's product. Reports received should contain the following information for identification and classification purposes:

3.1.1 A stated purpose of the report including significant items which have effected changes in the performance or characteristics of the product.

3.1.2 Complete identification of the product by device type number, manufacturer's family and process family. If the report deals with an existing device, description can relate to manufacturer's device type in catalog information.

3.1.3 New product developments that do not relate to a manufacturer's current catalog device should include complete device description. Items of description include the following:

a) Logic type or functional description
b) Number of equivalent discrete devices
c) Packaging details
d) Metallization details
e) Isolation method
f) Performance and parameter characteristics
g) Manufacturer's fabrication specifications
h) Manufacturer's assigned identification

3.1.4 Physics of failure and life acceleration studies should include the following types of information:

a) Complete device description
b) History of parts tested such as screening, preconditioning, burn-in, etc.

c) Test details including dates, number of samples, procedures, test conditions, total test hours and who performed test.

d) Failure details include criteria of failure, failure modes, mechanisms and plotted graphs.

e) Conclusions and Recommendations.

3.2 Fabrication Specification Requirements -- These documents guide the manufacturer in the processing of his product. The primary factors of interest are those that affect device performance and reliability. Interest in product design and processing specifications is directed toward the measurable and controllable physical and electrical properties of the item being fabricated in contrast to specific process facility control settings. A few examples of useful design and specification items are:

1) substrate resistivity
2) junction geometry
3) circuit interconnection particulars (layout, material, bonding)
4) surface protection details.

Screening and Quality assurance specifications shall provide details of methods, procedures, inspection plans and acceptance criteria.

3.3 Performance Data Requirements -- Reports which reveal performance capabilities and limitations are normally summarized into the technical data sheets and graphs. This information is useful in design application. To properly identify and classify this data, the following types of information should be known:

3.3.1 Device type number

3.3.2 Device type maximum ratings

3.3.3 Parameter variations versus temperature

3.3.4 Typical device electrical characteristics

3.4 Quality Assurance Data Requirements -- Results of the tests defined in paragraph 2.4 may be furnished in either of two forms; namely,

1) raw variables measurements or,
2) summary data resulting from reduction and analysis of the raw data

Early RAC data acquisition efforts are oriented toward the latter. As its capability expands, greater emphasis will be placed on incorporating raw variables data. The specific data items below define the descriptors that shall accompany either form as well as those summary items of interest (if so reduced).

3.4.1 Complete device identification including type number, family, manufacturer's name and lot number.

3.4.2 Screening, burn-in or other Pre-conditioning procedures performed prior to testing.

3.4.2.1 Results either in raw or summarized form shall be furnished for any such post-production measures performed on salable items and samples designated for further Q A testing.

3.4.3 Type of test conducted (such as qualification or lot acceptance, etc.).

3.4.4 Who performed the test and authorized signature of personnel validating the test report.

3.4.5 Start and completion date of test.

3.4.6 Identification of applicable test specifications and detailed te conditions.

3.4.7 Parameter readout points.

3.4.8 Additional summary Data Items.

3.4.8.1 Failure criteria for each parameter monitored.

3.4.8.2 Number of samples tested, number of samples failed and indication whether test results were acceptable or a failure.

3.4.8.3 Total number of part test hours (life tests).

3.4.8.4 Time to failure of each failed sample (life tests).

3.4.8.5 Failure cause or mechanisms of the failed samples.

3.4.9 The results of any further statistical and graphical analysis performed on test results are also desirable RAC input information. Some pertinent analyses of interest include:

3.4.9.1 Failure rate vs. stress plot

3.4.9.2 Failure rate distributions demonstrating Weibull, exponential, etc.

3.4.9.3 Acceleration factor tables

3.4.9.4 Failure mode and mechanism summaries

3.4.9.5 Circuit parameter drift characteristics versus stress

3.4.9.6 Parameter stability characteristics versus stress

3.4.9.7 Parameter density histogram plot

3.4.9.8 Parameter correlation plot

3.4.9.9 Step stress test summaries

3.4.9.10 Parameter measurement lot history

3.9 Data Input Guidelines for Systems Contractors and Manufacturers

SP-ID-02
1/4/68

Data Input Guidelines for

Equipment Manufacturers and Systems Contractors

1.0 Purpose and Scope: The prime objective is to acquire field microelectronics data from equipment and systems contractors. In support of this objective it will be necessary to acquire certain procurement requirements, test procedures, test reports and failure reports as detailed in the following sections. These documents will be used to provide a firm basis for correlating microelectronic reliability results with device material, design, fabrication, quality assurance and application factors. Specific requests in the following sections outline the detailed requirements.

2.0 Proprietary/Classified Data: All furnished data items of a proprietary or classified nature shall be positively identified as such by the source. These items will receive appropriate restrictions in the dissemination to users of RAC.

3.0 Formats: RAC shall accept source data in the formats in which they are presently available. Primary concern is that furnished data be identified as defined in subsequent sections. This is to insure correct classification within RAC.

4.0 Sources of Information: There are five (5) major sources of input data of interest to RAC. Additional details in the subsequent paragraphs will describe the following information sources:

4.1 Microelectronic Procurement Requirements

4.2 Special Test Procedures

4.3 Special Test Reports

4.4 Failure Analysis Reports

4.5 Device/Count Application Stress Summary

4.1 Microelectronic Procurement Requirements

4.1.1 Purchase Specifications

Item	Example or Explanation
Description	Manufacturer name ________ Name of Device ___________ User Name and No. ________
Systems Application	Operating Requirements, Environmental protection, type application
Cognizant Center	SPO or Contractor
Control Drawing Number	
Fabrication Specification	
Quality Control Procedures	
Screening or Burn-in Specification	
Quality and Reliability Test Specifications	Group A, Group B Test Requirements

4.1.2 Control Drawings

Outline Drawing	Needed only when device is a special non-standard part
Device Description and Construction	" "
Functional Circuit Diagram	" "
Absolute Maximum Ratings	Those ratings (power, freq, temp.) not to be exceeded during testing or operating of device
Electrical Characteristics	All of those applicable to testing or operation of device
Special Test and Measurement Specifications	1. Descriptions, schematics of test and measurements circuits 2. Test equipment, condition and methods requirements 3. Tabulations of inputs and other conditions vs. outputs expected within limitations allowed
Performance Curves	With respect to test conditions required and measurements to be made
Applicable Documents	Mil Specs, Mil Stds. and other documents

4.2 Special Test Procedures

4.2.1 Laboratory Test Procedures at the Part Level

4.2.1.1 Screen and Burn-In Test Procedures

Item	Example or Explanation
Identification	Microcircuit devices covered by this procedure
Screen Test Procedures	Detailed procedures including measurement circuits, environmental conditions, length of tests, acceptance criteria, electrical stresses
Reference Documents	Specifications and Standards

4.2.1.2 Qualification Test Procedures

Item	Example or Explanation
Identification	Microcircuit Devices covered by this procedure
Qualification Test Procedures	Detailed procedures including sample sizes, measurement circuits, environmental conditions, length of tests, acceptance criteria, electrical stresses
Reference Documents	Specifications and Standards

4.2.1.3 Lot Acceptance Test Procedures

Item	Example or Explanation
Identification	Microcircuit Devices covered by this procedure

Lot Acceptance Test	Detailed procedures including sample sizes, measurement circuits, environmental conditions, length of tests, acceptance criteria, electrical stresses, criteria for lot formation
Reference Documents	Specifications and Standards

4.2.1.4 Special Environmental or Life Test Evaluations

Item	Example or Explanation
Identification	Microcircuit Devices covered by this procedure
Evaluation Procedure	Detailed procedures including sample sizes, measurement circuits, environmental conditions, length of tests, acceptance criteria, electrical stresses
Reference Documents	Specifications and Standards

4.2.2 Laboratory Test Procedures at the Equipment Level

4.2.2.1 Laboratory Equipment Test Procedures

Item	Example or Explanation
Identification	Microcircuit devices covered by this procedure, number of each device used in the equipment
Equipment Identification	Assembly name and number. Equipment type and military number. End system designation and program Security Restrictions

Equipment Test Procedures	Detailed procedures including environmental conditions, length of tests, types of test (factory checkout, reliability demonstration, etc.) acceptance criteria, electrical stresses, failure analysis requirements, handling of malfunctions, forms required
Reference Documents	Specifications and Standards as required

4.2.3 Equipment Level Field Test Procedures

4.2.3.1 Field Equipment Test and Usage Procedures

Item	Example or Explanation
Identification	Microcircuit devices covered by this procedure
Field Equipment Test Procedures	Field tests may include ground checkout, acceptance, category tests, etc. In addition, there is regular field operation of the equipment. Procedures for the above test activities and operating usage may include: 1. Approximate description of operating environment 2. Field test operating time period required 3. Recording formats and procedures for time to failure, type of failure, total operating time, responsible parts, part manufacturer, calendar period covered 4. Equipment type designation 5. End system and Program 6. Originating Agency and document number

	7. Security Restrictions 8. Failure analysis procedure and forms needed for each failing item or appropriate reference
Reference Documents	Specifications and Standards as required

4.3 Special Test Reports

4.3.1 Laboratory Test Reports at the Part Level

4.3.1.1 Screen and Burn-In Test Reports

Item	Example or Explanation
Device Identification	
Report Number	
Screen Test Location	Manufacturer's plant location (if applicable)
Cognizant Monitor	Air Force or Contractor
Specific Procurement Source	Sponsor Program Name Application
Applicable Reference Documents for Testing	Identification of: Screen Test Procedures. Specifications and Standards. Pertinent Purchasing Requirements
Screen Test Data	Complete or summary data showing: 1. Quantity of 100% non-destructive tested 2. Quantity of sample destructive tested 3. Failures, modes, and mechanisms detected with quantities or reference to Failure Analysis Report Number

4.3.1.2 Qualification Test Reports

Item	Example or Explanation
Device Identification	
Report Number	

Qualification Test Location	Manufacturer's plant location (if applicable)
Cognizant Monitor	Air Force or Contractor
Specific Procurement Source	Sponsor Program Name Application
Applicable Reference Documents for Testing	Identification of: Qualification Test Procedures Specifications and Standards Special Purchasing Requirements
Qualification Test Data	Complete or summarized data showing: 1) Sample size 2) Number of failures, causes and time to failure 3) Failure analysis including modes and mechanisms or reference to Failure Analysis Report Number

4.3.1.3 Lot Acceptance Test Reports

Item	Example or Explanation
Device Identification	
Report Number	

Lot Identification	Lot number and approximate date of manufacture
Lot Test Location	Manufacturer's plant location (if applicable)
Cognizant Monitor	Air Force or Contractor
Applicable Reference Documents for Testing	Identification of: Lot Acceptance Test Procedures. Specifications and Standards. Special Purchasing Requirements
Lot Acceptance Test Data	Complete or summarized data showing: 1) Sample size 2) Number of failures, causes and time to failure 3) Failure analysis including modes and mechanisms or reference to Failure Analysis Report Number

4.3.1.4 Special Environmental or Life Test Evaluations

Item	Example or Explanation
Device Identification	
Report Number	
Special Test Location	Equipment manufacturer's plant site (if applicable)
Cognizant Monitor	Air Force or Contractor
Specific Procurement Source	Sponsor Program name Application

Applicable Reference Documents for Testing	Identification of: Special evaluation procedures Specifications and Standards Special Purchasing Requirements
Life Test Data and Environmental Test Data	Complete or summarize data showing: 1) Sample size 2) Number of failures. causes, time to failure 3) Reference to Failure Analysis Report No.

4.3.2 Laboratory Test Reports at the Equipment Level

4.3.2.1 Laboratory Equipment Test Reports

Item	Example or Explanation
Device Identification	
Report Number	
Equipment Test Location	Equipment manufacturer's plant site (if applicable)
Equipment Identity Number	
Cognizant Monitor	Air Force or Contractor
Specific Procurement Source	Sponsor Program Name Application
Applicable Reference Documents for Testing	Identification of: Equipment test procedures. Specifications and Standards. Special Purchasing Requirements

Laboratory Equipment Test Data	Complete or summarized data showing: 1) Number of equipments tested 2) Calendar time elapsed and number of operating hours 3) Log of all malfunctions including hours to failure, responsible parts and part manufacturer 4) Failure Analysis Report Number (if any) 5) Number of identical devices per equipment 6) Part operating hours

4.3.3 Field Test Reports at the Equipment Level

4.3.3.1 Field Equipment Test and Usage Reports

Item	Example or Explanation
Device Identification	
Report Number	
Equipment Location	
Equipment Identity Number	
Cognizant Monitor	Air Force or Contractor
Specific Procurement Source	Sponsor Program Name Application
Type of Field Test	Ground Checkout, Acceptance Test, Category Test (if applicable)
Applicable Reference Documents for Testing and Usage	Identification of: Equipment Test Procedures. Specifications and Standards. Special Purchasing Requirements.

Field Equipment Test and Usage Data	Complete or summarized showing: 1) Number of equipments in use 2) Calendar time elapsed and number of operating hours 3) Part operating hours 4) Log of malfunctions including hours to failure, responsible parts and part manufacturer 5) Failure Analysis Report No. (if any) 6) Number of identical devices per equipment

4.4 Failure Analysis Reports

4.4.1 Failure Analysis Reports at the Part Level

Item	Example or Explanation
Device Identification	
Report Number	
Source of Report and Date	Part manufacturers, R & D organization, Air Force Contractor, Subcontractor, or other Government sponsored source
Applicable Test Report Number	Test report describing results, conditions, test data, etc.
Report Data	Investigation and results Supporting references: Test circuits and equipment. Calculations, if required. Photographs Documents and procedures used.
Failure Analysis	Modes and mechanisms, if this can be established
Recommendations	Corrective Action requires changes in: Mfg. Process Physical Hdlg. Other Requalification for changes in: Screening procedures Control dwgs. Fabrication Specifications. Quality Assurance Procedures. Other

4.4.2 Failure Analysis Reports at the Equipment Level

Item	Example or Explanation
Device Identification	
Report Number	
Source of Report and Date	Air Force Contractor, Subcontractor, or other Government Source
Applicable Test Report Number	Test report describing results, conditions, data, etc.
Laboratory Report Data (where applicable)	Investigation and results Supporting references: Test circuits and equipment. Calculations, if required. Photographs Documents and Procedures Used Equipment Programs and sponsor Specific Application Circuit Electrical Operating specifications. Environmental conditions
Field Failure Report Data (where applicable)	In addition to the items listed under Laboratory Report Data are the following: 1) Number of device operating hours to time of failure 2) Total number of identical devices per equipment 3) Total number of equipment operating hours

Failure Analysis	Modes and mechanisms which caused failure, where failure analysis has been performed.
Recommendations	Corrective action requires changes in: Mfg. Processes Physical Hdlg. Installation Application Screening Procedures Control Drwgs Quality Assurance Procedures Other

4.5 Device/Count Application Stress Summary

4.5.1 This summary form is used to provide RAC with military applications of microelectronic devices. It will be useful in conjunction with field failure report data concerning devices named in this summary. Section 3.7 contains a copy of the form with the appropriate completion instructions.

3.10 Device Description

RAC 68-8 (Date of this Letter)

DEVICE DESCRIPTION

INFORMATION REQUEST LETTER

Subject: Information Requirements for the Reliability Analysis Center (RAC)

Dear Mr. ______________:

Within the past few months we have been in contact with you for reliability data on microelectronic devices. In compliance with continuing Air Force requirements, we are seeking descriptions on the attached list of your microelectronic devices. These particular device types are of greatest interest because of accumulated test data on them in our data bank. Further manufacturing details are needed on these devices, however, to establish a firm basis for correlating reliability data with device material, design, fabrication techniques, quality assurance and application factors.

Therefore, I am enclosing a set of three forms to further identify each of your microelectronic device types of greatest interest to us at the present time. Each of the three forms consists of the following information:

1. Family Fabrication Information (Form RAC 68-2) Pertains to the unpackaged chip. An entire family or series of devices possibly may be described in this form.

2. Packaging Information (Form RAC 68-3) Pertains to wire bonding, die bonding, and package configuration. The number of forms to be completed correspond to the numbers of different packages offered by the manufacturer for the device types listed.

3. Individual Circuit Information (Form RAC 68-4) Pertains to circuit configuration, chip layout, screening and testing. This form must be completed for each of the device types listed.

A set of instructions to help interpret some of the items listed in each form is attached.

We recognize that some of the desired information may be of a proprietary nature. Where this is true, we suggest you so indicate in order that RAC may apply proper dissemination controls. However, such information is necessary for internal analyses to validate findings and recommendations.

As we indicated at the time of our initial contacts with you, the Reliability Analysis Center is a continuing effort to provide Air Force users with vitally needed reliability and application information. It is our sincere hope that you will continue to cooperate in this work by completing the enclosed forms. We will greatly appreciate your reply by (2 weeks after typing letter). Please call me at (312) 225-9630, extension 4041 should any questions arise.

Yours very truly,

H. C. Edfors

HCE/pmp
Encls.

Form RAC 68-2

Accession No:______
Page: 1 of 5
Date:______

RELIABILITY ANALYSIS CENTER
MICROELECTRONIC DEVICE DESCRIPTION
FAMILY FABRICATION INFORMATION

1.0 FAMILY IDENTIFICATION

Manufacturer:______________________________
Family Designation:________________________
Applicable Part Numbers:___________________
____
____

2.0 SUBSTRATE MATERIAL

_____Silicon Resistivity:____________
_____Germanium Dopant:____________
Original Wafer Size:____________
Die Size:____________________

3 0 ISOLATION METHOD

_____Junction
_____Resistive
_____Dielectric
___Air
___Oxide
___Nitride
___Carbide
___Ceramic
___Glass

4 0 BURIED LAYER USED

_____No
_____Yes
Sheet Resistance:______________
Dopant:________________

5 0 EPITAXIAL LAYER USED

_____No
_____Yes
Thickness:____________________
Dopant:____________________
Resistivity:____________________
Isolation Diffusion Dopant:________________

6.0 COLLECTOR DIFFUSION USED

___No
___Yes
Sheet Resistance:______________
Dopant:______________
Final Diffusion Depth:______________

7.0 BASE DIFFUSION

Sheet Resistance:______________
Dopant:______________
Final Diffusion Depth:______________

8.0 EMITTER DIFFUSION

Sheet Resistance:______________
Dopant:______________
Final Diffusion Depth:______________

9.0 MOS/MNS DEVICES

9.1 Dielectric Type
___Oxide
___Nitride

9.2 TRANSISTORS (IGFETS)

9.2.1 Operational Mode
___Enhancement
___Depletion
Channel Size:__________
Channel Dopant:__________
Channel Sheet Resistance:__________

9.2.2 Channel Type
___P-Channel
___N-Channel

9.2.3 Source & Drain Diffusion
Sheet Resistance:______________
Dopant:______________
Final Diffusion Depth:______________

TRANSISTORS (IGFETS) (cont'd)

9.2.4 Dielectric Thickness:______________

9.3 MOS/MNS CAPACITORS

9.3.1 Lower Plate Diffusion
Sheet Resistance:______________
Dopant:______________
Final Diffusion Depth:______________

9.3.2 Dielectric Thickness:______________

10.0 SURFACE PASSIVATION
Type
___Oxide
___Nitride
___Other:______________

Thickness (Minimum):______________
Additional Passivation Processes & Materials:
____
____

11.0 INTERCONNECTION METALLIZATION (Bipolar & MOS/MNS Devices)

11.1 Metal(s) Used
Primary Metal
___Aluminum - Thickness:______________
___Gold - Thickness:______________
___Other:__________Thickness__________

Deposition Method
___Vacuum Deposition
___Cathode Sputtering
___Vapor Plating

Secondary Metal(s) Used (wetting agents, etc.)
Specify Metal, Thickness and Deposition Method______________________________
____
____

12.0 FILM DEVICES

12.1 Conductors

Material:________________

Thickness:________________

Sheet Resistance:________________

Deposition Method:________________

12.2 Resistive Elements

Material:________________

Thickness:________________

Sheet Resistance:________________

Deposition Method:________________

12.3 Dielectric

Material:________________

Thickness:________________

Deposition Method:________________

13.0 QUALITY CONTROL CHECKS - Specify method or procedure used to check and/or control the following parameters before sealing the package: (i.e.-Electrical Function: Probing)

13.1 Sheet Resistance:

13.2 Junction Profiles:

13.3 Passivation Thickness:

13.4 Passivation Quality:

QUALITY CONTROL CHECKS (cont'd)

13.5 Device Geometry:

13.6 Ohmic Contacts:

13.7 Electrical Function:

13.8 Metallization Adherence:

13.9 Metallization Thickness:

13.10 Bond Strength:

Form RAC 68-3

Accession No:______
Page: 1 of 2
Date:______

RELIABILITY ANALYSIS CENTER
MICROELECTRONIC DEVICE DESCRIPTION
PACKAGING INFORMATION

1.0 IDENTIFICATION

Manufacturer:____________________
Package Configuration
___Can - Hermetically Sealed
___Flat Pack - Glass
___Flat Pack - Ceramic
___Plastic Encapsulated (other than DIP)
___Dual In Line - Hermetically Sealed
___Dual In Line - Plastic
___Module
Manufacturer's Package Designation:_______________
JEDEC Package Designation:_______________

2.0 DIE BONDING METHOD

2.1 ___Eutectic Alloy Braze
2.2 ___Glass Frit
2.3 ___Solder
2.4 ___Direct
2.4.1 ___Beam Lead
2.4.2 ___Flip Chip
2.4.3 ___Ultrasonic Flip Chip
2.4.4 ___LID
2.5 ___Other:____________________

2.6 Direct Bonding Techniques (if used)

2.6.1 Metallization Material (if metallization is used to connect die to package leads)
___Gold
___Aluminum
___Other:____________________

2.6.2 Direct Bonding Method
___Thermocompression
___Ultrasonic
___Solder Balls

3.0 WIRE BONDING (if used)

3.1 Wire Material
___Gold
___Aluminum
___Other:______________

3.2 Wire Diameter:________________

3.3 Maximum Length Wire Used:_______________

3.4 Bonding Method
___Ball - Thermocompression
___Wedge - Thermocompression
___Stitch - Thermocompression
___Ultrasonic

4.0 SUBSTRATE BONDING (If an insulating substrate is used such as with thin film, multichip, flip chip, and beam lead construction, specify method of bonding substrate to package.)

Form RAC 68-4

Accession No:_______
Page: 1 of 2
Date:_______

RELIABILITY ANALYSIS CENTER
MICROELECTRONIC DEVICE DESCRIPTION
INDIVIDUAL CIRCUIT INFORMATION

1.0 IDENTIFICATION

Manufacturer:____________________
Part Number:____________________
Part Name:____________________
User Name & Part Number:____________________

2.0 FUNCTIONAL PROPERTIES

2.1 Circuit Configuration - (Attach schematics showing ALL circuit components including isolation diodes or isolation regions, zener diodes on IGFET gates, and method of connecting transistors as diodes.)

2.2 Chip Topography - (Attach photograph or scale drawing of top surface of chip showing device layout, interconnection pattern, and bonded wire layout.)

3.0 PROCESSING DETAILS

3.1 Processing Flow Chart (Attach copy of Flow Chart)

(Attach specs and/or details of photolithographic, washing, cleaning, epitaxy, diffusion, metallization and thin/thick film processing steps.)

(Detail Special, Non Standard, processing steps required by user - give user spec number if applicable.)

4.0 POST PRODUCTION SCREENING PROCEDURES

4.1 Test Specification Source:____________________

4.2 Test Specification Number:____________________

Provide either a copy of the specifications (preferable) or detailed conditions of each screening measure used. (i.e., electrical burn in, temperature aging, hermeticity, etc.)

5.0 DESTRUCTIVE TESTS - Indicate any limit or other destructive tests (i.e., Step Stress) that are conducted on each lot as part of Lot Acceptance procedure. State stress type and conditions and whether test vehicles are marketable items, non-functional items, or special test patterns.

6.0 DEVIATIONS FROM STANDARD FAMILY PROCESSING: Specify any deviations from standard family processing (as described in Form RC 68-2) peculiar to this part number, and not otherwise specified.

4.0 DOCUMENT INPUT PROCESSING

4.1 Introduction

The Reliability Analysis Center (RAC) has been established to collect, analyze and disseminate technical information and data on microelectronic device reliability. It places special emphasis on correlating reliability factors with device materials, fabrication, quality assurance and application factors. To carry out these objectives RAC has implemented and inverted the term matrix (Termatrex) system for document storage and retrieval. With this system the various documents under file are indexed according to a detailed set of descriptor terms, devised to provide meaningful access to stored information.

