NASA Contractor Report 2984

Development of Integrated Programs for Aerospace-Vehicle Design (IPAD) - Integrated Information Processing Requirements

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Development of Integrated Programs for Aerospace-Vehicle Design (IPAD) - Integrated Information Processing Requirements

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Prepared for
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and Space Administration

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FOREWORD

This document was developed as part of the Integrated Programs for Aerospace-Vehicle Design (IPAD) program documentation in accordance with contract NAS1-14700. Other closely related IPAD documents are:

NASA CR 2981	Reference Design Process (D6-IPAD-70010-D)
NASA CR 2982	Product Manufacture Interactions With the Design Process (D6-IPAD-70011-D)
NASA CR 2983	Product Program Management Systems (D6-IPAD-70035-D)
NASA CR 2985	IPAD User Requirements (D6-IPAD-70013-D)

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Measurements included in this document were not generated on the IPAD program; therefore, they are shown here in U. S. Customary units. A conversion table (U. S. to SI) is included in appendix C.

CONTENTS

TABLES

FIGURES

1.0 SUMMARY

This document presents the IPAD design requirements for integrated information processing. It is used in conjunction with CR 2985, the IPAD user requirements. Requirements covered by this document are summarized as:

Data Analysis--A data flow model based on a typical aerospace design process and a computing resources model representative of a large aerospace scientific data processing installation are described and analyzed. These models are referenced information and serve as a basis for estimating data volume and frequency. Parameters should be monitored to indicate when the IPAD computing system needs adjustment or new resources to improve performance.

General Data Management--This capability is provided by means of a single-source bank of current and historic information accessible to all users. This data, which is organized according to the structure of the organization that produced it, comprises a company resource enabling management to improve its operations by ensuring common access by all using organizations to a uniform information source that is continuously maintained and updated. Provisions are required for generation, storage, retrieval, communication, and maintenance of data in a distributed system.

Information Management--Requirements are specified for management of information at the element level as well as the set level, including a logical information model and definitions of data elements, relationship between data elements, and format of data sets. This allows for the retrieval of data elements or sets by users and computer programs based on relationships and/or values of specific elements or a range of element values.

Computer Program Management--This requirement includes a computer program library with provision for control of such programs and installation into IPAD. Computer programs will be executed as IPAD jobs. Each IPAD job will have sufficient library information installed with it to describe the job's purpose, input/out, and capabilities (abstract, keywords, etc.).

2.0 INTRODUCTION

The Integrated Programs for Aerospace-Vehicle Design (IPAD) system is envisioned to be a total system oriented to support the product design process. The IPAD system design must address 1) integrated information processing requirements and 2) user requirements.

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2.1 SCOPE

This document presents the integrated information processing requirements and is the result of IPAD WBS task 1.3. Document D6-IPAD-70013-D presents the system user requirements. Figure 1 illustrates the relationship of this document to other task 1 documents.

2.2 OBJECTIVES

The objective is to identify: 1) a reference data model; 2) management requirements for data storage, retrieval, generation, communication, and maintenance; 3) management requirements for definition and control of information; and 4) management requirements for computer programs.

2.3 APPROACH

This task was accomplished in accordance with NASA statement of work "Development of Integrated Programs for Aerospace Design (IPAD)," 1-15-4934A, Exhibit A, and the technical plan (D6-IPAD-70002-P). The staff assigned to IPAD WBS task 1.3 included engineers reassigned from tasks 1.1 (Reference Design Process) and 1.2 (Manufacture Interactions) and others with special skills in computing and geometry definition. In addition, Boeing engineers outside the direct contractual work organization were available to assist and critique the IPAD work.

A data flow model is presented in section 4.0. This model was constructed using a systematic modeling method and represents the data flow for subsonic transport based on project 1, described in section 6.0 of CR 2981 and the manufacturing interactions described and quantified in CR 2982. This model is for reference purposes to quantify the data flow of a typical aerospace product development.