4.1.1 Scope

This section has been prepared to provide detailed guidance for personnel assigned the actual tasks of processing information and data into the file system. It contains (in Section 4.2) an overview of the input document processing operation and defines the responsibilities and general functions of individuals assigned the various tasks. Specific elements and procedural guidelines for performing each of the major tasks are provided in the following two sections. Appropriate forms as employed are included in Section 4.5; instructions for their completion are contained in the corresponding descriptive text.

4.1.2 Manufacturers' Catalogs

Entry procedures for catalogs and other sales literature published by device manufacturers is not within the scope of this procedure. Such documents are considered to be of unique nature and hence do not require the same file and cross-reference control exercised for technical documents. Handling procedures are sufficiently covered in Section 2.0, "System Configuration and Maintenance."

4.2 Document Processing Elements

4.2.1 Process Flow

The sequence and movement of documents and associated items through the input entry process is illustrated in Figure 6. It identifies the principal work elements of each station and indicates how they interface to accomplish the intended entry control function. It is to be understood that items being transferred from a work station are all those that have been operated on at that station, except where deviations are specifically shown.

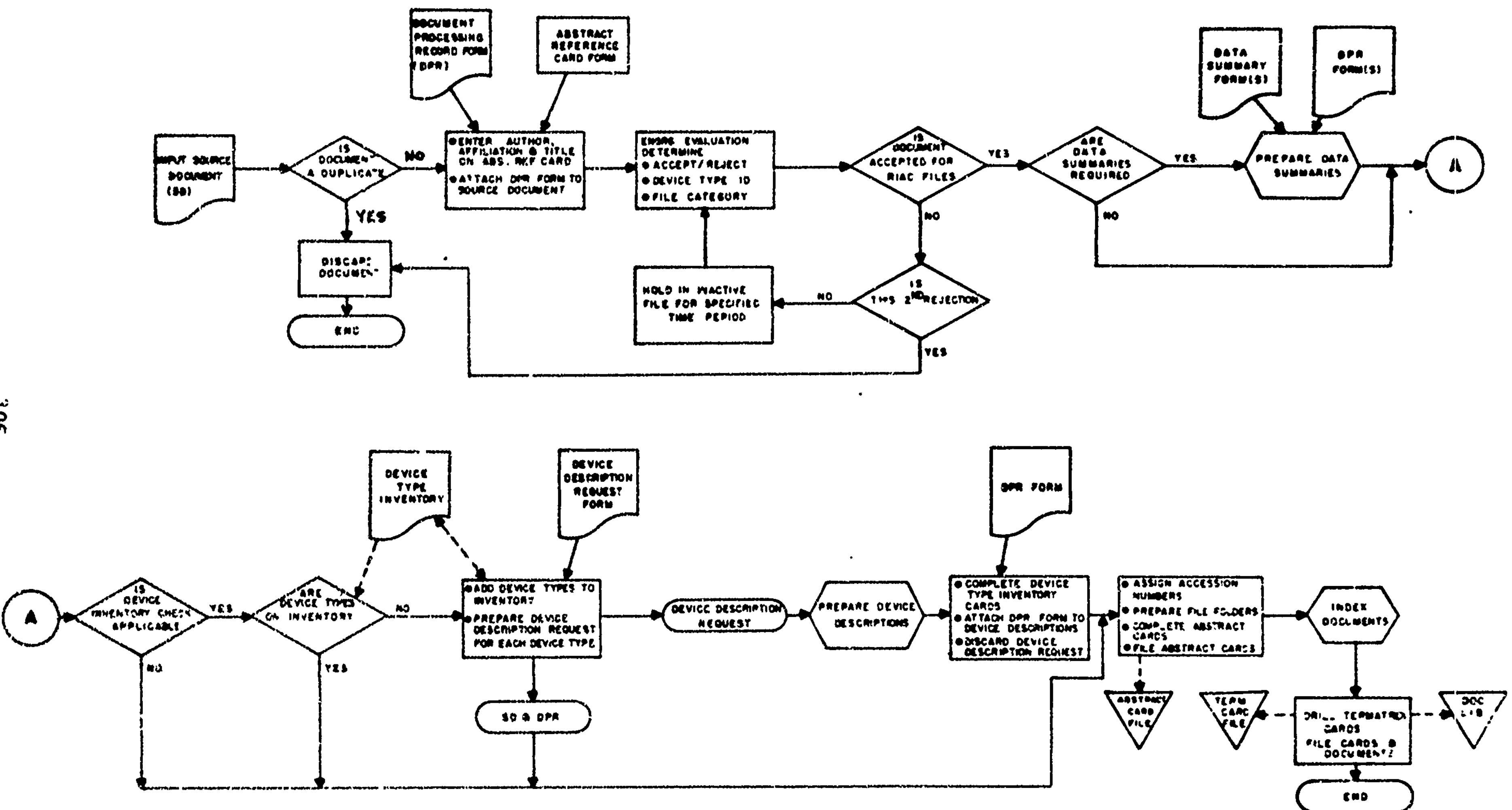


Figure 6. DOCUMENT INPUT PROCESSING PROCEDURE

4.2.2 RAC Document Processing Record

Document processing is controlled by the RAC Document Processing Record (DPR), form number RAC 68-5. This form, attached to each information document as a first step in its processing flow, accompanies it throughout remaining process steps and remains as an active part of the document after filing. The result of each action is indicated by the responsible individual along with his initials and date in the spaces provided.

4.2.3 Processing Steps

4.2.3.1 Source Document Receipt. Upon receipt of each document its personal or corporate author, title and publication date are checked against the Reference Card File by a library technician to ascertain duplication. As an additional check, the AD# is checked against the AD Card File. Duplicate documents are then discarded. If the source document is not a duplicate, a Document Process Record is attached and the receipt date is entered under "Date Initiated." At this time a Reference Card for the document is also initiated by entering the author, his affiliation, document title, AD# and date. Reference Card content and preparation guidelines are contained in Subsection 4.4.2.

Source documents produced under Government Contract (identified by presence of a contract number) require also that a check be made to ascertain whether the document is one of a series of periodic progress reports. (See Subsection 4.4.3 for instructions.)

4.2.3.2 Document Evaluation. The source document with attached DPR form is forwarded to an assigned RAC staff engineer for evaluation. He shall:

1. Determine whether the document merits entry into RAC files. His decision is recorded on the DPR as to accept or reject.

2. If accepted for entry, he shall determine whether the document contains data suitable for reduction into a Data Summary. A check is entered at _____ "Summary Req'd" when applicable as determined by criteria defined in Subsection 4.3.2.

3. Check whether there are any device types identified. If so, he records the applicable device type number(s) and manufacturer(s) in the space provided. Individual numbers are separated by a vertical slash. Should additional space be required, a second sheet may be attached -- this should be so indicated on the DPR.

4. Indicate into which File Category the document is to be filed by checking the appropriate space on the DPR form.

5. Enter his initials and current date in the spaces provided.

NOTE: If the document is rejected, steps 2, 3 and 4 are omitted.

4.2.3.3 Rejected Document Disposal. The engineer returns rejected documents to the library technician whereupon they are held in an inactive file for a six-month period. They are then returned for a second Document Evaluation. Documents again rejected are discarded and removed from further consideration. The partially completed document reference card is marked accordingly but remains on file for reference should the same document enter the system at a later date.

4.2.3.4 Prepare Data Summaries. Data Summaries, when required as noted under "Document Evaluation," are prepared by RAC staff engineers. A separate summary is prepared for each device type/test condition combination reported on in the source document. They are to be prepared in accordance with the instructions outlined in Subsection 4.3.3.

As part of this task, the engineer completes the following items on a separate DPR for each Data Summary and attaches the two together:

1. Checks File Category: "Internal Data Summary"

2. Initials and dates "Summary Complete"

Subsequent to Data Summary preparation, the library technician shall complete the entry of Source Document and Device Description Identifiers as required by Subsection 4.4.4.

4.2.3.5 Device Inventory Updating. Device inventory updating is applicable for source documents where one or more device type numbers are identified under "Document Evaluation." It is not applicable for Data Summaries as any device types included therein have been extracted from a source document.

The task is performed by the library technician by comparing each device type number on the DPR to the Device Type Inventory. Results of the Review are recorded on the DPR by entering 'YES' for types already posted and 'NO' for those not posted. At this time type numbers in the latter group are entered onto the inventory by preparing a Device Type Inventory Card according to the procedure defined in Subsection 4.4.5.

4.2.3.6 Initiate Preparation of Device Description. A Device Description (DD) must be prepared for each device type identified on a Data Summary and for which a Device Description has not been previously prepared. Hence, the library technician must check each Data Summary for a device type and this type must be checked against the Device Type Inventory to see if a DD is on file. If one is not on file, the library technician initiates a Device Description Request for that particular part type number, and enters the date of the Device Description Request on the Device Type Inventory Card as described in Subsection 4.5.2.

4.2.3.7 Prepare Device Description. Upon receipt of the request, the cognizant RAC staff engineer prepares the Device Description from internal and external information sources as defined in Subsection 4.3.4. The library technician completes the Device Description preparation task by duplicating and assembling its several sections, and initiating a DPR for their subsequent processing, as described in paragraph 4.4.6.3. The Device Description Request form has served its purpose and now may be discarded. All the remaining entries to the Device Type Inventory card for the device types of interest are made.

4.2.3.8 Accession Number Assignment and File Preparation. Source documents, Data Summaries, and Device Descriptions with their accompanying DPR's are returned to the library technician to prepare for file entry. The following tasks are performed at this stage:

1. An accession number is assigned in accordance with the designated File Category. (See Table 3 for appropriate accession number sequence assignments.) This number is entered onto the document itself, the DPR, the file folder and abstract reference cards.

2. Prepare file folder. Accession number, author, his affiliation and the document title (partial) are entered on the folder tab.

3. The abstract reference index card in duplicate (partial) is completed and indexed for each document in the RAC library. See Subsection 4.4.2 for abstract reference card preparation instructions.

4.2.3.9 Index Document. Indexing is performed by information science specialists. This task is carried out according to the guidelines of Subsection 4.3.5 using the Thesaurus Term List of Sections 8.0 and 9.0.

Termatrex card identification numbers, corresponding to relevant index terms, are entered as noted on the DPR. Upon completion, the indexer enters his initials and date under "Doc. Indexed."

4.2.3.10 Drill Termatrex Cards. The designated Termatrex cards are drilled in matrix position corresponding to the accession number of the document. This task is performed by library technicians in accordance with Subsection 4.4.8. Upon completion of drilling, the DPR is initialed and dated in appropriate spaces.

Table 3

ACCESSION NUMBER ASSIGNMENTS

Accession Number	Folder	File Category
1-1399	Red Label	Vendor
1400-2899	Blue Label	Journal articles
2900-2999	Turquoise Label	Specs
3000-3399	Orange Label	Proceeding, Symposia Conferences
3400-3999	Coral Label	Bibliography, Surveys and Reviews, Handbook
4000-5599	Green Label	Technical Reports, R/D Reports, etc.
5600-7599	Yellow Label	Test Data
7600-8599	Brown Label	Summary
8600-9999	Brown Label	Device Descriptor

4.2.3.11 File Termatrex Cards and Documents. As a final step in the document entry process the documents are filed by the library technician. Termatrex cards are filed according to color and card number, whereas documents are inserted into the previously prepared folders and placed in project file category in accession number sequence.

4.3 Detail Processing Procedures

4.3.1 Introduction

The previous section defined the essential tasks that are required for processing input documents into RAC files. It dealt with what is done. In this section, each major technically oriented task is treated independently in considerable detail. The emphasis herein is how the task is accomplished. Step-by-step instructions are provided as appropriate. However, due to the variable nature of the documents being operated on, much of the information is presented in guideline form, intended to define the important criteria on which to base the required decisions. A separate subsection is devoted to each task involving technical competence. Those primarily clerical in nature are compiled in Subsection 4.4.

4.3.2 Document Evaluation

4.3.2.1 Scope. An engineering evaluation is performed on each incoming document to establish that its contents represent a worthy addition to the files. This evaluation shall encompass, in addition to screening for part types, the decision as to whether it requires reduction and summarization and the decision of into which File Category it is to be entered.

4.3.2.2 Document Qualification. Document qualification refers to whether the candidate document meets the minimum requirements to be accepted as useful input. This decision is based on the following factors:

Relevance	Subject Investigated
Technical Contribution	Action Reported
	Documentation

In particular, the information contained in the document must be concerned with the subject of current interest, i.e., microelectronics and reliability oriented actions. It must also make a technical contribution to the RAC files. The action reported must be significant, and it must be supported with adequate documentation. Some specific guidelines are given in the following paragraphs.

4.3.2.3 Relevancy. To be useful, the subject of reported actions must be directed toward microelectronic devices or microelectronic technology; that is materials, processes,

techniques, component elements, etc., used in the design and manufacture of microelectronic devices, are applicable subjects. Tests, application or R&D work on specific discrete semiconductor or other electronic devices is not relevant unless they are of such design and construction as may be used on hybrid microelectronics.

Actions that are relevant for RAC purposes are somewhat more difficult to define. Obviously, information must be related to reliability: methodology, research investigations, test and operating procedures, test and operating results, failure analysis procedures and findings, material, process, and design improvement activities and application guidelines all represent relevant activities. It is important for the document to be acceptable, that these reported reliability oriented activities pertain to the subject of microelectronics.

4.3.2.4 Technical Contribution. As noted above to evaluate incoming information for technical contribution, reported action and accompanying documentation must be examined. Several points may be made in regard to the former:

1. The reported action must be meaningful; it should not be so limited in scope such that findings have little chance of extension. Likewise, general treatment of a broad subject is of little value.

2. Investigations and tests shall have been conducted in such a manner that results are credible. Techniques and instrumentation must be consistent with the precision required to assure repeatibility.

3. Where test results are being reported, data shall be accumulated under meaningful, realistic stress conditions, using recognized acceptable procedures.

4. Data shall be current: 1 to 5 years maximum depending on currency of technology and findings involved.

As a minimum, accompanying documentation shall permit positive identification of item or subject under investigation, description of the actions performed, and conditions of data accumulation and identification of the report document itself. Some important items of documentation are:

1. The subject investigated shall be identified by a device type number and manufacturer, or a suitable description of the important properties as guided by the RAC Thesaurus.

2. Period covered by the investigation or, as a minimum, the report date must be given.

3. The document must contain sufficient detail and at a reasonable technical level to be consistent with scientific reporting practices. Many journal articles and manufacturer's marketing oriented "reliability reports" fail this criterion and should be carefully scrutinized.

4.3.2.5 Criteria for Summarization. At this stage it is not necessary to ascertain what kind and how many summaries are to be produced. The evaluation need only establish whether the document is to be summarized.

The purpose of summarizing incoming documents is to simplify preparation and updating of standard tabular products as well as to provide useful backup to the products for interested users. Thus all documents containing reliability test or field usage data and failure analysis results require summarization. Research and development reports ordinarily will not be summarized except if they contain test or failure data.

4.3.2.6 Device Type Identification. The document shall be scrutinized to identify all device types or families as are reported on. Where the subject or item under investigation is identified by descriptors other than type or family number, these are not to be indicated on the DPR.

4.3.2.7 File Category. Relevant File Category types are shown on the DPR form. Determination of proper categorization is self-evident and needs no further clarification.

4.3.3 Data Summary Form Preparation

The data in the source document is to be summarized on Form RAC 68-7A (shown in Section 4.5) in order to facilitate the preparation of the tabular outputs. Essentially, the form requires information on the identification of the source document and device to which the data pertains, the test or usage conditions to which the device was subjected, the mode(s) and mechanism(s) of failures associated with the data, and the statistical data itself.

The numbered boxes on Form RAC 68-7A correspond to numbered columns on the Failure Data Table. The boxes without numbers contain information in addition to that required for output purposes. This additional information supplements the output information in the event that an inquiry about it should be received.

The following describes the procedure to be followed in summarizing the data in a source document using Form RAC 68-7A. Except as noted in the following procedure, this form is to be prepared by a RAC staff engineer. Note the special Data Summary procedure for Government Contract reports described in paragraph 4.3.3.3.

4.3.3.1 Number of Forms Required. A separate summary form will be required for each data entity (i.e., part number/stress domain/stress level combination and the associated test or usage data) reported in the source document. Where identical part number/stress domain/stress level combinations are reported in the same source document (such as the results of identical tests run on two or more lots of the same part number), the data is to be entered on the same form but not merged. If necessary, additional copies of the form can be used in this case.

4.3.3.2 Preparing the Summary. Unless otherwise specified, enter N/A in a box when it is not applicable to data being summarized, and a dash if the information is not available in the source document.

A. Source Document ID

Enter the title and author of the source document in the appropriate boxes. Leave box 18 and "Source Doc. Acc. No." to be completed by the clerical staff as described in Subsection 4.4.4 of this procedure.

B. Device ID

Enter the name of the manufacturer, the part number, and the name (function) of the device (associated with the data being summarized) in the appropriate boxes.

Boxes 1-3 and 11-15 are only to be filled out by the RAC staff engineer when the manufacturer and part number are not given. Otherwise, these boxes are to be filled in by the clerical staff. The values to be entered in these boxes are to be selected from the generic class descriptor value codes appearing at the right side of Table 4.

In box 16, "Special Screen/Burn-In," enter a mnemonically coded description of any special processing, screening, burn-in or quality control procedures (described in the source document) to which the device was subjected prior to the test or usage which generated the data being summarized. This coded

Table 4

GENERIC CLASS DESCRIPTOR VALUE CODES

Term Name	Code
I. Microelectronic Category	MEL CTGY
1. Monolithic Epitaxial	MonEpi
2. Monolithic Diffused	MonDif
3. Monolithic NOC	MonNOC
4. Composite IC Epitaxial	CmpEpi
5. Composite IC Diffused	CmpDif
6. Composite IC NOC	CmpNOC
7. Monolithic IGFET	IGFET
8. Thin Film - Pure IC	ThnFlm
9. Thick Film - Pure IC	ThkFlm
10. Hybrid Microcircuit	Hybrid
11. Multichip Microcircuit	MltChp
II. Functional Category	FCTL CTGY
1. Digital	Dig
2. Linear	Lin
III. Package Configuration	PKG CNFG
1. Can, hermetically sealed	Can
2. Flat Pack, Ceramic	FPkCm
3. Flat Pack, Glass	FPkGl
4. Dual In-Line Hermetically Sealed	DlInL
5. Plastic Encapsulated (Non DIP)	Plstc
6. Dual In-Line, Plastic	DIP
7. Module	Modul
IV. Operational Type	OPRNL TYPE
1. TTL	TTL
2. DTL	DTL
3. CML	CML
4. CTL	CTL

Table 4 - (Continued)

GENERIC CLASS DESCRIPTOR VALUE CODES

Term Name	Code
IV. Operational Type (Cont')	
5. RCTL	RCTL
6. RTL	RTL
7. DCTL	DCTL
8. MOSTL	MOSL
9. NOC (digital or linear)	NOC
10. DIFFERENTIAL LINEAR DEVICE	Diff
11. SINGLE ENDED LINEAR DEVICE	SglE
V. Qualification Class	QUAL CLSS
1. High Reliability Certification	HiRl
2. Military Upgraded	MilU
3. Military	Mil
4. Industrial/Commercial	Ind
5. Consumer	Csmr
VI. Interconnection System	INTRCON SYS
1. Gold-to-Aluminum Wire Bond	AuAlWir
2. Gold-to-Aluminum Direct	AuAlDct
3. Aluminum-to-Aluminum Wire Bond	AlAlWir
4. Aluminum-to-Aluminum Direct	AlAlDct
5. Gold-to-Gold Wire Bond	AuAuWir
6. Gold-to-Gold Direct	AuAuDct
7. Gold-to-Silicon-to-Aluminum Wire Bond	AuSiAlW
VII. Isolation Method	ISLN MTD
1. Junction	Jctn
2. Dielectric, Oxide	DiOx
3. Dielectric, Nitride	DiNt
4. Dielectric, Air (Beam Lead)	DiAr
5. Dielectric, Ceramic	DiCm
6. Dielectric, Glass	DiGl
7. Dielectric, NOC	Diel
8. Resistive	Rstv

Table 4 - (Continued)

GENERIC CLASS DESCRIPTOR VALUE CODES

Term Name	Code
VIII. Circuit Complexity	CKT CPXTY
1. Gate (Logic Gate)	Gate
2. Storage Element	StgEl
3. Multivibrator	Mltvb
4. Arithmetic Functional Unit	ArithU
5. Differential Amplifier	DfAmp
6. Audio Amplifier	AdAmp
7. RF-IF Amplifier	RFAmp
8. Video Amplifier	VdAmp
9. Special NOC	Specl

description must contain a maximum of two lines having a maximum of 16 characters (upper or lower case) each.

In the box labeled "Previous Testing," enter the testing to which the device was subjected (other than normal screening and testing during fabrication) prior to the test or usage which generated the data being summarized.

C. Test/Usage Conditions

Enter the month and year of the test or usage (which generated the data being summarized) in box 17.

In box 4 enter the appropriate code selected from those given under "Data Source Level" in Table 5. The data source level is the level at which the data was observed.

In box 5 enter the code for the particular test type or application environment pertaining to the data being summarized. This code is to be selected from those given in Table 5 under the heading "Test Type/Application Envir." and corresponding to the value selected for "Data Source Level" above.

If testing was performed to a military, NASA or other specification, enter the specification number, paragraph, method, etc., in the box labeled "Test Spec. Ref."

In the box labeled "Stress Level/Equip. Class" enter a complete description of the stress domain(s), level(s), duration(s), step stress increment(s), etc. for each stress applied to the device during use or testing and/or the class of equipment in which the device was used. The appropriate portions of this information must then be coded into the format given in Table 5. The format to be used is the one appearing under the heading "Stress Level/Equip. Class" and directly to the right of the code which was entered in box 5 above.

This coded format consists of either one or two lines with a maximum of 11 characters per line including the units of the stress level.

Table 5

TEST/USAGE CODES

DATA SOURCE LEVEL	TEST TYPE/APPLICATION ENVIR.		STRESS LEVEL/EQUIP. CLASS
Laboratory Life Test (Lab)	Intermittent Life Test	(IntLif)	Amb Temp C %Rated Load % Duty Cycle % Cycle Rate CPM
	Operational, Constant Stress	(OpCnst)	Amb Temp C %Rated Load* %
	Operation, Dynamic	(OpDyn)	Amb Temp C %Rated Load %
	Ring Counter Test	(RngCnt)	Amb Temp C %Rated Load %
	Storage Life	(StgLif)	Ambient Temp C
Laboratory Environmental Test (Env)	Constant Acceleration	(CstAcc)	Max. Accel. G No. Axes AXES
	EM or Particle Radiation	(Rdtn)	Type of Rdtn Energy Level ev Dosage rads
	Immersion	(Immsn)	Max.Bath Temp C NaCl% solute %NaC
	Low Barometric Pressure	(LoPres)	Amb Temp C Gas Pressure psia
	Mechanical Shock	(Mechsk)	Max. Accel. G No. Axes AXES Pulse Duration sec
	Moisture	(Moistr)	Max. Temp C Min. Temp C Rel. Humidity % Humdy
	Radio Freq. Interference	(RFInt)	Frequency Hz Level
	Salt Atmosphere	(SltAtm)	Amb Temp C NaCl % solute % NaCl
	Salt Spray	(SltSpy)	(See Salt Atmosphere)
	Solder Heat	(SldrHt)	Test Spec Method

*Load: Voltage, Power, Fan-out or Current

Table 5 (Continued)

TEST/USAGE CODES

DATA SOURCE LEVEL (Continued)	TEST TYPE/APPLICATION ENVIR.		STRESS LEVEL/EQUIP. CLASS
Laboratory Environmental Test (Env)	Temperature Cycling	(TmpCyc)	[Min. Temp] C/[Max. Temp] C [Dwell, Low] min [Dwell, Hi] min
	Terminal Strength	(TrmStr)	[Test Spec] [Method]
	Thermal Shock	(ThrmSk)	(See Temperature Cycling)
	Vibration Fatigue	(VibFtg)	[Peak Accel.] G [No. Axes] AXES [Min.Freq] Hz/[Max. Freq] Hz
	Vibration Noise	(VbNois)	(See Vibration Fatigue)
	Vibration Random	(VibRdm)	"
	Vibration Variable Freq.	(VbVrFq)	"
Laboratory Step Stress (Stp)	(See entries for Lab & Env, above: all applicable)		
Device Mfr's Screen Test (Scr)	(See entries for Lab & Env)		(See entries associated with Test Types for Lab & Env: all applicable)
Device Mfr's Burn-In Test (Brn)	(See entries for Lab & Env)		(See entries associated with Test Types for Lab & Env: all applicable)

Table 5 (Continued)

TEST/USAGE CODES

DATA SOURCE LEVEL	TEST TYPE/APPLICATION ENVIR.	STRESS LEVEL/EQUIP. CLASS
Equip. Checkout, Factory or On site (Chk)	Aircraft, Airborne, Inhabited (AirInhab)	Combination & other (Combin) Communications (Cmctns) Computation (Comput) Control (Contrl) Instrumentation & Display (IDspy) Navigation (Navgtn) Power Supply (Power) Radar System (Radar) Signal Processing (SgProc) Unspecified (Unspc)
	Aircraft, Airborne, Uninhabited (AirUninh)	(See entries associated with AirInhab)
	Aircraft, Ground Checkout (AcftGChk)	(See entries associated with AirInhab)
	Ground, Fixed Installation (GrndFixd)	(See entries for AirInhab)
	Ground, Laboratory (GrndLbty)	(See entries for AirInhab)
	Ground, Mobile (GrndMobl)	(See entries for AirInhab)
	Ground, Portable (GrndPtbl)	(See entries for AirInhab)

Table 5 (Continued)

TEST/USAGE CODES

DATA SOURCE LEVEL (Continued)	TEST TYPE/APPLICATION ENVIR.		STRESS LEVEL/EQUIP. CLASS
Equip. Checkout, Factory or On Site (Chk)	Missile, Ground Checkout	(MislGChk)	(See entries for AirInhab)
	Missile, Launch & Flight	(MislL&F)	(See entries for AirInhab)
	Shipboard, Submarine	(ShipSubm)	(See entries for AirInhab)
	Shipboard, Surface Vessel	(ShipSurf)	(" " " ")
	Spacecraft, Ground Checkout	(SpcrGChk)	(" " " ")
	Spacecraft, Satellite Launch	(StltLnch)	(" " " ")
	Spacecraft, Satellite Orbit	(StltOrbt)	(" " " ")
	Unspecified Environment	(UnspEnv)	(" " " ")
Equip. Rel. Demonstration or Product Acceptance Test (Rel)	(See entries associated with Chk: all applicable)		(See entries associated with Application Environments for Chk)

Table 5 (Continued)

TEST/USAGE CODES

DATA SOURCE LEVEL	TEST TYPE/APPLICATION ENVIR.	STRESS LEVEL/EQUIP. CLASS
Equip./System Field Test or Use (Fld)	(See entries associated with Chk: all applicable)	(See entries associated wit Application Environments for Chk)
AGREE Test Sequence (AGR)	Device Level Test Type (DevLvl) (Applicable to part level data)	(None)
AGREE Test Sequence (AGR)	Equipment or Application Level (See entries associated with Chk, as applicable)	(See entries associated wit Application Environments for Chk)

Example: for a vibration fatigue test of 1500G peak acceleration in all six axes at a minimum frequency of 500 Hz and a maximum frequency of 10,000 Hz, the coded stresses would be

15000G6AXES
500 Hz/10 kHz

This coded information is to be entered in box 6.

For step stress tests, code each of the stress levels at which a failure occurred, label them A, B, C, etc., to correspond to failure/mode mech information given in boxes 7A, 7B, 7C, etc., and enter them in box 6.

D. Failure Mode/Mechanism Information

Boxes 7, 8 and the box labeled "Time to Failure" are to be used for describing the failure mode and mechanism for each failure being summarized, as well as the number of failures caused by each mode, and the time at which each failure occurred.

In the case of step stress test data, a separate portion of these boxes (A, B, etc.) is to be used to record each stress level/failure mode combination, and the point at which the failure occurred is to be entered in the box labeled "Time to Failure." This point can either be indicated by the number of steps after which the failure occurred or the elapsed test time at which the failure occurred (maximum of 8 characters). These boxes then are to be labeled 10A, 10B, etc., to correspond to 7A and 8A, etc. Then the words "See: Time to Flr" are to be entered in box 10 at the bottom of the page.

For all other types of tests, enter each failure mode in a separate portion of box 7 (e.g., 7A), the number of failures attributed to that mode (4 characters maximum) in a separate portion of box 8 (e.g., 8A corresponding to the flr. mode given in 7A), and the time(s) at which the failure(s) occurred in the box labeled "Time to Failure." For environmental tests, enter an appropriate descriptor of the point in the test at which the failure was detected (e.g., if a failure was detected after 5 cycles of a 10-cycle thermal shock test, enter "5 cycles" in the box).

The information to be given in box 7 should consist of the failure mode, and the results of any failure analysis work performed in terms of the cause of failure, physical defects, and failure phenomena. Keep this entry above the dashed line in the box since the space below this line is reserved for coding the failure mode and mechanism information for the output tabulations.

E. Reliability Data

The actual reliability data being summarized is to be entered in the bottom row of boxes on Form RAC 68-7A. Enter the total number of devices tested or used in box 9 (not to exceed 7 characters). Enter the duration of the test in terms of hours, cycles, etc., as is appropriate for the test being summarized in box 10 (not to exceed 8 characters), except for step stress tests as noted above. Enter the total number of devices which failed during the test or usage being summarized into the box labeled "Total Flrs." This entry should be the sum of the numbers entered in boxes 8A to 8E. Enter the total number of part hours included in life test data or field use data in the box labeled "Total Part Hrs." Enter the upper 60% CL failure rate in percent per thousand hours in the box labeled "Flr. Rate" only when it is given in the source document.

For environmental and other "Go, No-Go" type tests, give the percentage of tested devices found to be defective in the box labeled "% Defective."

4.3.3.3 Procedure for Summarizing Government Contract Reports. Since progress reports on Government contracts sometimes give partial results of tests when the test period overlaps the progress report period, the same data may be repeated in later progress reports or final reports. In order to avoid summarizing the same data twice, a modified procedure for data summarization is required.

If a report is the first in a series of progress reports, it is to be summarized according to the standard procedure described in the previous subsection.

If a report other than the first of a series requires summarization, the previous reports and their Data Summaries are to be extracted from the files before summarizing the new document. The accession numbers of the previous progress reports can be obtained from the DPR of the new document, and

the accession numbers of the Data Summaries for each previous progress report can be obtained from the DPR of each report.

The Data Summaries and the previous reports must then be compared to the new report in order to determine whether the new document reports on the continuation of a test which was previously summarized. This will usually be evident from the test name, the test stresses, the generic descriptors, the report context, etc.

If a continuation of a previously summarized test is reported, a new Data Summary is to be made for the entire test and the previous Data Summary is to be marked "VOID" and attached to the new Data Summary. The new Data Summary replaces the one marked "VOID" and has the same accession number. No additional indexing of the new summary is required.

If the new document does not report on the continuation of a previously summarized test, it can be summarized according to the standard procedure.

4.3.4 Preparation of the Device Description

Preparation of the Device Description is initiated by the library technician each time a new part number is identified in the RAC system. A Device Description Request form (RAC 68-9 shown in Section 4.5) is prepared by the library technician and forwarded to the RAC staff engineer as described in subsection 4.4.5 of this procedure.

Upon receipt of Form RAC 68-9, the RAC staff engineer enters all available part information (from vendor catalogs, etc.) on Form RAC 68-4, and either Form RAC 68-2, RAC 68-3, or both as indicated on the Device Description Request. These forms must then be sent to the device manufacturer along with cover letter Form RAC 68-8, and a copy of "Instructions for Completing Microelectronic Device Description Forms" (shown along with Forms RAC 68-2, 3, and 4 in Section 4.5).

The forms sent, date sent, and the name of the person at the manufacturer's facilities to whom the letter was addressed must be recorded on Form RAC 68-9, and this form is to be filed in a loose-leaf notebook for follow up.

If the forms are not returned within three weeks of the date they were sent, a follow-up contact should be made with the manufacturer. All follow-up contacts should be recorded on RAC 68-9.

Upon the return of the completed forms by the manufacturer, the date of receipt is to be entered on RAC 68-9. Before returning the form(s) to the library technician, the RAC staff engineer must determine the set of generic descriptors for the part number, and write them (in abbreviated form) across the

top of Form RAC 68-4. The forms returned by the manufacturer along with the Device Description Request are then returned to the library technician for processing.

4.3.5 Indexing

4.3.5.1 Introduction. Access to the RAC data files is exclusively through indexed concept descriptors. Thus indexing -- the task of interpreting the essential contents of a document into appropriate descriptor terms -- is the most crucial in the entire document entry process. Yet, it is difficult to convey in procedural terms how one does an effective indexing job.

The task perhaps can be divided into two basic subtasks, one being the mechanics of indexing, and the second, the art of indexing. The former lends itself to procedural discipline. The latter, unfortunately, is amenable to treatment only through generalized statements of objectives and principles. The indexer, for the most part, must gain proficiency in searching out and interpreting important concepts through trial and error experience. The material in this subsection attempts to bring the essential concerns into focus so that the learning process is directed toward the overall program goals and objectives.

4.3.5.2 Index Terms. Every item of information of concern to RAC has three fundamental features or elements, namely:

1) It identifies some physical object that is being investigated. This is usually a microelectronic device or some constituent component of a complete device.

2) The intelligence is conveyed by some vehicle of communication referred to as the document.

3) It contains a description of some event or action carried out in conjunction with the object.

The index term list has been devised around these characteristics and organized in such a manner so as to assure inclusion of terms from each element as a natural result of indexing. The final Term List organization sections are shown below.

OBJECT INVESTIGATED

8.1 Generic Class Descriptors

8.2 Manufacturing Descriptors

8.3 Item Descriptors

COMMUNICATIONS VEHICLE

8.4 Document Descriptors

CONTENT DESCRIPTORS

8.5 Microelectronic Design and Development

8.6 Failure Analysis Studies

8.7 Fabrication Techniques and Equipment

8.8 Specifications

8.9 Reliability Technology

8.10 Part Level Data

8.11 Applications

8.12 Not Otherwise Classified

The complete term list organized as above and a second version, organized alphabetically, is presented in Sections 8.0 and 9.0 respectively.

4.3.5.3 General Indexing Requirements. As a general rule, documents must be indexed with terms from each of the three major elements. Certain exceptions to this rule must be observed, however. Table 6 defines in more detail precisely which class of index descriptors are to be used with each basic document type. Further distinctions are made as to whether the document specifically identifies a microelectronic device type number or whether it merely refers to some component element of a device. The significance of this difference is described below.

Note also that the table itemizes specific index term groupings for the elements Object Investigated and Communications Vehicle but treats Content Descriptors as a single entity. This apparent inconsistency is useful for present purposes to explain the general indexing strategy. Individual Content Descriptor term groupings are of no concern at this level.

4.3.5.3.1 Indexing "Object Investigated" Descriptors. Perhaps the most complex aspect of indexing is the manner in which the physical object being investigated is to be identified and treated. This arises from the fact that, in its simplest form, this object is a "microelectronic device" which can be positively identified by its assigned sales type number. However, RAC must deal not only with information that fails to identify the device type number(s), but also with subelements of the complete device. A further constraint placed on RAC requires that information, disseminated to outside users, is not identified by type numbers but rather by a predefined set of

Table 6

INDEX REQUIREMENT MATRIX

Descriptors To Index \ Object Identi. Level	Document Type: Device Descriptions	Data Summaries		Source Documents	
	Device Type	Device Type	Type Not Ident.	Device Type	Type Not Ident.
Generic Class Descriptors	X	X	X	X	X
Manufacturer	X	X	X	X	X
Device Type Number	X	X		X	
Item Descriptors	X	Note 1	X	Note 1	X
Document Descriptors		X	X	X	X
File Entry Date	X	X	X	X	X
Content Descriptors		X	X	X	X

Note 1. Item Descriptors identified in the document under analysis should be indexed.

"Generic Class Descriptors." A scheme has been devised that allows operation within these constraints yet provides positive identification control. The scheme utilizes four description types as shown in Table 6. They are:

Generic Class Descriptors

Manufacturer (a term from Section 8.2)

Device Type Number (also from Section 8.2)

Item Descriptors

The key to positive identification in this system is the Device Description, which contains the most complete complement of property information that can be acquired for the device. In indexing Device Descriptors, it is absolutely essential that all the above descriptors be indexed as completely as possible. Values must be indexed for each descriptor in the Generic Class, and extra attention should be paid to indexing all applicable Item Descriptor terms. Since the contents of the Device Description have been gathered from several sources and is self-explanatory, it is not necessary to index terms from either the Document Descriptor or Content Descriptor elements. This is reflected in Table 6.

Employment of the device descriptions permits certain indexing liberties, Data Summaries and Source Documents that identify the device type. Referring to Table 6, it is not necessary to index all of the Item Descriptors corresponding to that device type. It is desirable, however, to index those that are explicitly given since they may represent a deviation from the standard part. But, all of the Generic Class Descriptors must be indexed, even though they are not explicitly given in the document. These descriptors are available for index purposes from the Device Type Inventory card file.

Documents that do not identify the device type number are treated differently. First, it is obviously not possible to index the type number. It is therefore important to employ as many other descriptors as possible. Extra effort should be put into obtaining a complete complement of Generic Class Descriptors. Where the document is a Data Summary or where one or more Data Summaries have been produced from the source document in question, the applicable Generic Class Descriptors are itemized on the Data Summary.

The indexer will have to exercise greatest judgment with R&D type documents. They are the least likely to require internal summarization and, at the same time, least likely to identify the device type number. Although diligent effort is to be applied to classify the item thoroughly, caution must be observed to prevent making classifications that do not exist.

4.3.5.3.2 File Entry Date. This descriptor is actually a term contained in the Document Descriptor group. It was brought out in Table 6 to emphasize its purpose and importance.

Standard output products are updated periodically. To facilitate this process, it is desirable to have some mechanism to quickly ferret out those documents from the file that have been entered since the previous updating. The File Entry Date termatrex card set serves this purpose, by denoting the month and year in which each document actually was indexed into the file.

4.3.5.4 Basic Indexing Procedures. The indexer should be familiarized with the document content. This can be done by review of foreword, abstract, table of contents, report summary, conclusion, and major summary charts or figures. Where available, the IITRI generated Data Summary(s) accompanying the document should be reviewed carefully.

The indexer should then make a listing of terms that to him characterize the document. These should answer the questions: What does the document discuss? What research problems are discussed? etc. In order to keep a record of these terms, they should be recorded directly on the document.

The indexer shall now review the concepts he has listed and list any more inclusive terms, synonyms and near-synonyms not appearing in the document but related to the concepts of the document. A review of the system's categorically arranged terms will assist in this procedure.

The indexer shall take his comprehensive concept list and relate this to the alphabetically arranged termatrex term listing (Section 9.0). He will select appropriate terms and record their termatrex code on Form RAC 68-5. He must also select and record appropriate POST ON codings, and the Document Descriptors, such as document type, source, date, etc.

Any concept which cannot be handled by terms already in the termatrex system will be recorded on a 3 x 5 card along with the accession number of the document in which it appeared. These cards will be kept in an alphabetically arranged file and reviewed periodically to determine whether the concept should become part of the system.

4.4 Library Control Tasks

4.4.1 Introduction

This section provides additional procedural guidance for the various auxiliary tasks associated with document entry processing. It concentrates on those tasks which involve preparation and coordination of auxiliary forms and documents generally performed by the library technician. Tasks directly

associated with handling of the documents being processed and accompanying DPR forms are considered adequately covered in Section 4.2 and will not be expanded upon herein. Additionally, familiarization with the description of RAC document files in Section 2.0 of this procedure may prove helpful.

4.4.2 Abstract Reference Card

An Abstract Reference Card is prepared in duplicate (the abstract does not appear on the carbon copy) for each source document accepted for entry into the RAC files.

Card content and typing form for particular document types are described in a separate RAC internal operating procedure, Section 2.0, entitled "System Configuration and Maintenance."

4.4.2.1 Stress Environment Abstracting. Abstract Reference Cards for source documents, which report results of test activities, shall contain as part of or in lieu of a textual abstract, a listing of the stress environments and conditions that have been included in the test program.

Where the test results are included in a formal technical report, a textual abstract is usually included. For this case the abstract is transcribed onto the Abstract Reference Card followed by a listing of the test environments except where they may be included in the abstract itself.

A frequently encountered source document type consists simply of a compilation of test results with little or no accompanying text. For this case only a listing of the pertinent stress environments and conditions is required.

Because of potential misinterpretation difficulties, Stress Environment descriptors should be taken from the appropriate Data Summary documents generated internally from the source documents.

4.4.2.2 Card Preparation and Filing. Abstract Reference Cards are prepared in two steps as denoted by the flow diagram of Figure 6. A minimal set of identification information, including the author and affiliation, document title, ID number and publication date are entered immediately after it has been established that the document is not a duplicate. The cards are then filed in author/affiliation sequence to serve as a reference on documents in the entry process pipeline.

Remaining Abstract Reference Card items including the accession number, abstract and stress environment descriptors are entered just prior to indexing when it is definitely established that the source document will enter RAC active files and the necessary information is available.

Abstract Reference Card originals (those containing the abstract) are filed according to accession number sequence. The second set is filed alphabetically by author and if anonymous, by originating organization.

4.4.3 Handling Government Contract Reports

4.4.3.1 Government Contract Number File. The File of Government Contract Numbers is an alphanumerically organized card file containing one card for each government contract number (i.e. military, NASA, DOD) on which progress reports (i.e. interim, quarterly, etc. and/or final reports) have been received and entered into the RAC system. The document accession numbers, the report period designation ("interim," "first quarterly," etc.) and the contract period covered by the report are also given for each report in the RAC system on each of the above described contract numbers.

4.4.3.2 Government Contract Report Entry Procedure. Each time a unique (nonduplicate) report on a Government contract is received, an abstract reference card is made up for it and a Document Procession Record form is attached to it. The number of the contract (on which the report is written) is to be checked against those given on the file of Government Contract Numbers. If the number does not appear on the file, it is to be added to the list in correct alphanumeric order, along with the report period designation and the contract period covered by the report.

If the contract number already is given on the file, the accession number, report period designation and the reported contract period are to be entered under the number of the contract, and the accession numbers of all other documents in the RAC system on the same contract are to be entered under "COMMENTS" on the DPR form of the document being entered in the RAC system.

If a final report on a Government contract is received and all previous progress reports have been received, the accession numbers of the previous reports are to be entered on the DPR of the final report, and the words "All Reports Received" are to be entered at the bottom of the contract number card.

4.4.4 Completion of Data Summary Form

The clerical tasks described in this subsection correspond to those referred to in Subsection 4.3.3 of this procedure, and deal with the preparation of Form RAC 68-7A of Section 4.5.

The following tasks are to be performed immediately prior to indexing of the Source Documents and Data Summaries.

A. The accession number of the source document is to be entered in the appropriate box.

B. If boxes 1-3 and 11-15 are not complete, enter the coded values for the generic descriptors in the appropriate boxes. The generic descriptor values can be obtained from the Device Description for the manufacturer and part number listed on the form. The codes for these descriptors can be obtained from Table 4. If no part number and manufacturer are given, these boxes must be left incomplete.

4.4.5 Device Type Inventory Updating

There exists no *a priori* Device Type Inventory in the RAC system. Rather, the inventory is developed as devices are identified from newly arriving source documents. Hence, preparation and updating of the inventory is considered as a single function.

The inventory will be in one of three possible states in regard to a new device type number:

a) The family to which the device type belongs has been inventoried, i.e., a "Manufacturer's Family" card containing the device number is on file.

b) The family has not been inventoried.

c) It is not known whether the device type belongs to an inventoried family (user proprietory device or recent release), i.e., the device type has not been previously classified.

The inventory updating activity pursued depends upon the current state. For state "a," updating requires only that a "Device Type" card be completed and placed in the file in correct alphanumeric sequence.

For state "b," it is necessary to prepare both a "Manufacturer's Family" and a "Device Type" card.

A "Device Type" card is completed for state "c" and conditionally filed under "No Family Classification" pending a further investigation to identify the proper family. Once classified to proper family, the card is refiled in correct location.

4.4.5.1 Manufacturer's Family Classification and Card Preparation. In the early stages of document entry and inventory development it is anticipated that numerous device types will be identified which have not as yet been classified according to family. Even under steady-state RAC operation, many newly marketed types will require family classification. The primary information source is the catalog and other sales literature released by the manufacturer. Should this search fail to reveal the correct family, classification must be withheld pending completion of the Device Description form set by the manufacturer as per Subsection 4.3.4.

Once the new family is identified, a "Manufacturer's Family" card must be made up for it. The manufacturer's name, the family designation and the complete complement of family members (device type numbers) is entered onto this card. This card should be completed as soon as information becomes available, either from catalog information or from completed Form RAC 68-2 of the Device Description. If the card is completed from catalog information, it is suggested that it be verified with information from the RAC 68-2 form.

4.4.5.2 Preparation of Device Type Inventory Card. Preparation of the Device Type Inventory card shall be initiated as soon as the inventory check proved negative as indicated in paragraph 4.2.3.5.

Minimal initial entries include:

Device Type Number

Manufacturer

Manufacturer's Family (where known)

Device Name

Date Device Description Request was Initiated (if required)

Electrical Characteristics

The first two items are taken from the applicable DPR form, and the third from the corresponding "Manufacturer's Family" inventory card. Entry date is self-explanatory. Electrical characteristics shall be obtained from the manufacturer's catalog and specification sheets. Where neither is available, a special request must be made to the manufacturer. Nominal or typical parameter values are entered.

Remaining entries, including generic class descriptors, user organization, where applicable, and Device Description completion date are made only for those device types appearing on Data Summary forms. These entries are to be obtained from information given in the Device Description after it has been completed.

4.4.6 Device Description Form Preparation

This subsection describes the clerical duties associated with the preparation of the Device Description. These duties are performed in conjunction with those of the engineer described in Subsection 4.3.4 of this procedure. (See Subsection 4.3.4 for additional background information about the Device Description forms and their file.)

4.4.6.1 Family Check. Upon the identification of a new part number, the library technician is to enter the manufacturer and part number on the Device Description Request (Form RAC 68-9 shown in Section 4.5). At this point the part number must be checked against those listed under each family on the Manufacturer's Family card in the Device Type Inventory in order to determine whether the part is a member of a family for which Form RAC 68-2 is already on file. The technician must then check the appropriate line under "Family Check" on Form RAC 68-9 and enter the number of the family if it is not new.

4.4.6.2 Package Check. Next, the package type must be checked against those given at the front of the Manufacturer's card in the Device Type Inventory. The technician must then check the appropriate line under "Package Check" on Form RAC 68-9 and enter the package type ID.

Form RAC 68-9 must then be forwarded to the cognizant RAC staff engineer for completion (as described in Subsection 4.3.4 of this procedure). The completed forms are then returned to the library technician for processing.

4.4.6.3 Final Device Description Processing. Upon the return of the requested forms and the Device Description Request, the library technician must make copies of Forms RAC 68-2 and 68-3 as indicated on the request. These copies are to be made from the appropriate forms located at the front of the manufacturer's section of the file as described in Section 2.0 of the RAC Internal Operating Procedure.

The new forms must then be assembled with the copies of existing forms and a Document Processing Record prepared for the newly assembled Document Description. DPR preparation is accomplished by entering the current date under "Date Initiated," the Device Type number and manufacturer in proper location and indicating the File Category as "Device Description." The Device Description Request form may now be discarded.

Sufficient information is now available from the completed Device Descriptions to complete the information entries onto the Device Inventory cards as described in paragraph 4.4.5.1.

4.4.7 Accession Number Assignments

An initial sequence of accession numbers from 1 through 9999 have been set aside for assignment to RAC file documents. Subset ranges have been reserved for the various File Categories that have been defined. These are shown in Table 3 which also gives the corresponding document file folder tab color.

The accession number to a particular assignment is made according to the "File Category" indicated on the DPR accompanying the document being processed. Within the correct subset, numbers are assigned sequentially as documents are processed.

4.4.8 Drilling Procedures

Two technicians are required to efficiently and accurately carry out the drilling procedures. One technician reading from the document processing sheet RAC 68-5 calls out the termatrex cards to be drilled. The second technician selects these cards and hands them to the first technician. The first technician then will identify the cards as the second technician checks them against the list on the document processing sheet. The document accession number is set on the drill and verified by the second technician. A "bottom" and "top" card is used for all drillings. Date cverlay cards should be used for all drillings. A maximum of 20 cards should be drilled at one time. After the drilling is complete, the cards are returned to their appropriate color set.

4.5 Referenced Forms

The following referenced forms are herewith included.

RAC 68-2	Microelectronic Device Description Family Fabrication Information
RAC 68-3	Microelectronic Device Description Packaging Information
RAC 68-4	Microelectronic Device Description Individual Circuit Information
	Termatrex Indexing & Coding Sheet
RAC 68-5	RAC Document Processing Record
RAC 68-7A	Data Summary Form
RAC 68-9	Device Description Request

Form RAC 68-2

Accession No:______
Page: 1 of 5
Date:______

RELIABILITY ANALYSIS CENTER
MICROELECTRONIC DEVICE DESCRIPTION
FAMILY FABRICATION INFORMATION

1.0 FAMILY IDENTIFICATION

Manufacturer:______________________________
Family Designation:________________________
Applicable Part Numbers:___________________
____
____

2.0 SUBSTRATE MATERIAL

_____Silicon Resistivity:____________
_____Germanium Dopant:____________
Original Wafer Size:____________
Die Size:____________________

3.0 ISOLATION METHOD

_____Junction
_____Resistive
_____Dielectric
___Air
___Oxide
___Nitride
___Carbide
___Ceramic
___Glass

4 0 BURIED LAYER USED

_____No
_____Yes
Sheet Resistance:_______________
Dopant:________________

5 0 EPITAXIAL LAYER USED

_____No
_____Yes
Thickness:____________________
Dopant:____________________
Resistivity:____________________
Isolation Diffusion Dopant:_________________

6.0 COLLECTOR DIFFUSION USED

___No
___Yes
Sheet Resistance:______________
Dopant:______________
Final Diffusion Depth:______________

7.0 BASE DIFFUSION

Sheet Resistance:______________
Dopant:______________
Final Diffusion Depth:______________

8.0 EMITTER DIFFUSION

Sheet Resistance:______________
Dopant:______________
Final Diffusion Depth:______________

9 0 MOS/MNS DEVICES

9.1 Dielectric Type
___Oxide
___Nitride

9.2 TRANSISTORS (IGFETS)

9 2.1 Operational Mode
___Enhancement
___Depletion
Channel Size:__________
Channel Dopant:__________
Channel Sheet Resistance:__________

9.2.2 Channel Type
___P-Channel
___N-Channel

9.2.3 Source & Drain Diffusion
Sheet Resistance:______________
Dopant:______________
Final Diffusion Depth:______________

TRANSISTORS (IGFETS) (cont'd)

9.2.4 Dielectric Thickness:______________

9.3 MOS/MNS CAPACITORS

9.3.1 Lower Plate Diffusion
Sheet Resistance:______________
Dopant:______________
Final Diffusion Depth:______________

9.3.2 Dielectric Thickness:______________

10.0 SURFACE PASSIVATION
Type
___Oxide
___Nitride
___Other:______________

Thickness (Minimum):______________
Additional Passivation Processes & Materials:
____
____

11.0 INTERCONNECTION METALLIZATION (Bipolar & MOS/MNS Devices)

11.1 Metal(s) Used
Primary Metal
___Aluminum - Thickness:______________
___Gold - Thickness:______________
___Other:__________Thickness__________

Deposition Method
___Vacuum Deposition
___Cathode Sputtering
___Vapor Plating

Secondary Metal(s) Used (wetting agents, etc.)
Specify Metal, Thickness and Deposition Method______________________________
____
____

12.0 FILM DEVICES

12.1 Conductors

Material:________________

Thickness:________________

Sheet Resistance:________________

Deposition Method:________________

12.2 Resistive Elements

Material:________________

Thickness:________________

Sheet Resistance:________________

Deposition Method:________________

12.3 Dielectric

Material:________________

Thickness:________________

Deposition Method:________________

13.0 QUALITY CONTROL CHECKS - Specify method or procedure used to check and/or control the following parameters before sealing the package: (i.e.-Electrical Function: Probing)

13.1 Sheet Resistance:

13.2 Junction Profiles:

13.3 Passivation Thickness:

13.4 Passivation Quality:

QUALITY CONTROL CHECKS (cont'd)

13.5 Device Geometry:

13.6 Ohmic Contacts:

13.7 Electrical Function:

13.8 Metallization Adherence:

13.9 Metallization Thickness:

13.10 Bond Strength:

Form RAC 68-3

Accession No:______
Page: 1 of 2
Date:______

RELIABILITY ANALYSIS CENTER
MICROELECTRONIC DEVICE DESCRIPTION
PACKAGING INFORMATION

1.0 IDENTIFICATION

Manufacturer:____________________
Package Configuration
___Can - Hermetically Sealed
___Flat Pack - Glass
___Flat Pack - Ceramic
___Plastic Encapsulated (other than DIP)
___Dual In Line - Hermetically Sealed
___Dual In Line - Plastic
___Module
Manufacturer's Package Designation:______________
JEDEC Package Designation:______________

2.0 DIE BONDING METHOD

2.1 ___Eutectic Alloy Braze
2.2 ___Glass Frit
2.3 ___Solder
2.4 ___Direct
2.4.1 ___Beam Lead
2.4.2 ___Flip Chip
2.4.3 ___Ultrasonic Flip Chip
2.4.4 ___LID
2.5 ___Other:____________________

2.6 Direct Bonding Techniques (if used)

2.6.1 Metallization Material (if metallization is used to connect die to package leads)
___Gold
___Aluminum
___Other:____________________

2.6.2 Direct Bonding Method
___Thermocompression
___Ultrasonic
___Solder Balls

3.0 WIRE BONDING (if used)

3.1 Wire Material
___Gold
___Aluminum
___Other:______________

3.2 Wire Diameter:__ ____________

3.3 Maximum Length Wire Used:______________

3.4 Bonding Method
___Ball - Thermocompression
___Wedge - Thermocompression
___Stitch - Thermocompression
___Ultrasonic

4.0 SUBSTRATE BONDING (If an insulating substrate is used such as with thin film, multichip, flip chip, and beam lead construction, specify method of bonding substrate to package.)

Form RAC 68-4

Accession No:_______
Page: 1 of 2
Date:_______

RELIABILITY ANALYSIS CENTER
MICROELECTRONIC DEVICE DESCRIPTION
INDIVIDUAL CIRCUIT INFORMATION

1.0 IDENTIFICATION

Manufacturer:____________________
Part Number:_____________________
Part Name:_______________________
User Name & Part Number:____________________

2.0 FUNCTIONAL PROPERTIES

2.1 Circuit Configuration - (Attach schematics showing ALL circuit components including isolation diodes or isolation regions, zener diodes on IGFET gates, and method of connecting transistors as diodes.)

2.2 Chip Topography - (Attach photograph or scale drawing of top surface of chip showing device layout, interconnection pattern, and bonded wire layout.)

3.0 PROCESSING DETAILS

3.1 Processing Flow Chart (Attach copy of Flow Chart)

(Attach specs and/or details of photolithographic, washing, cleaning, epitaxy, diffusion, metallization and thin/thick film processing steps.)

(Detail Special, Non Standard, processing steps required by user - give user spec number if applicable.)

4.0 POST PRODUCTION SCREENING PROCEDURES

4.1 Test Specification Source:______________________

4.2 Test Specification Number:______________________

Provide either a copy of the specifications (preferable) or detailed conditions of each screening measure used. (i.e., electrical burn in, temperature aging, hermeticity, etc.)

5.0 DESTRUCTIVE TESTS - Indicate any limit or other destructive tests (i.e., Step Stress) that are conducted on each lot as part of Lot Acceptance procedure. State stress type and conditions and whether test vehicles are marketable items, non-functional items, or special test patterns.

6.0 DEVIATIONS FROM STANDARD FAMILY PROCESSING: Specify any deviations from standard family processing (as described in Form RAC 68-2) peculiar to this part number, and not otherwise specified.

RAC Document Acc. No._______

Date_______

TERMATREX INDEXING & CODING SHEET

Indexer_______

Red I		Red II		Grey I		Black I		Black II		Green I		Green II	
00	50	00	50	00	50	00	50	00	50	00	50	00	50
01	51	01	51	01	51	01	51	01	51	01	51	01	51
02	52	02	52	02	52	02	52	02	52	02	52	02	52
03	53	03	53	03	53	03	53	03	53	03	53	03	53
04	54	04	54	04	54	04	54	04	54	04	54	04	54
05	55	05	55	05	55	05	55	05	55	05	55	05	55
06	56	06	56	06	56	06	56	06	56	06	56	06	56
07	57	07	57	07	57	07	57	07	57	07	57	07	57
08	58	08	58	08	58	08	58	08	58	08	58	08	58
09	59	09	59	09	59	09	59	09	59	09	59	09	59
10	60	10	60	10	60	10	60	10	60	10	60	10	60
11	61	11	61	11	61	11	61	11	61	11	61	11	61
12	62	12	62	12	62	12	62	12	62	12	62	12	62
13	63	13	63	13	63	13	63	13	63	13	63	13	63
14	64	14	64	14	64	14	64	14	64	14	64	14	64
15	65	15	65	15	65	15	65	15	65	15	65	15	65
16	66	16	66	16	66	16	66	16	66	16	66	16	66
17	67	17	67	17	67	17	67	17	67	17	67	17	67
18	68	18	68	18	68	18	68	18	68	18	68	18	68
19	69	19	69	19	69	19	69	19	69	19	69	19	69
20	70	20	70	20	70	20	70	20	70	20	70	20	70
21	71	21	71	21	71	21	71	21	71	21	71	21	71
22	72	22	72	22	72	22	72	22	72	22	72	22	72
23	73	23	73	23	73	23	73	23	73	23	73	23	73
24	74	24	74	24	74	24	74	24	74	24	74	24	74
25	75	25	75	25	75	25	75	25	75	25	75	25	75
26	76	26	76	26	76	26	76	26	76	26	76	26	76
27	77	27	77	27	77	27	77	27	77	27	77	27	77
28	78	28	78	28	78	28	78	28	78	28	78	28	78
29	79	29	79	29	79	29	79	29	79	29	79	29	79
30	80	30	80	30	80	30	80	30	80	30	80	30	80
31	81	31	81	31	81	31	81	31	81	31	81	31	81
32	82	32	82	32	82	32	82	32	82	32	82	32	82
33	83	33	83	33	83	33	83	33	83	33	83	33	83
34	84	34	84	34	84	34	84	34	84	34	84	34	84
35	85	35	85	35	85	35	85	35	85	35	85	35	85
36	86	36	86	36	86	36	86	36	86	36	86	36	86
37	87	37	87	37	87	37	87	37	87	37	87	37	87
38	88	38	88	38	88	38	88	38	88	38	88	38	88
39	89	39	89	39	89	39	89	39	89	39	89	39	89
40	90	40	90	40	90	40	90	40	90	40	90	40	90
41	91	41	91	41	91	41	91	41	91	41	91	41	91
42	92	42	92	42	92	42	92	42	92	42	92	42	92
43	93	43	93	43	93	43	93	43	93	43	93	43	93
44	94	44	94	44	94	44	94	44	94	44	94	44	94
45	95	45	95	45	95	45	95	45	95	45	95	45	95
46	96	46	96	46	96	46	96	46	96	46	96	46	96
47	97	47	97	47	97	47	97	47	97	47	97	47	97
48	98	48	98	48	98	48	98	48	98	48	98	48	98
49	99	49	99	49	99	49	99	49	99	49	99	49	99

Side 1

RAC Document Acc. No.______

Date________

TERMATREX INDEXING & CODING SHEET

Indexer________

White I		Blue I		Sand I		Purple I		Orange I		Yellow I	
00	50	00	50	00	50	00	50	00	50	00	50
01	51	01	51	01	51	01	51	01	51	01	51
02	52	02	52	02	52	02	52	02	52	02	52
03	53	03	53	03	53	03	53	03	53	03	53
04	54	04	54	04	54	04	54	04	54	04	54
05	55	05	55	05	55	05	55	05	55	05	55
06	56	06	56	06	56	06	56	06	56	06	56
07	57	07	57	07	57	07	57	07	57	07	57
08	58	08	58	08	58	08	58	08	58	08	58
09	59	09	59	09	59	09	59	09	59	09	59
10	60	10	60	10	60	10	60	10	60	10	60
11	61	11	61	11	61	11	61	11	61	11	61
12	62	12	62	12	62	12	62	12	62	12	62
13	63	13	63	13	63	13	63	13	63	13	63
14	64	14	64	14	64	14	64	14	64	14	64
15	65	15	65	15	65	15	65	15	65	15	65
16	66	16	66	16	66	16	66	16	66	16	66
17	67	17	67	17	67	17	67	17	67	17	67
18	68	18	68	18	68	18	68	18	68	18	68
19	69	19	69	19	69	19	69	19	69	19	69
20	70	20	70	20	70	20	70	20	70	20	70
21	71	21	71	21	71	21	71	21	71	21	71
22	72	22	72	22	72	22	72	22	72	22	72
23	73	23	73	23	73	23	73	23	73	23	73
24	74	24	74	24	74	24	74	24	74	24	74
25	75	25	75	25	75	25	75	25	75	25	75
26	76	26	76	26	76	26	76	26	76	26	76
27	77	27	77	27	77	27	77	27	77	27	77
28	78	28	78	28	78	28	78	28	78	28	78
29	79	29	79	29	79	29	79	29	79	29	79
30	80	30	80	30	80	30	80	30	80	30	80
31	81	31	81	31	81	31	81	31	81	31	81
32	82	32	82	32	82	32	82	32	82	32	82
33	83	33	83	33	83	33	83	33	83	33	83
34	84	34	84	34	84	34	84	34	84	34	84
35	85	35	85	35	85	35	85	35	85	35	85
36	86	36	86	36	86	36	86	36	86	36	86
37	87	37	87	37	87	37	87	37	87	37	87
38	88	38	88	38	88	38	88	38	88	38	88
39	89	39	89	39	89	39	89	39	89	39	89
40	90	40	90	40	90	40	90	40	90	40	90
41	91	41	91	41	91	41	91	41	91	41	91
42	92	42	92	42	92	42	92	42	92	42	92
43	93	43	93	43	93	43	93	43	93	43	93
44	94	44	94	44	94	44	94	44	94	44	94
45	95	45	95	45	95	45	95	45	95	45	95
46	96	46	96	46	96	46	96	46	96	46	96
47	97	47	97	47	97	47	97	47	97	47	97
48	98	48	98	48	98	48	98	48	98	48	98
49	99	49	99	49	99	49	99	49	99	49	99

Side 2

Form RAC 68-5

RAC DOCUMENT PROCESSING RECORD

Date Initiated ____________ Doc. Acc. No.__________

ENGINEERING EVALUATION

____Accepted ____Rejected ____Summary Required ____Initial ______Date

Summary Acc. #'s

DEVICE TYPE INVENTORY

Type #'s ____

Mfgr. ____

Posted ____

FILE CATEGORY

____Test/Usage Data ____R/D Rept. ____Spec. ____Proceedings, etc.

____Vendor ____J. '. icle ____Biblio., Survey, etc.

____Internal Data Summary ____Device Description

Summaries Compl. ____Initial ______Date

Doc. Indexed ____Initial ______Date Drilled ____Initial ______Date

SUPPLEMENTAL INDEX TERMS

`OMMENTS

DATA SUMMARY DATE PREPARED ___/___/___ BY _______ | 18. ACC. NO.

FORM RAC 68-7A

SOURCE DOCUMENT TITLE	AUTHOR & AFFILIATION	SOURCE DOC. ACC. NO.

DEVICE MFGR & PART NO.	1. MEL CTGY	2. FCTL CTGY	3. PKG CONFIG	11. OPRNL TYPE
PART NAME (FUNCTION)	12. QUAL CLASS	13. INTERCON SYS.	14. ISOLATION MTD	15. CKT CPXTY

16. SPECIAL SCREEN/BURN-IN	PREVIOUS TESTING

17. DTA DATE	4. DTA SRC LVL	5. TEST TYPE/APP. ENV.	TEST SPEC REF

STRESS LEVEL/EQUIP. CLASS	6. CODED STRS LVL/EQ CLS.

FLR MODE/MECH	FLRS DUE TO MODE	TIME TO FLR
7A. FLR MODE/MECH CODED FORM	8A. FLRS DUE TO MODE	TIME TO FLR
7B. FLR MODE/MECH CODED FORM	8B. FLRS DUE TO MODE	TIME TO FLR
7C. FLR MODE/MECH CODED FORM	8C. FLRS DUE TO MODE	TIME TO FLR
7D. FLR MODE/MECH CODED FORM	8D. FLRS DUE TO MODE	TIME TO FLR
7E. FLR MODE/MECH CODED FORM	8E. FLRS DUE TO MODE	TIME TO FLR

9. NO. TESTED	10. TEST DURATION	TOTAL FLRS.	TOTAL PART HRS.	FLR RATE	% DEFECTIVE

Form RAC 68-9

DEVICE DESCRIPTION REQUEST

DEVICE MANUFACTURER: ________________________________

DEVICE PART NUMBER: ________________

FAMILY CHECK

___NEW FAMILY - FORM RAC 68-2 REQ'D

___MEMBER OF EXISTING FAMILY - REPRODUCE FORM RAC 68-2, FAMILY #__________

PACKAGE CHECK

___NEW PACKAGE TYPE - FORM RAC 68-3 REQ'D, PKG TYPE______

___EXISTING PACKAGE TYPE - REPRODUCE FORM RAC 68-3, PKG TYPE __________

FORMS SENT OUT

___RAC 68-2 ___RAC 68-3 ___ RAC 68-4

DATE SENT: ______________ TO ATT. OF: ________________

FOLLOW UP: LIST DATE, CONTACT, AND RESULT

FORMS RECEIVED

___RAC 68-2 DATE______________

___RAC 68-3 DATE______________

___RAC 68-4 DATE______________

PROCESSING OF FORMS

___REQUIRED FORMS REPRODUCED

___ALL FORMS ASSEMBLED AND DPR PREPARED

___FORMS ENTERED INTO SYSTEM

5.0 FILE SEARCH AND OUTPUT PROCESSING

5.1 Introduction

This Section describes the responsibilities and procedures associated with preparation of central output intelligence. Procedures are defined for preparing regularly scheduled periodic publications as well as those produced on a less regular basis, such as monographs and responses to ad hoc user queries. Where required, output formats have been designed and internal working forms devised to assure uniformity of methodology and presentation.

5.2 Accessing the Termatrex File

A file search is initiated by consulting one or both of the system term lists (structured-Section 8.0, alphabetical-Section 9.0) to identify the appropriate Termatrex cards to be employed in the search. The RAC engineering analyst desiring information from the files (searcher) must review the term lists in conjunction with the library technician to structure the search logic; that is, describe the manner in which selected Termatrex cards are to be combined and sequenced for viewing. Search requests coming from individuals not having access to the official term lists are to be reviewed and structured by RAC personnel before the search is initiated.

The generalized search strategy is illustrated in Figure 7. The preliminary aspects of problem definition and Termatrex card selection discussed above are indicated. The file search strategy itself is an iterative process with the search being broadened if too few or no suitable file documents are identified and narrowed for the opposite situation.

The Termatrex system gives instantaneous feedback. This allows the search to browse the system by viewing selected cards on the lightbox. In general, it is best to begin with the broad aspect of the question and narrow the field dependent upon the number of source documents identified. Narrowing of the field is done by adding more specific terms to the search. However, should the descriptor most important to the searcher be an infrequently used term (that is, only a small number of file documents were indexed with this term) the search should begin with this term.

A record shall be made of search question and terms used for the search, as well as the results of the search. These records assist in the vocabulary control and future development of the system. Terms referred to frequently during a search may require further subdivision in order to obtain more specific information. A search question repeated frequently and resulting in no answer indicates an area where more information should be sought for the system.

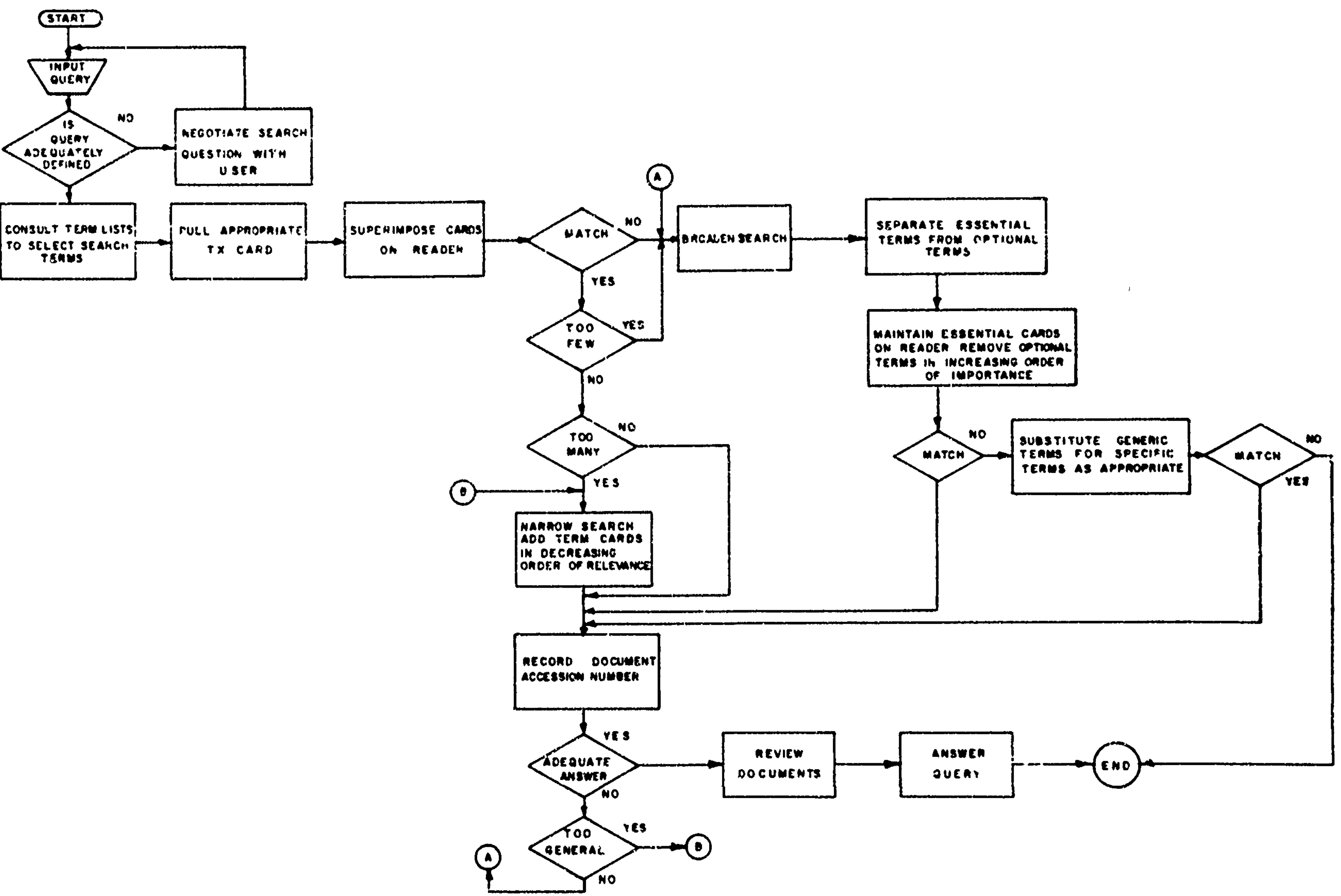


Figure 7. SEARCH STRATEGY

5.3 Periodic Products

There are three fairly standardized RAC output products that will be updated and published at regular intervals. They are:

Reliability Analysis Center Bibliography Listing

Microelectronic Failure Data Tabulation

Microelectronic Failure Rate Tabulation

The first is a listing of all source documents in the active RAC information files at the time of issuance. It is organized according to fairly broad subject categories to assist outside users in document selection.

The latter two products contain, as indicated by their title, information and data entries in tabular form. The MICROELECTRONIC FAILURE DATA table is an unmerged listing of test/usage experience wherein failure modes have been reported. The MICROELECTRONIC FAILURE RATE table presents failure rates merged according to certain upper level generic class descriptors and common stress environments. The procedural tasks of file search, retrieval and document sorting for these two tabular products are essentially identical. Both utilize the DATA SUMMARY as its primary information source. For efficiency then, it is recommended that the two products be prepared and/or updated at the same time. That is, once the documents for a particular device generic class are retrieved from the file, the necessary information items for updating both products should be extracted. The operating procedures described in the following paragraphs are defined accordingly.

5.3.1 Bibliography Listings

Bibliography listings are prepared directly from ABSTRACT REFERENCE CARDS. The listing is organized according to broad subject categories. Within each category, individual title entries are put in alphabetical order according to personal or corporate author. Since a particular document may contain information on several of the subject categories selected, a given document title may be repeated in two or more categories.

5.3.1.1 Subject Categories

Table 7 lists the subject categories into which the Bibliography listing will be organized. Presentation order of the various categories shall be as shown on this table.

Table 7

BIBLIOGRAPHY SUBJECT CATEGORIES

Subject Name	Termatrex Card(s)
Circuit/Device Design & Development	SD(60), SD(71)
Circuit/Device Theory	SD(0)
Fabrication Techniques	W(0)
Failure Analysis Studies	P(0)
Part Level Data	Y(0)
Reliability Data-Application Level	OR(72)
Reliability Techniques	OR(0)
Application Design Considerations	OR(35), OR(79)
Vendor Application Data	OR(87)
Proceedings-Symposia, Conference, etc.	BL(56)
Surveys and Technical Reviews	BL(59)
Specifications	BL(58)
Bibliographies	BL(50)
Not Otherwise Classified	- -

5.3.1.2 Entry Content and Listing Order

Each entry shall contain the following information items in essentially the form shown.

Personal or Corporate Author (Research Facility)

Report or Document Title, Report Number,
Work period covered, total number of pages or
cited pages, where published, publication date,
contract number, AD and/or N number, RAC
Accession Number.

In addition, entries in the "Part Level Data" and "Reliability Data, Applications" categories are to contain a listing of the tests performed or application environment as it appears on the ABSTRACT REFERENCE CARD.

All entries on the output listing are to be transcribed exactly as they appear on the ABSTRACT REFERENCE CARD.

Entries are presented on the output listing alphabetically according to Personal or Corporate Author. All anonymous entries are listed alphabetically according to Corporate Author ahead of titles where the personal author is named.

5.3.1.3 General Format

The bibliography listing shall be typed onto 8½" x 11" bond or other material suitable for reproduction. It is to be incorporated within a cover of appropriate design and lettering. A table of contents follows. It itemizes the subject categories and correct page locations.

The first page of the main body listing shall contain the following header items, positioned approximately as shown.

FILE BIBLIOGRAPHY RELIABILITY ANALYSIS CENTER

[Subject Category Name] Issue Date: Page:

Subsequent pages shall contain the Subject Category Name, Issue Date and Page Number. Item entry information is typed single spaced with double spacing between successive entries.

5.3.1.4 Preparation Procedure Detail

The listing is prepared according to the following itemized procedure.

a) Accession numbers for the first Subject Categories are identified with the appropriate Termatrex (Tx) card(s). The correct card(s) for each Subject Category appears in right-hand column of Table 7. Where more than one Tx card is shown, the search is made as logical OR, that is accession numbers are identified for each individually. Of course, common accessions are listed only once.

b) The corresponding ABSTRACT REFERENCE CARDS are withdrawn from the file desk.

c) Sort by Personal Author; where author is anonymous, sort by Corporate Author and place these cards at front of deck.

d) Type specified content according to specifications of paragraphs 5.3.1.2 and 5.3.1.3 above.

e) Replace ABSTRACT REFERENCE CARDS in file deck and repeat process with the next Subject Category. Note the same cards (document titles) may be used in more than one Subject Category.

f) Those cards (document titles) that are not used in <u>any</u> Subject Category must be identified and listed under "Not Otherwise Classified."

5.3.1.5 Updating

The Bibliography listing is to be updated to reflect current file status and reissued at regularly scheduled intervals: a modification of the above procedure is recommended for this updating task. The essential elements of the modified procedure are:

a) A copy of the latest issue of the Bibliography is maintained as a working copy.

b) Deletions: as the file is purged of obsolete documents, the working copy is corrected by striking out the obsolete entry titles. Be sure each is deleted from each Subject Category.

c) Identifying File Additions: It is necessary to identify those accession numbers that have entered the file since the previous update cycle. This is accomplished by using the FILE ENTRY DATE Tx cards, for the period of interest, one at a time over the "Subject Category" cards during file search.

d) The ABSTRACT REFERENCE CARDS for new file additions are sorted as above.

e) The correct position of each title is indicated on the Bibliography working copy of some convenient means, i.e., marking on the accession number.

f) As the new listing is typed, previous entries are transcribed from the working copy and new entries from the corresponding ABSTRACT REFERENCE CARD.

5.3.2 Tabular Products

The MICROCIRCUIT FAILURE DATA table and the MICROCIRCUIT FAILURE RATES table are periodic standard RAC output products. In general, output entries are organized according to generic device descriptors and stress identifiers. Output formats appear in Section 5.7. They are:

Form RAC 68-10 MICROCIRCUIT FAILURE DATA

Form RAC 68-11 MICROCIRCUIT FAILURE RATES

Column and table header item names are numbered on the forms to facilitate entry of data values by non-technically oriented personnel. For both products, these entry values are obtained entirely from the DATA SUMMARY, making it unnecessary to extract information from source documents when preparing the outputs.

Specific instructions for carrying out the various task elements are given in the following paragraphs.

5.3.2.1 Table Organization

5.3.2.1.1 Microcircuit Failure Data Table

Primary organization is according to three Generic Class Descriptors:

Microelectronic Category

Functional Category, and

Package Configuration

Together they delineate the tabulation into discrete sections. Although line entries for a particular set of values for these descriptors may encompass more than one page, a new page is initiated for each unique combination of values. Hierarchial priority is according to above listing order; value iterations are exhausted for lower priority descriptors before progressing to the next level. Table body entries are further organized according to the following stress descriptors listed according to hierarchial priority:

Data Source Level

Test Type/Application Environment

Stress Level/Equipment Class

As above, descriptor value iterations are done in reverse order of priority level.

Value entries for both device (generic class) and stress descriptors shall be ordered according to the predetermined hierarchy of Tables 8 and 9. Although Table 8 includes values for all generic class descriptors, only the three indicated above are of interest for the FAILURE DATA table. The remaining generic class descriptors on this output have no bearing on entry listing order.

Stress levels are ordered in ascending order of magnitude. Where the stress level is denoted with two parameters, i.e., temperature and percent rated load, that parameter listed first has higher priority. That is, all values of the lower priority parameter are iterated, until they are exhausted while keeping higher level values constant. Since there is to be a separate line entry for each applicable test entity, the exact stress level as reported is entered in coded form.

5.3.2.1.2 Microcircuit Failure Rates Table

A single generic descriptor Microelectronic Category is employed to delineate major table sections. As above, a new page is initiated for each value change of this descriptor. Sections are ordered according to the hierarchy of values shown in Table 8.

Line entries, organized according to the following eight descriptors, are shown in the order of priority ranks.

Table 8

GENERIC CLASS DESCRIPTOR VALUE HIERARCHY

TERM NAME	CODE
I. Microelectronic Category	MEL CTGY
1. Monolithic Epitaxial	MonEpi
2. Monolithic Diffused	MonDif
3. Monolithic NOC	MonNoc
4. Composite IC Epitaxial	CmpEpi
5. Composite IC Diffused	CmpDif
6. Composite IC NOC	CmpNOC
7. Monolithic IGFET	IGFET
8. Thin Film - Pure IC	ThnFlm
9. Thick Film - Pure IC	ThkFlm
10. Hybrid Microcircuit	Hybrid
11. Multichip Microcircuit	MltChp
II. Functional Category	FCTL CTGY
1. Digital	Dig
2. Linear	Lin
III. Package Configuration	PKG CNFG
1. Can, hermetically sealed	Can
2. Flat Pack, Ceramic	FPkCm
3. Flat Pack, Glass	FPkGl
4. Dual In-Line Hermetically Sealed	DlInL
5. Plastic Encapsulated (Non DIP)	Plstc
6. Dual In-Line, Plastic	DIP
7. Module	Modul
IV. Operational Type	OPRNL TYPE
1. TTL	TTL
2. DTL	DTL
3. CML	CML
4. CTL	CTL

Table 8 (Continued)

GENERIC CLASS DESCRIPTOR VALUE HIERARCHY

	TERM NAME	CODE
IV.	Operational Type (Cont')	
5.	RCTL	RCTI
6.	RTL	RTL
7.	DCTL	DCTL
8.	MOSTL	MOSL
9.	NOC (digital or linear)	NOC
10.	DIFFERENTIAL LINEAR DEVICE	Diff
11.	SINGLE ENDED LINEAR DEVICE	SglE
V.	Qualification Class	QUAL CLSS
1.	High Reliability Certification	HiRl
2.	Military Upgraded	MilU
3.	Military	Mil
4.	Industrial/Commercial	Ind
5.	Consumer	Csmr
VI.	Interconnection System	INTRCON SYS
1.	Gold-to-Aluminum Wire Bond	AuAlWir
2.	Gold-to-Aluminum Direct	AuAlDct
3.	Aluminum-to-Aluminum Wire Bond	AlAlWir
4.	Aluminum-to-Aluminum Direct	AlAlDct
5.	Gold-to-Gold Wire Bond	AuAuWir
6.	Gold-to-Gold Direct	AuAuDct
7.	Gold-to-Silicon-to-Aluminum Wire Bond	AuSiAlW
VII.	Isolation Method	ISLN MTD
1.	Junction	Jctn
2.	Dielectric, Oxide	DiOx
3.	Dielectric, Nitride	DiNt
4.	Dielectric, Air (Beam Lead)	DiAr
5.	Dielectric, Ceramic	DiCm
6.	Dielectric, Glass	DiGl
7.	Dielectric, NOC	Diel
8.	Resistive	Rstv

Table 8 (Continued)

GENERIC CLASS DESCRIPTOR VALUE HIERARCHY

TERM NAME	CODE
VIII. Circuit Complexity	CKT CPXTY
1. Gate (Logic Gate)	Gate
2. Storage Element	StgEl
3. Multivibrator	Mltvb
4. Arithmetic Functional Unit	ArithU
5. Differential Amplifier	DfAmp
6. Audio Amplifier	AdAmp
7. RF-IF Amplifier	RFAmp
8. Video Amplifier	VdAmp
9. Special NOC	Specl

Table 9

STRESS DESCRIPTOR VALUE OUTPUT LISTING HIERARCHY

DTA SRC LVL	TST TYP/ APP ENV	STRS LVL/ EQP CLASS
1. Lab	1. StgLif 2. OpCnst 3. OpDyn 4. RngCnt 5. IntLif	NOTE 1. Value are entered in the order of increasing magnitudes, at a given TST TYP/APP ENV value and a prior specification of STRS LVL/ EQP CLASS value.
2. Env	1. ThrmSk 2. TmpCyc 3. SldrHt 4. MechSk 5. VbNois 6. VibRdm 7. VbVrFq 8. VibFtg 9. CstAcc 10. TrmStr 11. Moistr 12. Immsn 13. SltAtm 14. SltSpy 15. LoPres 16. RFInt 17. Rdtn	(See NOTE 1)
3. Stp	NOTE 2. Entries are ranked the same as respectively listed in above combined order.	(See NOTE 1)
4. Scr	(See NOTE 2)	(See NOTE 1)

Table 9 (Continued)

STRESS DESCRIPTOR VALUE OUTPUT LISTING HIERARCHY

DTA SRC LVL	TST TYP/ APP ENV	STRS LVL/ EQP CLASS
5. Brn	(See NOTE 2)	(See NOTE 1)
6. AGR	1. DevLvl	(No entries)
7. APR (Application Level)	1. GrndLbty	1. Cmctns 2. SgProc 3. Comput 4. Navgtn 5. IDspy 6. Contrl 7. Radar 8. Power 9. Combin 10. Unspc
	2. GrndFixd	NOTE 3. Entries and ordering are identical to those associated with GrndLbty.
	3. GrndMobl	(See NOTE 3)
	4. GrndPtbl	(See NOTE 3)
	5. ShipSurf	(See NOTE 3)
	6. ShipSubm	(See NOTE 3)
	7. AcftGChk	(See NOTE 3)
	8. AirInhab	(See NOTE 3)
	9. AirUnInh	(See NOTE 3)

Table 9 (Continued)

STRESS DESCRIPTOR VALUE OUTPUT LISTING HIERARCHY

DTA SRC LVL	TST TYP/ APP ENV	STRS LVL/ EQP CLASS
(Cont'd: 7. APP)	10. MislGChk	(See NOTE 3)
	11. MislL&F	(See NOTE 3)
	12. SpcrGChk	(See NOTE 3)
	13. StltLnch	(See NOTE 3)
	14. StltOrbt	(See NOTE 3)
	15. UnspEnv	(See NOTE 3)
8. Chk	NOTE 4. Entries and ordering are identical to those associated with 7. APP.	(See NOTE 3)
9. Rel	(See NOTE 4)	(See NOTE 3)
10. Fld	(See NOTE 4)	(See NOTE 3)

Functional Category

Package Configuration

Operational Category

Qualification Class

Interconnection System

Data Source Level

Test Type/Application Environment

Stress Level/Equipment Class

Within each descriptor group, values are to be ordered on the output according to the hierarchy of Tables 8 and 9 completely exhausting all values of the lowest priority descriptor before iterating at the next higher level. Notice on Table 9, not all of the stress condition values are applicable to the Failure Rates table. Also, Tables 10 and 11 are provided to indicate "equivalent" stress level groupings and their entry order as required for merging part level life test data. Further application of these tables is described in paragraph 5.3.2.3 below.

5.3.2.2 File Search Strategy

Since both tables are organized at their highest level according to three common generic device descriptors, it is convenient to make a single file search (for each unique set of generic descriptor values) to extract DATA SUMMARIES which might be used for either or both tables. The file search thus identifies all DATA SUMMARIES complying with these three descriptor terms. Further classification of individual DATA SUMMARIES by remaining generic device descriptors and stress descriptors is performed manually by reviewing DATA SUMMARY content directly, as will be described below.

The search is performed using Termatrex card BL(54) (IITRI Generated Data Summary) in conjunction with three generic descriptor value cards; one from the values under Microelectronic Category; one from the values under Functional Category, and one from the values under Package Configuration. The initial search is performed using the highest priority value from each descriptor.

After the DATA SUMMARIES resulting from the search have been processed as described below, the search is repeated replacing the Package Configuration value card with the next value appearing in the hierarchy. This process is to be repeated (and the DATA SUMMARIES are to be processed) until all values under

Package Configuration have been exhausted. Then the Functional Category value card is to be replaced with the next value in the hierarchy and the search is to be repeated until all values under Functional Category have been used in conjunction with all values under Package Configuration. Then the Microelectronic Category value card is replaced with the next value in the hierarchy and the search is to be repeated until all values under this level have been used in conjunction with all values under the two levels below it.

5.3.2.2.1 Unused Summaries

Because some DATA SUMMARIES do not have the three required generic descriptor values identified, they will not have met the search criteria and will not have been included in the tabulations at this point.

These SUMMARIES can be identified as those which have not been checked off on the list of DATA SUMMARY accession numbers. They are to be extracted from the files and each is to be evaluated as to its usefulness for the tabulations. Those DATA SUMMARIES deemed useful must then be organized, processed and entered at the end of the tabulations in order of the hierarchy of generic descriptor values and stresses as described above.

5.3.2.3 Temperature & Electrical Stress Levels

As noted previously, device level test reports generally contain fairly precise statements of applied conditions. To maximize the usefulness of output information of the FAILURE RATE table, it is desirable to segment the range of possible severity values into a manageable number of discrete groups. This approach avoids treating each variation as a separate and distinct test/inspection condition. Of particular concern are the stresses associated with laboratory life tests from which data for this table is derived. These are generally temperature and applied electrical load, which may be power, voltage or current. Since it is difficult with microelectronic circuits to positively determine the distribution of stress among different device elements, RAC will simply treat the electrical stress in terms of "electrical load." Handling of these stress severity conditions is outlined in the following paragraphs.

5.3.2.3.1 Temperature Conditions

Severity values for temperature are generally grouped within intervals of 10 to 25 degrees (^{o}C) in width. A reported temperature value, T, falls within a given class interval when:

$$T_L \leq T < T_u ,$$

where T_L and T_u are respectively the lower bound and upper bound values of the interval. All values within this class are then represented by a nominal value essentially at the midpoint of the class interval. A table of nominal values with corresponding class intervals to be used in combining data appears in Table 10. It is expected that most reported data will be generated under a small number of standard test/inspection temperature conditions. However, a full range is provided to take care of non-standard situations.

Should temperature values lie outside the range covered in this table, class grouping and severity representation are handled as follows:

1. High Temperature - the temperature class table is effectively extended in increments of 25 degrees (^oC). Each new class is accordingly represented by a nominal temperature at the midpoint of the interval bounds.

2. Low Temperature - severity levels below (more negative than) the lowest bound of the temperature class table are not grouped into segmented intervals. Each discrete condition is treated as a distinct temperature level.

5.3.2.3.2 Electrical Severity Conditions

Severity values for electrical load stress are classified in terms of percent relative to the rated value.

If V_L and V_u are respectively the lower bound and upper bound of relative values of a given class interval, then, this group includes the relative value V when:

$$V_L \leq V < V_u, \text{ for } V_L > 0$$

When applied electrical stress is zero (0), it is not associated with a class interval but is treated as a distinct severity level.

All reported electrical stress values within the class interval are represented by a nominal value essentially at the interval midpoint. Table 11 defines applicable nominal values and corresponding class intervals for the most commonly encountered range. The table of class intervals may be extended as required by increments of 25 percent to become inclusive of the extreme value. This relative value is represented by a class nominal severity at the midpoint of its interval bounds.

Table 10

TEMPERATURE STRESS LEVEL CLASSIFICATION

(VALUES IN °C)

CLASS NOMINAL	LOWER BOUND	UPPER BOUND (> INTERVAL VALUES)	INTERVAL WIDTH
-90°C	-100	-80	20
-70	- 80	-62.5	17.5
-55	- 62.5	-47.5	15
-40	- 47.5	-32.5	15
-25	- 32.5	-17.5	15
-10	- 17.5	- 5	12.5
0	- 5	7.5	12.5
15	7.5	20	12.5
25	20	30	10
35	30	42.5	12.5
50	42.5	57.5	15
65	57.5	75	17.5
85	75	92.5	17.5
100	92.5	112.5	20
125	112.5	137.5	25
150	137.5	162.5	25
175	162.5	187.5	25
200	187.5	212.5	25
225	212.5	237.5	25
250	237.5	262.5	25
275	262.5	287.5	25
300	287.5	312.5	25
325	312.5	337.5	25
350	337.5	362.5	25

Table 11

NORMALIZED ELECTRICAL LOAD STRESS LEVEL CLASSIFICATION
(VALUES IN %)

CLASS NOMINAL	LOWER BOUND	UPPER BOUND (> INTERVAL VALUES)	INTERVAL WIDTH
0%	0	0	
10	>0	17.5	17.5
25	17.5	32.5	15
40	32.5	45	12.5
50	45	57.5	12.5
65	57.5	70	12.5
75	70	82.5	12.5
90	82.5	95	12.5
100	95	105	10
115	105	122.5	17.5
130	122.5	140	17.5
150	140	162.5	22.5
175	162.5	187.5	25
200	187.5	212.5	25

Frequently, electrical stress is reported in absolute magnitude, necessitating normalization to percent rated prior to classification. This is computed as:

$$\text{Rel. Value in \%} = \frac{\text{TEST CONDITION VALUE}}{\text{RATED VALUE}} \times 100$$

where: TEST CONDITION VALUE is that value of stress level reported by the test data source.

RATED VALUE is the device rating for the corresponding stress domain (voltage, current or power).

A supplementary search of the library files may be required to locate the desired rating. A first source is the DEVICE TYPE INVENTORY CARD. If it is incomplete, vendor catalog or specification sheets should be consulted.

5.3.2.4 Table Preparation Procedures

The procedures described herein utilize the concept of "batch" processing. A batch is defined as that set of DATA SUMMARIES extracted from the files as the result of a single search on the three generic device descriptors as described in the preceding section. Further, both tabular products are to be produced on a given batch prior to initiating processing of the next batch.

For efficiency of operations, it is recommended that the processing for the FAILURE RATE table be undertaken first. Step-by-step processing instructions for each tabular product are described separately in the following sections.

5.3.2.4.1 Failure Rate Table

a) The FAILURE RATE table contains data only from life tests and application usage reports, hence as a first step, non-applicable DATA SUMMARIES are sorted out.

b) The remaining DATA SUMMARIES are sorted according to Operational Category, Qualification Class, Interconnection System, Data Source Level, Test Type/Application Environment, and Stress Level/Equipment Class descriptor values.

   1) Consult Tables 10 and 11 for temperature and electrical life test stress level grouping criteria. DATA SUMMARIES having stress levels falling

within the range of a given nominal value are considered for output purposes as having the nominal value of applied stress, hence they are equivalent.

2) Each unique combination of descriptor values for which one or more DATA SUMMARY is present are henceforth treated as independent sub-batches. Except for certain special cases as described later, each sub-batch represents a single line entry of output.

c) A single FAILURE RATE WORKSHEET, form RAC 68-12 (see Section 5.7), is completed by the analyst for each sub-batch. This form contains space for each entry to be made on the MICROCIRCUIT FAILURE RATE form, RAC 68-11, cross-referenced by entry number.

d) The information entered into the numbered boxes on the RAC 68-12 form must be in coded form (except for MICROELECTRONIC CATEGORY) exactly as they are to appear on the output tabulation. This is to ensure accuracy in presentation as transcription (typing) is performed by clerical personnel. Actually, most entries are already in coded form on the DATA SUMMARY. Temperature and electrical load stress values entered onto the form are the nominal figures from Tables 10 and 11, respectively.

e) The accession number, number tested (n_i), total part hours (T_i), number of failures (r_i), and best estimate failure rate ($\hat{\lambda}$) for each DATA SUMMARY in the sub-batch are listed in the spaces provided.

1) $\hat{\lambda}_i = r_i/T_i$. If r_i for the particular test entity is zero (0), $\hat{\lambda}$ cannot be computed.

2) Should more space be required, continue entries in some format on a second blank page attached to the worksheet.

f) The $\hat{\lambda}$ values in the last column should be checked for consistency. Since devices and stress conditions for all tests were similar, results should fall within approximately an order of magnitude from the next closest value. If not, the homogeneity test described in Section 3.6 should be applied.

1) If the hypothesis of equivalence is rejected, the deviating entry or entries should be segregated out and outputed as separate line entries.

g) Compute $T_T = \sum_{i=1}^{m} T_i$, $R_T = \sum_{i=1}^{m} r_i$ & $n_T = \sum_{i=1}^{m} n_i$

and record the values in the boxes provided at the bottom of each column.

h) Compute df = $2(R_T + 1)$ and enter value on worksheet.

i) Locate χ^2 value from Table 12 for df and enter value onto worksheet.

j) Compute $\lambda 0.60 = \frac{\chi^2}{2T_T}$ and enter value onto worksheet.

note: proper mathematical form of this expression is

$$\lambda 0.60 = \frac{\chi^2 \Big|^{0.60}_{2(R_T + 1)}}{2T_T}$$

k) The DATA SUMMARIES in the sub-batch are reviewed for failure mode information. Significant reported modes are entered onto the worksheet in exact form for output presentation. The total failure count attributed to each mode is also recorded.

l) Each sub-batch is processed in the same manner, then all DATA SUMMARIES for the batch are reassembled with those sorted out and held for preparation of the FAILURE DATA table.

m) Upon completion of all batches, the worksheets are sorted as described in paragraph 5.3.2.1.2 above and submitted for typing onto the output format.

5.3.2.4.2 Updating the Failure Rate Table

This product is periodically updated by deleting obsolete data and incorporating data acquired since the previous processing.

Table 12

PERCENTILES OF THE χ^2 DISTRIBUTION FOR $(1-\alpha) = 60\%$

df	χ^2 % POINT	df	χ^2 % POINT
1	0.708	46	47.8
2	1.83	48	49.8
3	2.95	50	51.9
4	4.04	52	53.9
5	5.13	54	56.0
6	6.21	56	58.0
7	7.28	58	60.1
8	8.35	60	62.1
9	9.41	62	64.2
10	10.5	64	66.2
12	12.6	66	68.3
14	14.7	68	70.3
16	16.8	70	72.4
18	18.9	72	74.4
20	21.0	74	76.4
22	23.0	76	78.5
24	25.1	78	80.5
26	27.2	80	82.6
28	29.2	82	84.6
30	31.3	84	86.6
[illegible]2	33.4	86	88.7
34	35.4	88	90.7
36	37.5	90	92.8
38	39.6	92	94.8
40	41.6	94	96.8
42	43.7	96	98.9
44	45.7	98	100.9
		100	102.9

For large values of degrees of freedom the approximate formula

$$\chi_{\alpha}^{2} = n \left(1 - \frac{2}{9n} + z_{\alpha} \sqrt{2/9n} \right)^{3}$$

where z_{α} is the normal deviate and n is the number of degrees of freedom, may be used.

The key element in correlating previous data figures to the present is the worksheet. All worksheets are maintained on file and become an integral item of the update process. The essential steps are:

a) A record is kept of DATA SUMMARY accession numbers that have been obsoleted during the period of interest. As a first step in the updating process, each obsoleted DATA SUMMARY is extracted from the file and matched by generic device and stress descriptor values to its correct worksheet. The accession number entry on the worksheet serves as positive identification. This entry is encircled in red and the corresponding (Ti) and (ri) values are subtracted from the totals and the new figures prominently indicated in red.

b) To isolate DATA SUMMARY accessions that have been <u>added</u> since previous processing, the FILE ENTRY DATE Tx cards, for the period of interest, are used in conjunction with the generic class cards during the file search.

c) The DATA SUMMARIES resulting from this search are sorted as described in instructions (a) and (b) of paragraph 5.3.2.4.1 above, and each sub-batch is matched to its corresponding worksheet from the previous update cycle.

d) Initiate a new worksheet by entering required descriptive items according to instruction (d) of paragraph 5.3.2.4.1.

e) Enter under "Previous Totals" the correct totals for each column from the corresponding worksheet of the previous update cycle. Attach the old worksheet(s) to the latest one for reference purposes.

f) Enter the data values from the new DATA SUMMARIES and complete the worksheet per instructions of paragraph 5.3.2.4.1 above.

5.3.2.4.3 <u>Preparing the Failure Rate Table Output Format</u>

Upon completion of all analysis and computations as described above, the individual worksheets are ordered in preparation for typing in accordance with the organization previously described.

The information is entered onto the output format, Form RAC 68-11, by typing a line entry for each worksheet entity. Worksheet entries are correlated to its correct table column by number. These entries must be transcribed onto the output format exactly as they appear on the worksheet.

Line entries are made in the order that worksheets are sorted. Successive entries within a particular "Microelectronic Category" are double spaced, continuing onto additional pages as required. An "Entry number" is typed into the first column of the table. These numbers are assigned in consecutive sequential order from 1 to (m), when (m) is the total number of line entries in the current issue of the tabulation.

A separate page is initiated for each unique "Microelectronic Category." The typist enters, at the top of each page in spaces provided, the correct "Microelectronic Category" and "Issue Date" as they appear on worksheet. Each sheet of output is assigned a page number. These numbers are in consecutive order from 1 to (n) where (n) is the total number of pages in the current issue of the FAILURE RATES tabulation.

5.3.2.4.4 Failure Data Table

Upon completion of data processing for the FAILURE RATES tabulation, all the DATA SUMMARIES extracted from the search (one batch) are assembled for use in preparation of the FAILURE DATA tabulation. Since the FAILURE DATA table is only concerned with data which identifies failure modes, those DATA SUMMARIES in which failure modes are not identified are sorted out.

The DATA SUMMARIES remaining after the above sorting are then organized according to the hierarchy of Data Source Level, Test Type/Application Environment and Stress Level/Equipment Class, as described in a previous paragraph. No other processing of the information is required in preparation for transcription to the output format.

5.3.2.4.5 Updating the Failure Data Table

As noted in previous paragraphs on FAILURE RATE table preparation, only DATA SUMMARIES entered into the file since the previous update cycle will be extracted during current file search. These new items or entries must be correctly interspersed among the entries appearing on the previous issue of the FAILURE DATA tabulation. This may be accomplished by marking the front of each DATA SUMMARY to be added with its proper position on the

listing, keying to the line "Entry No." For example, if a new entry is to be made between existing "Entry Nos." (4) and (5), the notation (4A) is prominently marked on the particular DATA SUMMARY. Should more than one new entry be required between a single pair of "Entry Nos.," the DATA SUMMARIES are marked as 4A, 4B, 4C, etc.

5.3.2.4.6 Preparing the Failure Data Table Output Format

The entries are typed onto output format, Form RAC 68-10 directly from the DATA SUMMARY. Each DATA SUMMARY represents one line entry, with entries ordered according to the order in which they have been sorted by the analyst. Successive entries are double spaced continuing onto additional pages as required.

Frequently more than one failure mode (entries 7A, 7B, 7C, etc.) is reported in a single DATA SUMMARY. Each of these items is listed on a separate line with single line spacing. A corresponding entry will appear as item 8A, 8B, etc. on the DATA SUMMARY which must be typed into column 8 of the output format. All other columns are to remain blank and this "entry set" is to be treated as a single line "Entry No." (see below for assignment of line "Entry Nos.").

A new page is initiated for each unique set of "Microelectronic Category," "Functional Category" and "Package Configuration" values.

Entries are typed onto the output format exactly as they appear on the DATA SUMMARY using the item number to key DATA SUMMARY values to their correct column. The line "Entry No." assigned consecutively from 1 to m, is typed into the first column.

Each page is completed by typing in appropriate Header items including issue date and page number. The latter are assigned sequentially for the entire listing.

When updating a previously issued FAILURE DATA tabulation, the typist must refer the previously issued listing in conjunction with the new DATA SUMMARIES. Currently active entries carried over from the previous update cycle are transcribed from the previous issue. New entries are typed into their correct location as noted on the DATA SUMMARY. Of course, as new entries are inserted between existing entries, the line "Entry No." of all following entries is "pushed down" accordingly. To illustrate using the example of the previous paragraph, the newly entered item becomes entry number 5, whereas previous entry 5 now becomes entry 6. Each following entry is modified accordingly. Upon completion of table preparation, all active DATA SUMMARIES are returned to the RAC files.

5.4 Technical Monographs

5.4.1 Scope and Purpose

Technical monographs are prepared and disseminated on an irregular basis. These monographs are to be authoritative introductions to the current state-of-the-art to provide technical guidance in specific narrow technical topic areas related to the design, fabrication, test and application of semiconductor and microelectronic devices. Particular emphasis is being placed on those factors that influence system reliability and effectiveness.

In general, the monographs include a survey of the current state of knowledge in the problem area of concern as derived from indepth study of the literature, current practices, and analysis of relevant data. They are to contain specific engineering guidance for selection, design and analysis of devices, components, and other electronic system elements.

This procedural guide is intended to provide the RAC staff engineers responsible for monograph preparation with general principles and objectives by which their efforts may be channeled. Because each problem area to be treated is unique, it requires a unique solution; hence it is impractical to devise step-by-step instructions.

5.4.2 Topic Selection

Topics for monograph treatment are to be selected on the basis of the ability of RAC to make a definite contribution to the technical literature. Thus, the two overriding criteria are:

1. The topic must have current broad interest and application and fall within the scope of RAC's capabilities and objectives.

2. A reasonable level of scientific endeavor has been devoted to its study such that meaningful findings and progress have been reported.

The most logical areas from which applicable topics can be selected are:

1. New developments: included in this category are materials technology, device technology, processes fabrication techniques, testing, reliability analysis techniques, packaging and assembly techniques, environment control, etc.

2. Current problem areas: specific failure modes and mechanisms, critical environments, quality and process control difficulties, etc.

An ideal topic area is one in which there is wide current interest showing promise of important technological advances. A fairly large current level of effort by a sizable number of independent researchers should be underway, but the findings have not as yet been incorporated into "accepted industry practices." The monograph then serves as the vehicle whereby this scattered knowledge is consolidated into a single, useful compendium of current status and clearcut guidance recommendations.

The following list is representative of potential monograph topics of current interest. They are presented for reference purposes only and are not necessarily subjects for present or future monographs.

- Metallization Failures in IC Devices
- Flip-Chip Bonding Techniques
- Space Radiation Effects
- Survey of High Reliability Procurement Specifications
- Non-Destructive Testing of Discrete and IC Semiconductor Devices
- Compatible Techniques for IC's.
- Reliability Achievement in Plastic Packaged IC Devices
- Accelerated Test Techniques for IC Devices
- Reliability Prediction Techniques Applicable to IC Devices
- Current Problem Areas of LSI MOS Logic Elements
- Surface Phenomena in Semiconductor Devices
- Infrared Mapping Techniques for Screening
- Current Status and Future Potential of Dielectric Isolation Process
- Multilayer Metallization Interconnection Techniques

Final topic selection is a joint decision between the Contract Technical Monitor at RADC and IITRI. In practice, either party may suggest a candidate topic(s) subject to review and approval by the other.

5.4.3 Approach

Once a suitable topic is chosen, a preparation plan and schedule shall be determined. Although the approach will vary to some extent depending on the topic, the following general tasks are required:

1. Literature Search - including RAC files, other literature sources and personal contacts with workers in the particular area of interest.

2. Preliminary Investigation - to ascertain the important considerations, parameters and criteria.

3. Develop Draft Outline - to organize, classify and attach priorities to various aspects of the problem.

4. Indepth Analysis - all available information and data is analyzed thoroughly in relation to outline items to gain insight and understanding of problem, and proposed solutions.

5. Formulate Decisions and Supporting Evidence - define strong and weak points of various approaches, derive engineering data, functional relationships, statistical support, define recommendations, etc.

6. Document - actual preparation of the monograph textual material and graphical displays. The preliminary outline is reviewed and modified as necessary prior to final documentation to ensure orderly, integrated presentation of facts and supporting evidence.

It is entirely possible that the scope of the selected topic may require modification after the investigation has been initiated. For example, the effort being carried out by workers in the field may be taking a turn away from original objective in order to pursue a more fruitful path. Or the applied efforts are so broad that a single monograph could not adequately cope with the entire subject. In this case, the topic scope should be reviewed and narrowed accordingly. The opposite situation may also occur. Any proposed modifications of topic scope should be cleared by the contract technical monitor.

5.4.4 Monograph Content and Presentation

The precise items or informational content of the monographs is dependent to a large degree on the particular topic covered. It is possible, however, to outline some of the subject matter that should be included. Briefly, these following subject areas ought to be discussed as a minimum.

1. Introduction - description of topic or phenomena under consideration.

2. Scope of phenomena investigated - devices, processes, applications or environments affected by phenomena.

3. Survey of present knowledge - including:
   - study vehicle
   - analysis methods or investigation procedures
   - status and results to date
   - future activity and direction

4. Evaluation of Report Results
   - Comparison of alternative approaches
   - Unsolved problem areas

5. Engineering parameters and tradeoffs
   - formulae
   - graphical displays

6. Conclusions and Recommendations
   - applicability of techniques or methods
   - constraints on utility
   - alternative methods
   - future expectations

The technical content shall be oriented toward the practicing engineer. Textual content and data must be pertinent to practical situations such that the knowledge gained can be brought to bear on the problem at hand and result in optimal solutions and/or decisions. Monographs must be fairly short, and concisely written, yet be at a technical level consistent with the stated purpose and objective. Graphical, tabular and photographic displays shall be employed extensively to convey engineering intelligence in a meaningful manner. Clearcut, positive recommendations and application constraints must be incorporated into each monograph disseminated by RAC.

5.5 Ad Hoc Inquiries

5.5.1 Introduction

The Reliability Analysis Center, as one of its important functions, will provide a central source to answer specific inquiries by qualified members of the electronic Government-industry complex within its scope. Since this function provides the closest link between the Center and its user community, the RAC image will be greatly determined by its responsiveness to incoming inquiries. Consequently, user inquiries shall receive top priority by RAC operating personnel. This subsection defines the tasks and procedures for servicing ad hoc inquiries. Topics covered included: scope of service capability, communication channels, personnel responsibilities, and internal information processing.

5.5.2 Scope of Service

In essence, RAC will service user queries in those aspects of microelectronic device technology that has a bearing on improving and achieving reliable operation of military systems and equipments. The primary emphasis is on developing a better knowledge and deeper understanding of the nature of failure in electronic parts and their causes, and making this information available to the user community in a timely, readily usable manner so as to influence decisions related to the design, development, production and operation of military electronic components, equipment and systems. Within this broad framework then, it remains for RAC to develop the scope of its query capability. Admittedly, it is difficult to be completely definitive until some experience has been gained; instead imposition of a minimal set of general constraints seems more appropriate. These are:

1. At the present time, RAC service is limited to microelectronic devices. Within a short period of time, service will be expanded to include discrete semiconductor devices.

2. RAC cannot honor requests for test or use experience data or information on <u>specific device types</u> or products of a particular manufacturer. All test and use experience data disseminated by RAC must be identified at the generic class level. However, RAC can furnish specifications, characteristics, ratings and physical properties information on specific device types or families.

3. Device selection, i.e., recommendation of specific device types to meet a specified set of characteristics, is not a RAC function.

4. Requests to furnish copies of source documents cannot be honored. Should the occasion arise, individual pages such as charts and graphs from source documents (except copyrighted material) may be reproduced for dissemination as necessary to satisfy a user request, but reproduction and dissemination of entire documents is outside its purview.

Within these constraints, user queries shall be services as permitted by the accumulation of information and data in its files and the knowledge and experience of RAC engineering specialists. Further, it shall be RAC policy to suggest suitable outside sources of information, wherever possible, in answer to requests for service clearly beyond its scope and/or resources.

Responses to user queries generally will take one or more of the following forms:

1. Defined topic bibliography
   a) with or without abstract
   b) includes supporting information (audit trail) for tabular products

2. Referral to other data centers or information sources

3. Analysis of specific numerical data

4. Technical survey of specific narrow problem areas.

The first two response types are relatively straightforward and should require minimal staff time and effort.

The latter two may require substantial professional effort to perform the required analysis or evaluation and prepare a suitable response. No absolute limit is being placed on the size of the task that RAC is capable of effectively pursuing for this service; however, some constraints are in order.

It is recommended that the following guidelines be observed in servicing ad hoc user queries requiring data analysis and/or survey evaluation of technical information. These apply to expenditure of professional effort. Similar discretionary constraints are advised in the use of clerical and drafting support.

1. The investigation must be oriented and directed to achieve a satisfactory solution rather than attempting to achieve a "perfect" solution without regard to expended effort.

2. In connection with item 1, an arbitrary time constraint is being imposed. Although the limits are not absolutely rigid, they should be observed to insure timely responses to customer information requests.

   a) 8 manhours maximum for the majority of routine queries requiring nominal analysis and evaluation

   b) 24 manhours maximum for certain queries of a larger scope

3. In situations where the problem posed by the user is overly broad or appears to entail a sizable investigation, discussions shall be conducted with the customer to refine the problem so it can be more effectively treated. If it is not feasible, a priori, to narrow the scope effort should be made to treat the problem in phases. A first phase might be a fairly quick, general survey intended simply to reduce the problem to manageable proportions. Later phases then would be channelled into the most productive aspects.

The scope of query service and constraints imposed will be continually reviewed and modifications incorporated as justified.

5.5.3 User/RAC Communication

There is no restriction on the communications mode employed for making queries to or disseminating responses from RAC. The most logical forms are telephone, telegraph and U.S. mail. Users will be encouraged via the RAC publicity brochure to employ the telephone wherever practical. It has the advantage of speed as well as it permits direct interchange between the user and RAC staff member to interpret and refine the question.

RAC responses may also be made by any of the available communication forms. As a general policy, responses should be in writing and communicated via U. S. mail. However, telephone or telegram should be employed where priorities require faster response. Even here a telephone response should be followed with a formal written reply for confirmation. In certain instances, where the information or data to be transmitted is very minimal, a telephone response alone is permissible.

User requests for information will be accepted in free form. That is, users are not required to complete a standardized "request form." Requests must include, as a minimum, the following information:

Requesting individual's name
Organization and address
Government contract number
Statement of the problem
Urgency of request (date answer is required)

The government contract number serves to identify the requestor as a qualified recipient of RAC Query service. Greater detail on user qualification appears in another section of the RAC Internal Operating Procedure.

A simple request form will be used internally to record and document each incoming request. This form is used for internal control during processing of the response and serves as a permanent record of the service provided. This internal query form, designated RAC SERVICE REQUEST RECORD, Form RAC 68-13, is illustrated in Section 5.7. Completion instructions are contained in subsequent paragraphs of this document.

5.5.4 Staff Responsibilities

The query processing task is a joint effort of several RAC staff members, each responsible for a particular portion of the total task. They are:

Customer Liaison Engineer - acts as the single Reliability Analysis Center agent through which outside organizations access the Center. Responsibilities are described in greater detail in subsection 5.5.6 below.

Technical Specialist - members of the RAC engineering staff who have proficiency in the various technological areas associated with microelectronic and semiconductor technology. He is responsible for conducting the actual investigation and formulating the response.

Library Sciences Specialists - staff specialists responsible for maintaining the RAC file system. They provide assistance in structuring the file search question and conducting the file search.

Clerical and Drafting Support - support personnel responsible for preparing typed text and graphical displays as required for query responses. Clerical personnel also maintain schedule control over query processing and historical file records.

5.5.5 General Query Handling Procedures

Functionally, ad hoc query processing is quite simple, consisting of the following elements:

1. Receive query
2. Interpret problem
3. Define file search terms and logic
4. Perform file search and retrieve relevant documents
5. Analyze information and analysis
6. Prepare response
7. Communicate information to inquirer

As noted previously, the Customer Liaison Engineer is the recipient of the query. He shall record the pertinent information onto the RAC SERVICE REQUEST RECORD (SRR) and conduct the necessary correspondence with the inquirer to properly define and interpret the problem as described in Subsection 5.5.6 below.

Upon satisfactory problem definition, the SRR is forwarded to an appropriate Technical Specialist for processing. He then structures the problem into a suitable set of search descriptors and logic with the assistance of the Library Sciences Specialist. The search is performed by the latter in accordance with the strategies defined in Subsection 5.2 (with clerical assistance) and the identified documents or other information (e.g. Abstract Reference Cards) are extracted from the files.

The Technical Specialist reviews the material, makes the required analysis and prepares a suitable response. The assistance of typing, clerical and drafting support are used as required to type copy, draft graphical displays and reproduce material for dissemination. The approach taken to solve a query problem and the form of the response is pretty much left to the ingenuity of the Technical Specialist. The task shall be performed within the scope and constraints described in Subsection 5.5.2 above.

Upon completion of the response, it is conveyed to the customer by appropriate mode of communication as described in Subsection 5.5.3. Written (hard copy) responses are signed (prepared by) and dated by the responsible Technical Specialist and countersigned (approved) by the Customer Liaison Engineer. A form letter of transmittal signed by the latter shall accompany each written response--see Subsection 5.5.6 for details.

After completion of the response, the Technical Specialist completes the remaining items on the SRR, affixes his signature, time and calendar date that the response was issued. It is important to indicate the action taken and how the reply was made. A "COMMENTS" space is provided for denoting pertinent facts about the query, the investigation or the response that might indicate the effectiveness of the information furnished.

A copy of all hard copy material furnished the inquirer is affixed to the SRR for reference purposes. The closed out SRRs are filed according to a sequential accession number for future reference.

5.5.6 Customer Liaison

A single individual, hereafter referred to as Customer Liaison Engineer, is assigned complete responsibility as RAC agent to whom all user queries are addressed. He is responsible for initiating the RAC SERVICE REQUEST RECORD (RAC 68-13) and interpreting the problem into a form amenable to file search and response processing.

Queries received via telephone are transcribed directly onto the SRR. Suitable questions shall be raised and discussion carried on to ensure correct interpretation of the problem and information desired. Except for rare situations where RAC response can be extracted directly from readily available sources, i.e. RAC standard publications, no attempt should be made to supply an answer at this time. Instead, the query should be acknowledged with assurances given of prompt reply. Further, caution is to be observed in making negative replies during the initial contact. Even where it is established that the query is outside the scope of its jurisdiction, RAC's policy is to attempt to provide reference to other sources of the desired information. Thus, unless these references are readily known, it is best to accept the query and attempt to identify a suitable reference later.

The customer liaison engineer reviews hard copy (letter or telegram) input queries and initiates an SRR by recording the appropriate information. Should there be a question regarding the nature of service desired, he shall contact the requestor via telephone and work out a mutually acceptable interpretation.

It is expected that some information requests will be quite broad requiring a substantial effort to analyze the available information and formulate a suitable response. Where this occurs, it is desirable for the liaison engineer to advise the customer accordingly and attempt to work out an acceptable reduction in scope. Admittedly, it is difficult, a priori, to quickly and accurately estimate the effort required to service a particular request. It is expected, however, that as experience is gained in handling queries, patterns will emerge which will permit valid estimates of required effort.

Once the investigation is initiated, further questions of interpretation or problem scope may arise. To foster goodwill, it is desirable that such communications also be conducted by the customer liaison engineer. It is recognized, however, that situations may arise where it is preferred, and necessary, for technical continuity, that the RAC specialist conducting the investigation contact the user directly.

RAC responses shall be relayed through the Customer Liaison Engineer. Phone replies are handled by him and he shall countersign hard copy responses. Further, letter responses shall be accompanied by a letter of transmittal over his signature. A letter of the following form is appropriate:

> In response to your request for service, dated (   ), the Reliability Analysis Center is pleased to furnish the enclosed material.
>
> We trust that this information will satisfy your present requirements. Should you desire further assistance with your present problem or any time in the future, please call me at (phone no.).
>
> Sincerely yours,
>
> (Signature)

5.6 F-Test Procedure for Determining Failure Rate Equivalence

The Fisher F-test is used to compare failure rates (λ) from independent tests to determine whether they can be combined into a single pooled estimate. It is valid where the λ estimates and number of failure occurrences are parameters of the Poisson distribution.* Theory to validate the applicability of the test are not presented herein; rather detailed instructions for its use are outlined.

Procedure

The F-test shall be considered as part of the failure rate computation procedure described in paragraph 5.3.2.4.1, step (f). It shall be conducted as follows:

1. To ascertain whether the F-test is applicable all $\hat{\lambda}_i$ values computed in step (e) are ranked mentally or physically in ascending order from smallest to largest.
2. Test lots exhibiting zero (0) failures are excluded from this ordering process, hence are not included in any of the subsequent steps. In later merging they are combined into the subset (see step 8 below) having lowest λ.
3. The ordered $\hat{\lambda}$ values are now scanned to identify those successive pairs that differ by more than approximately one order of magnitude (10X). Some leeway is permissible here. For example, if the number of failures, r_i and r_{i+1}, associated with the successive values $\hat{\lambda}_i$ and $\hat{\lambda}_{i+1}$ respectively, are less than 3, $\hat{\lambda}$ differences of less that 10 are of no consequence. If, however, the number of failures are 3 or more, it is advisable to select, for statistical testing, those pairs where the difference is less than 10 (e.g. 7 or 8). These observations should be made mentally so that this process does not become a major time factor in preparing outputs.

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*A. H. Bowker and G. J. Lieberman, "Engineering Statistics," Prentice-Hall, Inc., 1959.

4. Once "suspect" $\hat{\lambda}$ value pairs are identified the F-test is applied as follows to the individual pairs.

5. Compute the ratio:

$$F_D = \frac{\hat{\lambda}_{i+1}\ (r_i)}{\hat{\lambda}_i\ (r_i+1)}$$

6. Look up the F_c percentage point in Table 13 (upper 5% points) for df (degrees of freedom) = $2(r_i + 1)$ for the numerator and df = $2r_{i+1}$ for the denominator.

7. The two $\hat{\lambda}$ values can be considered equivalent in which case the data can be combined if

$$F_D \leq F_c$$

8. If $F_D > F_c$, the outlying value cannot be combined with the other data and must be entered onto the output as a separate line entry. If, however, there are other data with $\hat{\lambda}$ values "equivalent" to the outlier ($\hat{\lambda}_{i+1}$) value above, they can be combined together into a single value.

An example of the test is shown below.

1. Assume the following ranked data

Test ID	$\hat{\lambda}$	r
a	.008	1
b	.09	2
c	.1	4
d	.9	3
e	2.9	2
f	7.4	3
g	9.6	1

Table 13

TABLE OF PERCENTAGE POINTS OF THE INVERTED BETA (F) DISTRIBUTION

F DISTRIBUTION, UPPER 5% POINTS ($F_{.95}$)*

Degrees of freedom for numerator (columns); Degrees of freedom for denominator (rows)

	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1	161	200	216	225	230	234	237	239	241	242	244	246	248	249	250	251	252	253	254
2	18.5	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.5	19.5	19.5	19.5	19.5	19.5
3	10.1	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	.62	4.56	4.53	4.50	4.46	4.43	4.40	4.37
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
120	3.92	3.07	2.68	2.45	2.29	2.18	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35	1.25
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

Interpolation should be performed using reciprocals of the degrees of freedom.

* This table is reproduced with the permission of Professor E. S. Pearson from M. Merrington, C. M. Thompson, "Tables of percentage points of the inverted beta (*F*) distribution," *Biometrika*, vol. 33 (1943), p. 73.

2. Observe $\hat{\lambda}$ differences: $\hat{\lambda}_b > 10\ \hat{\lambda}_a$ so this pair is a suspect. Also, $\hat{\lambda}_d = 9\ \hat{\lambda}_c$; this pair is also suspect because of the number of failures associated with each. All other pairs are sufficiently close together to negate equivalence testing.

3. Each suspect pair is tested separately.

4. Consider $\hat{\lambda}_a$ and $\hat{\lambda}_b$

$$F_D = \frac{\hat{\lambda}_b(r_a)}{\hat{\lambda}_a(r_a + 1)} = \frac{.09\ \ (1)}{.008\ (2)} = \frac{.09}{.016} = 5.63$$

$$df\ (num) = 2\ (r_a + 1) = 4$$
$$df\ (den) = 2\ r_b = 4$$

$$F_c = 6.39 \text{ from Table}$$

Since $5.63 < 6.39$ the data is considered equivalent.

5. Now consider $\hat{\lambda}_c + \hat{\lambda}_d$

$$F_D = \frac{.9\ (4)}{.1\ (5)} = \frac{3.6}{.5} = 7.2$$

$$F_c \text{ for } df = 10{,}6 = 4.06$$

Since $7.2 > 4.06$ the data from these two tests cannot be combined.

6. Referring back to the ordered listing of $\hat{\lambda}$ values it is concluded that there will be 2 failure rate line entries on the output, one containing combined data from tests a,b and c and the second combined data from d, e, f and g.

5.7 Referenced Forms

The following referenced forms are herewith included.

RAC 68-10	MICROCIRCUIT FAILURE DATA
RAC 68-11	MICROCIRCUIT FAILURE RATES
RAC 68-12	FAILURE RATES WORKSHEET
RAC 68-13	RAC SERVICE REQUEST RECORD

MICROCIRCUIT FAILURE DATA

CATEGORY ____________

FCTL CTGY ________ PKG ________

RELIABILITY ANALYSIS CENTER

ISSUE DATE ________ PAGE ________

ENTRY NO	DTA SRC LVL	TST TYP / APP ENV	STRS LVL / EQP CLASS	FAILURE MODE DESCRIPTION	FLRS DUE TO MODE	NO TESTED	TEST DURATION	OPRNL TYPE	QUAL CLSS	INTRCON SYSTEM	ISLN MTD	CKT CPXTY	SCRN / BURN IN DETAIL OR REF	DATA DATE	IN R

FORM RAC 16-1C

MICROCIRCUIT FAILURE RATES

CATEGORY ______________________

RELIABILITY ANALYSIS CENTER

ISSUE DATE __________ PAGE ________

ENTRY NO	[2] FCTL CTGY	[3] PKG CNFG	[4] OPRNL TYPE	[5] QUAL CLSS	[6] INTRCON SYSTEM	[7] CKT CPXTY	[8] DTA SRC LVL	[9] TST TYP / APP ENV	[10] STRS LVL / EQP CLASS	[11] NO TESTED	[12] NO FLD	[13] PART HOURS	[14] FLRS PER 10^6 HRS	[15] FAILURE MODE DESCRIPTION	[16] FLRS DUE TO MODE

FORM RAC 60-11

FORM RAC 68-12

FAILURE RATES WORKSHEET

1 MEL CATEGORY			PERIOD
2 FCTL CTGY	3 PKG CNFG	4 OPRNL TYPE	
5 QUAL CLASS	6 INTRCON SYSTEM	7 CKT CPXTY	
8 DTA SRC LVL	9 TST TYP/APP ENV	10 STRS LVL/EQP CLASS	

ACCESSION NUMBER	NO TESTED	NO FAILED	PART HOURS	r_i/T_i
PREVIOUS TOTALS				
TOTALS	11	12	13	

df= χ^2 = $\lambda = \chi^2/2T_T$ = = 14

15 FAILURE MODE DESCRIPTION	16 NO FLRS

	ANALYST	DATE

RAC SERVICE REQUEST RECORD

NAME			REQUEST #
			DATE — REC'D — COMP
COMPANY AND DIVISION			TIME
ADDRESS		PHONE	URGENCY
CONTRACT	AGENCY		SYSTEM

PROBLEM STATEMENT

ACTION: ☐ BIBLIO ☐ DATA ☐ SURVEY ☐ REFERRAL ☐ OTHER ____________

REPLY BY: ☐ PHONE ☐ LETTER ☐ TWX ☐ OTHER ____________

COMMENTS:

Form RAC 68-13

RAC ANALYST

6.0 PROJECT PROGRESS AND PRESENT STATUS

6.1 Data Collection

6.1.1 Organizations of Task

To establish the scope of the data collection effort, it was necessary to first define those specific integrated circuit devices of prime interest. Plans were then formulated to contact vendors, equipment manufacturers, and others involved in the design and application of the pertinent integrated circuits.

6.1.1.1 Integrated Circuit Categories of Interest. Microelectronic categories of greatest importance for the purpose of the initial data collection effort include the following digital or linear types of circuits:

1. Monolithic Epitaxial
2. Monolithic Diffused
3. Composite I.C. Epitaxial
4. Composite I.C. Diffused
5. Monolithic IGFET

Microelectronic circuit types not included in this early phase of data collection because of their more specialized design and use are listed as follows:

1. Thin film - pure IC
2. Thick film - pure IC
3. Hybrid Microcircuits
4. Multichip Microcircuits

In essence, initial data collection effort was directed toward those circuit categories produced by the well-established semiconductor technology since they have found more widespread application in current military equipments.

6.1.1.2 Source Contact Planning. The scope of collection effort for RAC includes a wide range of failure analysis information from device vendors, system contractors, SPO's, other Government agencies, and other data centers. Specific documents

which fulfill RAC information needs include the following:

1. Vendor Catalogs
2. Vendor Specifications
3. Government Specifications
4. Contractor Specifications
5. Device Development Reports
6. Testing Specifications
7. Processing Specifications
8. Quality Assurance Specifications
9. Vendor Technical Information
10. Test Reports
11. Open Technical Literature
12. Vendor Analysis Reports
13. Contractor Analysis Reports
14. Field Analysis Reports
15. Government Agency Reports
16. IDEP Reports
17. FARADA Failure Analysis Reports
18. Other Data Center Reports
19. Independent Test Laboratory Reports
20. Burn-In Analysis Reports
21. Physics of Failure Reports

To evaluate those vendors who make devices meeting RAC microelectronic device categories, a "Microelectronic Information Company Survey Questionnaire" was sent out to all known microelectronic manufacturers. A sample questionnaire may be found in Section 3.0, page 47, of this report.

Nineteen vendors were chosen for data collection visits after studying the results of the questionnaires. These vendors along with names of the persons visited at each plant and data of the visit are listed in Table 14.

Identification of source contacts for microelectronic device users proved somewhat more difficult. This list was developed by such methods listed as follows:

1. Device manufacturers visited were asked to identify their major military users.

2. Journal and newspaper articles relating military programs and the equipment manufacturer's use of microelectronics therein.

3. IITRI staff personnel with acquaintances in equipment manufacturer's facilities.

Table 14

SUMMARY OF VENDOR VISITS

Name and Address of Vendor	Person(s) Visited	Date of Visit
1) Amelco Semiconductor 1300 Terra Bella Avenue Mt. View, California	Walter K. Heinzer, Reliability Engrg.	8-17-67
2) Amperex Electronic Corp. Providence Pike Slatersville, Rhode Island	John Clarke, Quality Assurance Mgr.	9-19-67
3) Fairchild Semiconductor 313 Fairchild Drive Mt. View, California	James Feldt, Sr. Reliability Engr. W. G. Vient, Program Mgr.	8-16-67
4) General Instrument Corp. 600 West John Street Hicksville, New York	John Cocking, Quality Assurance Mgr. Bernard Erde, Marketing	9-21-67
5) Motorola Semiconductor Div. 5005 E. McDowell Road Phoenix, Arizona	A. A. Procassini, Director of Reliability & Quality Assurance J. L. Flood, Mgr. of I.C. Reliability & Quality Assurance	10-4-67
6) National Semiconductor Corp. 2975 San Ysidro Way Santa Clara, California	J. E. Thompson, Director of Quality Assurance & Reliability	2-23-68
7) Philco-Ford Corporation Microelectronics Division Union Meeting Road Blue Bell, Pennsylvania	P. Gott, Reliability Engr.	10-4-67

Table 14 (Continued)

SUMMARY OF VENDOR VISITS

Name and Address of Vendor	Person(s) Visited	Date of Visit
8) Philco-Ford Corporation Microelectronics Division 2920 San Ysidro Way Santa Clara, California	J. L. Cortright, Market Engr. Gil Bowers, Mgr. of Quality Assurance & Reliability	8-16-67
9) Radio Corporation of America Route 202 Somerville, New Jersey	H. W. Trieckel, Mgr. of Government Programs	9-20-67
10) Raytheon Company Semiconductor Operation 350 Ellis Street Mt. View, California	Sidney Wiesner, Mgr. of Reliability & Quality Assurance N. E. Derkovits, Mgr. of Product Assurance	8-18-67
11) Signetics Corporation 811 East Arques Avenue Sunnyvale, California	H. M. Slavin, Mgr. of Quality Assurance O. G. Colvin, Section Head/Reliability Assurance	8-17-67
12) Siliconix Inc. 1140 W. Evelyn Avenue Sunnyvale, California	Ben Irwin, Quality Control Mgr.	8-18-67
13) Sprague Electric Company 115 Northeast Cutoff Worcester, Massachusetts	Charles Gray, Director of Quality Assurance & Reliability W. R. Rittman, Mgr. of Government Sales	9-13-67
14) Sylvania Electric Products Semiconductor Division 100 Sylvan Road Woburn, Massachusetts	W. B. McMakin, Marketing Engineer R. E. Barnes, Mgr. of Quality Control	9-12-67

Table 14 (Continued)

SUMMARY OF VENDOR VISITS

Name and Address of Vendor	Person(s) Visited	Date of Visit
15) Texas Instruments Inc. Semiconductor Division P. O. Box 5012 13500 N. Central Expressway Dallas, Texas	Berry Cash, Marketing Engineer Jim Adams, Quality Manager Don Blyth, Reliability Supervisor Don Denton, Head Quality Assurance Engineer	10-3-67
16) Transitron Electronics Corp. 168-182 Albion Street Wakefield, Massachusetts	R. E. Howard, Reliability Manager R. E. Shaut, Product Sales Manager	9-11-67
17) Union Carbide Corporation Electronics Division - Semiconductor Department 365 Middlefield Road Mt. View, California	C. W. Krebs, Mgr. of Order Processing Robert Townley, Mgr. of Quality & Reliability	8-18-67 8-21-67
18) Westinghouse Electric Corp. Molecular Electronics Div. Elkridge, Maryland	W. MacCrehan, Mgr. of Quality & Reliability D. Ludwig, Section Reliability Mgr.	10-3-67
19) Sperry Semiconductor 380 Main Street Norwalk, Connecticut	C. Van Leeuwen, Mgr. of Reliability L. S. Chase, Quality Control Mgr. E. V. Murphy, Product Marketing Mgr.	10-2-67

4. RADC contacts with Air Force Systems Project Offices.

5. Reference to the Defense Marketing Service reports.

The equipment manufacturers, listed in Table 15, were subsequently selected, on the basis of this information. In addition to the 18 equipment manufacturers, the FARADA data center at FMSAEG (Corona, California) and the Air Force Space and Missile System Organization (SAMSO) were also contacted.

Technical information services consulted on a monthly basis include the following sources:

1. Technical Abstract Bulletin

2. Scientific Technical Aerospace Reports

3. International Aerospace Abstracts

4. Reliability Abstracts and Technical Reports

5. U.S. Government Research and Development Reports

6. IDEP Reports on Microelectronic Devices

7. Several Periodicals scanned monthly for microelectronic articles.

Additional sources which have been helpful for technical information include the Visual Search Microfilm File, DATA, various symposium proceedings, technical seminars, and various microelectronic textbooks.

6.1.1.3 Collection Procedures. Needed procedures, forms, and specifications developed to guide and control the collection task are documented in Section 3.0, "Procedural Guide for Data Collectors." Its principal objectives are to:

1. establish methods used to determine the sources to be contacted, the item of interest, and their proper technical descriptions.

2. standardize the communications procedures leading to the collection visit.

3. provide guidance on the conduct of the actual visit in addition to data input specifications which detail the types of information being sought.

4. ensure complete and uniform documentation of all communications.

Table 15

SUMMARY OF EQUIPMENT MANUFACTURER CONTACTS

Name and Address	Person(s) Visited	Date of Visit
1) Autonetics, Division of North American Rockwell 3370 Miraloma Avenue Anaheim, California	E. H. Schaefer, Mark II Program Director E. H. Manuel, V.P. of Minuteman Program R. M. Bukaty, V.P. of Data Systems	No Visit (Letter Contacts)
2) A. C. Electronics, Division of General Motors Corp. 7929 South Howell Avenue Milwaukee, Wisconsin	T. C. O'Connell, Mgr. of Design Reliability and Assurance R. Johnson, Mgr. of Semiconductor Tests E. Bovich, Mgr. of Failure Analysis Program: Titan III	1-30-68
3) Avco Corporation 2630 Glendale-Milford Road Cincinnati, Ohio	F. E. Besco, Staff Engineer H. E. McGraw, Mgr. Marketing Publications Program: F-111 Countermeasures Receiving System	No Visit (Letter Contacts)
4) Bendix Navigation & Control Division Teterboro, New Jersey	W. P. Mergler, Sales Engineer Program: Saturn (NASA)	No Visit (Letter Contacts)
5) The Boeing Company Aerospace Group P. O. Box 3707 Seattle, Washington	J. W. Griswold, Director of Reliability Program: SRAM	No Visit (Letter Contacts)
6) Burroughs Corporation Defense, Space & Special Systems Group Paoli, Pennsylvania	X. B. Bennett, Mgr. Electronic Products Program: Pershing Missile (Army)	No Visit (Letter Contacts)

Table 15 (Continued)

SUMMARY OF EQUIPMENT MANUFACTURER CONTACTS

Name and Address	Person(s) Visited	Date of Visit
7) General Dynamics Corp. Fort Worth, Texas	L. P. Michaelis and Charles Brown Program: F-111	No Visit (Letter Contacts)
8) General Electric Company Defense Electronics Div. Utica, New York	R. E. Gaffney, Contracts Mgr. J. P. Harding, Mgr. of Engineering Program: F-111	No Visit (Letter Contacts)
9) Honeywell Inc. Ordnance Division 600 Second Street North Hopkins, Minnesota	C. L. Barron, Reliability Mgr. Program: BLU-26/B Proximity Fuze	No Visit (Letter Contacts)
10) Motorola Inc. Government Electronic Div. 8201 E. McDowell Road Scottsdale, Arizona	F. E. Dreste, Chief Engr. Reliability & Components Program: FMU 56B	No Visit (Letter Contacts)
11) United Aircraft Company Norden Division Helen Street Norwalk, Connecticut	F. P. Halas, V.P. of Sales & Service Program: IHAS	No Visit (Letter Contacts)
12) Sanders Associates, Inc. 95 Canal Street Nashua, New Hampshire	R. H. Hollis, Supervisor of Applications Reliability Section Program: F-111	No Visit (Letter Contacts)

Table 15 (Continued)

SUMMARY OF EQUIPMENT MANUFACTURER CONTACTS

	Name and Address	Person(s) Visited	Date of Visit
13)	Sperry Gyroscope Systems Management Div. Great Neck, New York	F. W. Campbell, Reliability Engineering Section Head Program: ILAAS (Navy)	No Visit (Letter Contacts)
14)	Sylvania Electronic Systems Div. 40 Sylvan Road Waltham, Massachusetts	H. Lehne, V.P. & General Mgr. Program: MSP 24 (Minuteman)	No Visit (Letter Contacts)
15)	Teledyne, Inc. 12525 S. Daphne Avenue Hawthorne, California	J. F. Battey, V.P. & General Mgr. Program: IHAS	No Visit (Letter Contacts)
16)	Hazeltine Corporation Little Neck, New York	R. Gauger, Reliability Mgr. Program: APX-64	No Visit (Letter Contacts)
17)	Hughes Aircraft Company Centinela & Teale Streets Culver City, California	Clifford Ryerson, Component Evaluation Mgr.	2-20-68
18)	Jet Propulsion Laboratory 4800 Oak Grove Drive Pasadena, California	Paul Antolch, Data Retrieval Coordinator W. R. Scott, Mgr. of Semiconductor Parts Engineering	2-21-68
19)	Philco-Ford Corporation Space & Re-Entry Systems Div. 3825 Fabian Way Palo Alto, California	Harrison D. Gray, Technical Staff Michael Economy, Product Analysis Mgr. W. D. Boltz, Supervisor of Component Parts Engineering Program: IDCSP/A	2-22-68

Table 15 (Continued)

SUMMARY OF EQUIPMENT MANUFACTURER CONTACTS

Name and Address	Person(s) Visited	Date of Visit
20) TRW Systems Group One Space Park Redondo Beach, California	R. Green, Design Assurance Head E. Boothman, Reliability Analyst Subject: Reliability Prediction and Demonstration for A. F. Missile and Satellite Electronics	4-18-68
21) Univac Defense Systems Division St. Paul, Minnesota	G. Anderson, Mgr. of Failure Analysis Grover Wulff, Reliability Mgr. Subject: Failure Rate Data for Airborne Computers	8-17-67

6.1.2 Present Collection Status

6.1.2.1 Vendor Status. Table 16 qualitatively displays the types of input data submitted to RAC as a result of visits and extensive follow-up by phone and letter. Most vendors who promised information have furnished at least some useful material. However, as can be seen in the chart, highly summarized device failure rate information is the item most frequently submitted. Failure mode and mechanisms information of greatest interest to RAC is essentially unavailable in useful form from most vendors. Detailed device descriptions have not as yet been submitted by the majority of vendors. A few vendors have recently updated the accumulative reliability data summaries originally furnished.

A possible reason for the relative unavailability of failure mode information is that vendors are guarding their proprietary interests. This information must instead be actively sought from user sources.

Device description information requires additional follow-up and emphasis by RAC personnel. Completion of RAC forms requires vendor engineering and marketing manpower. This primarily accounts for the delay between request and reply.

Coordination of visits and requests from vendors during this contract were handled through the marketing departments, rather than through technical personnel as was done on a previous contract. This resulted in more responsive action and release approval on data of interest. Marketing people are in a better position to handle internal liaison and have an active interest in assisting potential customers.

6.1.2.2 Equipment Manufacturer Status. As shown in Table 15, 15 equipment manufacturers were contacted by letter, and six additional manufacturers were visited. Letters were originally sent with a questionnaire entitled, "Device/Count Application Stress Summary." This questionnaire (page 63 of Section 3.0) was designed to supply RAC with quantitative information concerning the identity and the application environment of microelectronic devices used in military systems. From the responses, it was possible through telephone calls to determine those manufacturers having data of interest to RAC.

The types of data which were submitted or might be obtainable after proper authorizations include the following:

1. Equipment malfunction reports

2. Device Failure Analysis reports

Table 16

TYPES OF VENDOR DATA RECEIVED

Manufacturer's Name	Catalogs	Failure Summary	Lot Acceptance	Qualification	QA Procedures	Burn-in Data	Process Flow	Failure Mode	Acceler. Tests	Plastic Pkg. Data	Device Descriptions
Amelco	X	X	X		X						
Amperex	X			X				X	X		
Fairchild	X	X	X		X						
General Instru.	X	X		X							
Motorola	X	X			X		X	X		X	Partial Submission
National Semi.	X	X			X		X				
Philco (MOS)	X	X									
Philco (Bipolar)	X	X	X		X			X			Partial Submission
Raytheon	X	X	X		X						
RCA	X	X									
Signetics	X	X		X	X		X			X	
Siliconix	X		X								
Sperry	X			X	X						
Sprague	X	X	X		X						
Sylvania	X	X	X		X	X					
Texas Instru.	X	X			X			X	X	X	
Transitron	X	X	X		X						
Union Carbide	X	X									
Westinghouse	X	X									

3. Burn-in reports at the device or equipment level

4. Summarized failure rates on installed devices

5. Contractor's device specifications and test specifications

6. Program qualification test reports on devices or on equipments containing microelectronic devices

There are large stumbling blocks in gaining access to the various types of data which may be available from an equipment manufacturer. One of the most frequent problems posed is the cost of retrieving information not part of the original contractual agreement. Also, most programs with reliability report requirements do not require failure information below the modular hardware. Actual experience has taught RAC data collectors to expect a small token of cooperation from the equipment manufacturer because of his other priorities and cost constraints.

Some of these problems might be mitigated by a different approach. Through close cooperation between RAC and each appropriate Air Force Plant Representative's Office (AFPRO), it may be possible to obtain more effective feedback on major, new programs. This must also involve coordination with the System Project Office without interfering with its costs or security arrangements. An RAC representative could keep in close communication with the AFPRO who, in turn, would be in a position to coordinate contractual data items of interest to RAC. It should then be possible for RAC to work more closely with the equipment manufacturer.

Also, a growing number of systems and equipment hardware contracts provides for automatic reliability data submission to RAC. This will definitely be of help in improving the quality of information available.

6.1.2.3 Other Data Sources. In addition to previously mentioned device manufacturers and equipment manufacturers, the Navy's FARADA data center at Corona, California, was visited. Available data gathered stemmed primarily from IDEP reports being submitted to RAC on a continuing basis.

Much useful advice and program information came from a visit to the Air Force Space and Missile Systems Organization in Los Angeles, California. A list of SAMSO's programs utilizing microelectronics, along with the names of military personnel working on each program was obtained. This visit was not effected until late in the present program. Thus, we were unable to pursue these leads further, but should be scheduled as a priority effort in the forthcoming period.

6.2 File Status

The RAC storage and retrieval system is made up of the following major files:

- a Termatrex card file
- a RAC document file
- an abstract reference card file
- a reference card file
- a Government contract number file
- an order number file
- a device type inventory file
- a manufacturer file.

A description of these files and the procedures for their establishment and maintenance are found in Sections 2.0 and 4.0 of this report.

File status at the time of preparation of this report is discussed in the following paragraphs.

The Termatrex card file contains a card for each of the 1046 concept terms currently comprising the RAC termatrex thesaurus. These terms have been arranged in structured and alphabetical order for ease of use by RAC personnel.

The RAC Document file is made up of external source and IITRI generated documents. This file presently contains 1,239 documents, 662 of which are source documents, 575 of which are IITRI generated summaries and 2 of which are IITRI prepared monographs. Information from the source documents has been reviewed for inclusion in the RAC storage and retrieval system files and in preparation of the RAC file Bibliography. From the 662 source documents, 545 were applicable for the file Bibliography.

Reference abstract cards and reference cards have been prepared for each of the 1,239 documents in the file. They have been indexed and entered into the termatrex storage and retrieval system. An average of 30 entries (index terms) have been indexed for each document. These terms serve to catalog the information according to document source, properties of the device investigated, and phenomena investigated including experimental or test environments where applicable

The Government contract file identifies 158 contracts for which RAC has technical reports. The RAC accession number of these reports is recorded on each contract card. Final and interim project dates are also recorded.

The device type inventory file identifies 667 part numbers from 35 manufacturers. Specific information on each of these part numbers is filled in as determined either from manufacturer (i.e., Device Descriptions) contacts or the literature.

6.3 User Services

Reliability Analysis Center services will be provided within the following four major categories:

1) Ad Hoc Inquiry Service
2) Technical Monographs
3) File Bibliography
4) Tabular Products

The methodology described in this section has been documented into the operating procedures of Section 5.0. All other pertinent forms and references needed for interpretation are also incorporated therein. Methods of device identification and user services are described in subsequent paragraphs.

6.3.1 Microelectronic Device Identification

Microelectronic devices are identified and categorized for all user services by the following generic descriptors:

1) Microelectronic Category
2) Functional Category
3) Package Configuration
4) Operational Type
5) Qualification Class
6) Interconnection System
7) Isolation Method
8) Circuit Complexity

The position of the Reliability Analysis Center is that basic design materials and processing reflected in the above descriptors are the most influential factors in assessing the reliability characteristics of the device. Among the reasons for the validity of this approach in identifying device types are the following:

1. It is consistent with the reliability physics approach by making available meaningful data for correlation studies and the prediction model parameter verification.

2. Failure rates and predominant failure modes can be predicted for newly marketed devices on the basis of commonality of physical properties.

3. It permits reliability prediction of equipments or systems in the early design stages prior to device type selection or identification.

4. A generic set of descriptors, having optimal reliability characteristics for a specific application, can be used to identify device type numbers of manufacturers.

6.3.2 Ad Hoc Inquiry Service

One of the most important services of RAC is to answer, within the scope of its activity, specific inquiries for technical information and assistance. This service is intended to provide valid technical information and engineering data on explicit problems of immediate concern. Specialists in reliability and microelectronic device technology are available to work directly with the user to define his problem, perform the required file search and information analysis, and prepare appropriate answers. Typically, responses will take one or more of the following forms: analysis of specific numerical data; technical discussion of narrow problem areas; defined topic bibliographies and abstracts; and reference to other data sources.

Although the Center is prepared to respond to a wide variety of problems involving data analysis and literature surveys, users will be advised to exercise reasonable restraint in the breadth of their requests. Whenever RAC cannot reply to a query, every effort will be made to refer the user to an appropriate source.

Requests for information or assistance will be acceptable in writing or by telephone. Inquiries by telephone permit direct discussion of problems with RAC specialists and faster response time. No special request forms will be required, but the user will be encouraged to state his problem accurately and completely with all important constraints described. The user's name, title and affiliation, address and telephone number; and contracting agency and contract number (if non-military user) will also be requested.

Ad Hoc inquiries will be handled by mail, telephone or wire, depending upon the urgency of the request and the nature of the information needed.

6.3.3 Technical Monographs

Specific technical problem areas are treated in technical monographs. The monographs are authoritative introductions to the state of the art, and they provide professional guidance in

selected topic areas. Emphasis is placed upon those aspects of device design, fabrication, quality assurance, and application that influence reliability. These monographs include a bibliography, a survey of current knowledge and practices, and an analysis of relevant data. They usually contain guidance, based upon engineering practice, in the selection, design, analysis, and application of microelectronic devices. Technical monographs are published as problems or technological advances of widespread interest and concern arise. They are distributed to the list of regular RAC users and are available to others by specific request.

During this contract period two monographs have been issued and are now part of the File Bibliography. They are entitled Flip-Chip Microcircuit Bonding Systems and Failure of Aluminum Metallization on Silicon Integrated Circuits.

6.3.4 Microelectronic File Bibliography

The purpose of this listing is to assist outside users with identification of documents contained in RAC. Within the present 545 source documents are test data reports, specifications, R/D reports, surveys, reviews, and journal articles.

Since some of the 545 documents are indexed under more than one of the 13 subject headings, the bibliography listing contains 1264 entries. This listing will be updated periodically to reflect the current file status.

6.3.5 Tabular Products

The Microcircuit Failure Data table and Microcircuit Failure Rates table are periodic standard RAC output products. Discussion of each product's rationale and present status appears in the following paragraphs.

6.3.5.1 Microcircuit Failure Data Table. This table consists of an unmerged listing of all test or usage failure data entities reported to RAC. Its purpose is to identify failure modes which occur under a broad spectrum of stresses versus generic device types. As such, the listing is limited to source information where the mode or mechanism of failure has been identified. From an application standpoint this table is valuable to the user because it permits him access to failure mode information under time based or time independent conditions.

One of the ways the user can benefit from this product is to match the environmental and life requirements in his application to those failure results under similar conditions and for various generic devices and packages. As an end result, prevailing failure modes for the generic device selected may be subjected to special screens during processing.

Included in the initial issue of this table are a total of 128 line entries.

6.3.5.2 Microcircuit Failure Rates Tables. This is a tabulation of failure rates merged according to a unique set of generic descriptors and common stress environments. Data merging, computation of failure rates, and exclusive use of time based data mark the significant features of this output product. Environmental data and other stresses not amenable to failure rate computations are entirely excluded from this table. In the first issue, 224 line entries are listed in tables.

Failure rate calculations are based on the exponential function and Chi-square statistics as shown by B. Epstein in the Proceedings of the Third National Symposium on Reliability and Quality Control (1957). As a tabular standard the Chi-square distribution is assumed for selection of the upper failure rate confidence limit at the 60% level. Although detailed studies have indicated that microelectronic circuits and discrete semiconductor failure rates tend to decrease with time, RAC has used the exponential (constant failure rate) model for the following reasons:

1) Because devices are rigidly screened and burned in for military applications, there are often either no failures or very few failures shown in test reports. Insufficient failure results preclude the study of failure rate trends.

2) Many laboratory test results cover only a few thousand hours of operation. This, also, makes trend studies difficult or inconclusive.

3) The exponential failure rate model has been generally accepted and used for reliability estimates of electronic devices. Also, system reliability calculations have often included constant failure rate values for parts.

Merging of exponential failure rate values obtained on equivalent devices under similar stresses has been accomplished through the use of Fisher's F-distribution. It can be shown that the following ratio testing for failure rate equivalence $\lambda_1 = \lambda_2$ forms an F-distribution:

$$F = \frac{\chi_1^2/2r_1}{\chi_2^2/2r_2} = \frac{\hat{\lambda}_2(r_1)}{\hat{\lambda}_1(r_2)}$$

where:

χ^2 = Chi Square Distribution

$\hat{\lambda}_1$ = Failure Rate in Failures Per Million Hours for Life Test No. 1

$\hat{\lambda}_2$ = Failure Rate for Life Test No. 2

r_1 = Number of Failures During Life Test No. 1

r_2 = Number of Failures During Lift Test No. 2

and, $\hat{\lambda}_1 < \hat{\lambda}_2$

That value which has been computed for F is then compared with a critical tabular value of F at the 5% significance level. If the computed value is less than or equal to the critical $F_{.95}$, it is concluded that the failure rates of both life tests are equivalent and can be merged. If the computed value of F exceeds the critical $F_{.95}$, the failure rates cannot be considered equivalent and cannot be merged.

Based on the above methodology, a computer program for performing the statistical analysis was developed. This program was used at IITRI on a remote time sharing computer terminal. Basic functional processes of the program include:

1) Storage of tables (as 50-element and 300-element arrays)
2) Input parameters include document accession number, number tested, number failed and hours tested.
3) Preliminary processing and sorting.
4) Computation of parameters for statistical equivalence.
5) Test to merge criteria and failure rate computation with generation of separate statistics for each pool of homogeneous input.
6) An output format adaptable for use on worksheet form.

The program was stored with ready accessibility for on-line analysis of data. This provided an option which was fully compatible with the batch processing procedure, exhibiting particular efficiency where data from a large number of tests were to be combined.

Further refinement or modification of the program is relatively straightforward. As an example, the output format can be extended to completely print out the worksheet page, thus replacing the form itself.

6.3.5.3 Updating. Tabular products are to be periodically updated by deleting obsolete data and including data acquired since the last publication. All data worksheets are kept on file as an integral part of the updating process. Actual updating includes complete re-issuance of the tables with user responsibility for the destruction of obsolete tables. This will help to ensure that users always have the latest information available.

7.0 FUTURE DEVELOPMENT PLANS

7.1 General

The preceding section described the status of Reliability Analysis Center at the conclusion of the present contract. In summary RAC is now in readiness for initial service on Microelectronics Data, including dissemination of the first scheduled outputs and monographs, and wide distribution of an informational booklet. Direct inquiry service on the initial Microelectronics Data Base is also now available.

The present section will detail plans by which the operational status of RAC will be improved over the next five years so that it may provide a complete service on its assigned subject field of high-level integrated functions, microelectronics, and discrete semiconductor devices. This implementation plan is accompanied with organization and staffing plans.

7.2 Five-Year Development Plan

Figure 8 exhibits the planned steps through which RAC will become fully operational on its assigned subject field. At the end of FY 1968, which coincides approximately with the date of this report, services will be provided on the initial Microelectronics Data Base, including the following outputs:

- Microelectronic Failure Data Tabulations
- Microelectronic Failure Rate Tabulations
- Microelectronic File Bibliography
- Monograph on "Flip-Chip Microcircuit Bonding Systems"
- Monograph on "Failure of Aluminum Metallization on Silicon Integrated Circuits"
- Initiation of Direct User Inquiry Service

During the following fiscal year data acquisition will be vigorously pursued as a continuation of the previous effort on microelectronic parts, and data collection will be initiated in the area of higher level (MSI and LSI) assemblies. At the same time refinements will be initiated in the nature and quality of outputs. In particular, it is anticipated that an improved indexed version of the accession bibliography will be instituted. Additional monographs will be issued and augmented tabular outputs will be provided to users. At the end of FY 1969, service on microelectronic parts will include the full range of planned, scheduled and inquiry services. In addition, initial services on higher level parts will be provided both in terms of scheduled outputs and inquiry service capabilities. Improvements and additions in the format of scheduled outputs resulting in part from a higher level of computer utilization will be effectuated.

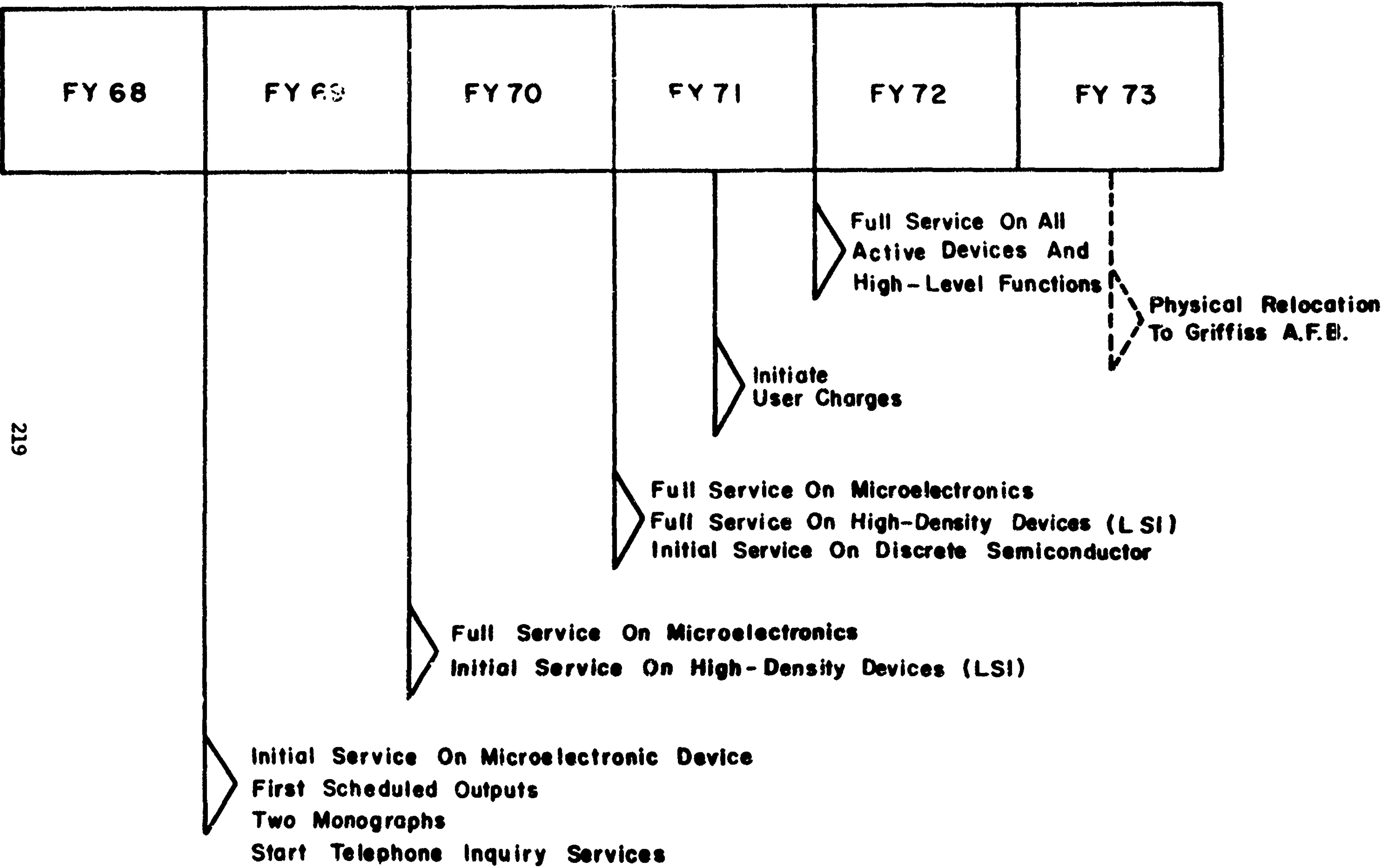

Figure 8. RELIABILITY ANALYSIS CENTER - IMPLEMENTATION SCHEDULE

During FY 1970 the Center will add to its files an existing collection of data relevant to discrete semiconductor devices, as well as collect up-to-date information for these devices. Data collection on low and high level microelectronic parts will, of course, proceed on a continuous basis. Additional services available at the end of FY 1970 include scheduled outputs and inquiry services on discrete semiconductor devices as well as services previously made available.

During FY 1971 the Center will initiate a transition from free services to a schedule of user charges. These charges will include an annual fee associated with scheduled outputs which will include moderate usage of the inquiry service. For complex or broad questions, the inquiry service will provide a schedule of charges specific to inquiries of this type. The Service Department operations of RAC is expected to be between 50% and 100% self-supporting by the end of FY 1971. At that time the Center will be prepared to provide full services on all devices within its charter.

During FY 1972 increasing usage of the Center and a continually increasing data base will justify increased computerization of the file and retrieval aspects of the operation, as well as for the production of tabular scheduled outputs. Meaningful savings in this area will be applied to a further increase of the professional competence of the staff as required by the analysis aspects of the Center. Dependent upon the availability at that time of an operational Generalized Data Management System at Griffiss Air Force Base, transfer of the data base to such a system can be initiated. All present data structures are and will continue to be designed in consonance with this objective.

During FY 1973 a physical transfer of the operation of RAC to Griffiss Air Force Base is under consideration.

7.3 Staffing and Organization

7.3.1 Staffing

Figure 9 shows a five-year staffing schedule in conformance with the implementation plan just described. Starting from present level of staff, RAC will increase to an eventual total staff of 18 over the five-year period. A high ratio of professionals to non-professionals is maintained throughout this period since the primary function of RAC is professional analysis and interpretation of the literature and of the data base. No difficulties are anticipated in attracting and holding a staff of exceptional competence under schedule shown in Figure 9.

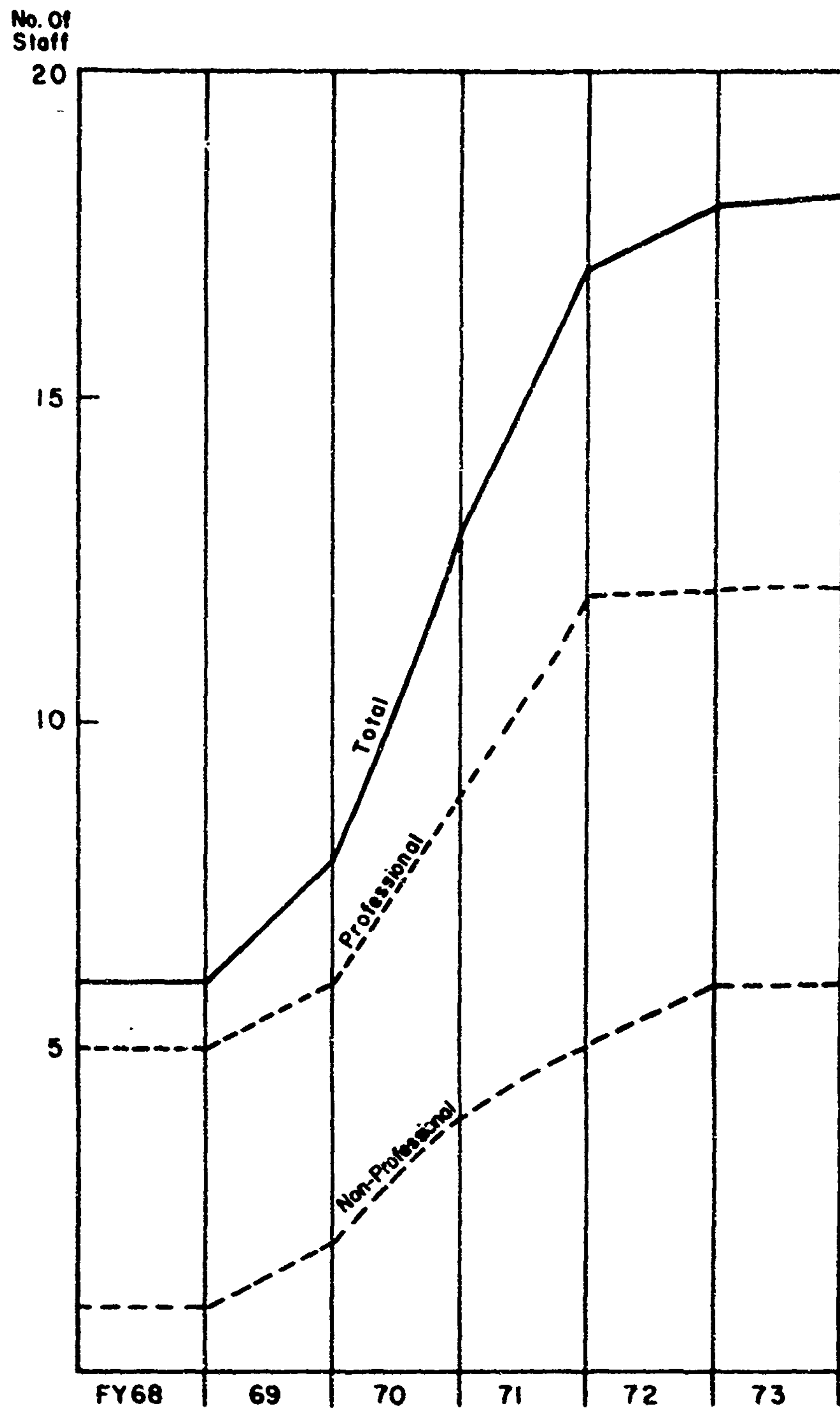

Figure 9. RELIABILITY ANALYSIS CENTER
5 - Year Staffing Schedule

7.3.2. Organization

The organizational structure of RAC will show an evolution appropriate to the implementation plans which have been described. Figure 10 illustrates this structure for FY 1970. Three departments are indicated. The first deals primarily with the documents and data as collected and effectuates their entry and retrieval as required by the activities of RAC.

The Technology Department is the center for the analysis and interpretation of the data and of the literature. It relies on the Files Department for retrieval of existing data, analyzes this data, and identifies and effectuates continued data collection to augment the files as required.

The Service Department is the liaison agent with the users. It generates and disseminates scheduled outputs based on the results of the Technology Department. It accepts and handles on an efficient basis direct user inquiries. Where these exceed in scope and complexity in the capabilities of the Service Department, the Technology Department will assist in the professional and prompt handling of such queries. In addition, the Service Department maintains continuous liaison with the user community and with other data exchange programs as appropriate.

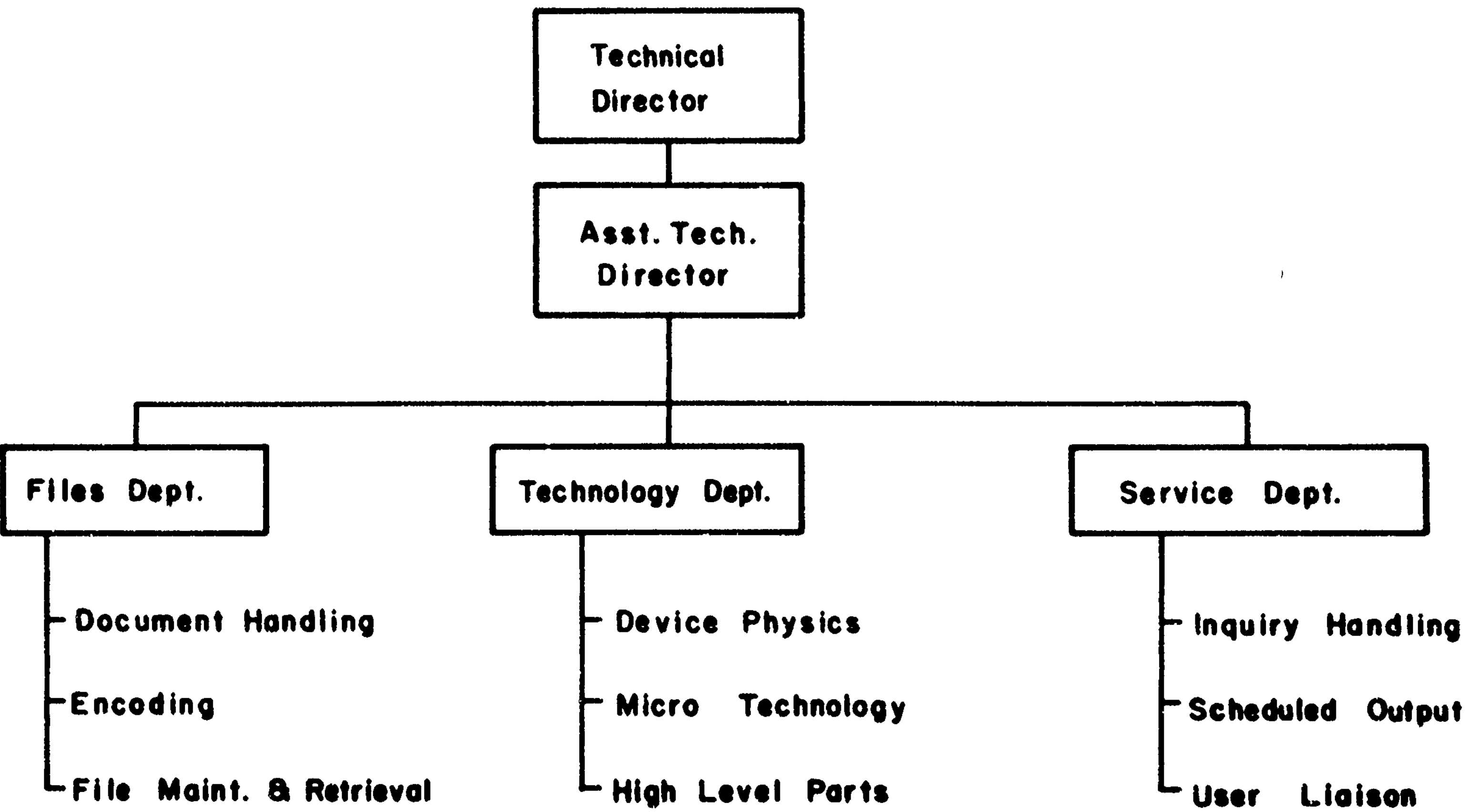

Figure 10. RELIABILITY ANALYSIS CENTER STRUCTURE FY 70

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13. ABSTRACT

The Reliability Analysis Center is being established as a Department of Defense Data Center for the collection, analysis, and dissemination of technical information on microelectronic device reliability. Its objective is to establish a basis for correlating reliability factors with device materials, design, fabrication, quality assurance and application factors. This report describes the development, implementation, and present status of a data collection and file entry effort supplemented by a Termetrex data retrieval system. Detailed operating procedures, periodic outputs, and user services from the Center are described in detail.

Future plans call for expansion of RAC into hybrid microelectronics and discrete semiconductors used in military weapons and communications systems.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Reliability Microelectronics Data Collection Data Processing Data Analysis						