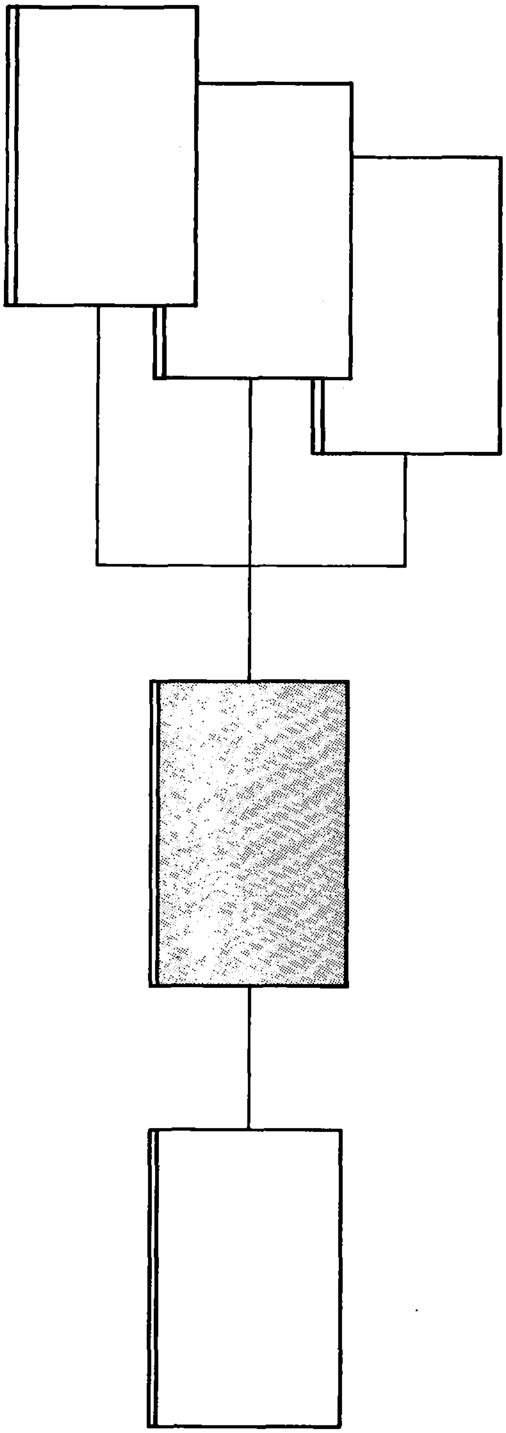

Figure 1.—Relationship of Task 1 Documents

Section 4.0 also includes a resources model based on typical aerospace scientific data processing. The model identifies system parameters which may be used by the information (data) bank administrator(s) to indicate adjustments required in the IPAD system to improve overall performance. They also can be used to indicate when additional host system resources, i.e., peripheral equipment and/or additional computers need to be added.

The primary IPAD management capabilities are intended to support construction and control of an integrated design process supported by an information bank and computer program library. Section 5.0 presents the general data management requirements at the level of sets and includes the principal requirements to define and manage a complex process such as the design process described in reference 3, the interactions with manufacturing described in reference 4 and the interface to product program management systems described in reference 5. Section 6.0 presents the principal requirements to define and manage information at the level of elements. Section 7.0 presents the principal requirements to define and manage a large library of computer programs used to perform the calculations which support design, analysis, and the technical definition of the product and its component parts.

It is intended that the management capabilities of IPAD provide the general tools required for any company to construct its unique design process, information bank, and computer program library.

Appendix A contains a list of typical questions which must be answered during the progress of a design development cycle of an aerospace product. These questions are for reference and are based on the subsonic transport, project 1, described in section 6.0 of CR 2981.

2.4 BACKGROUND

An aerospace vehicle manufacturing company develops a stream of products heavily dependent on historical experience. The complexity of modern products and greater specialization have resulted in poor communication between disciplines. Integrated systems have been developed to support some interdisciplinary technical analysis requirements but with limited consideration for management, communication, and control of information. Current attempts to handle this complex communication problem rely heavily on human resources. However, as the organization size and the volume of the data increase, the reliability of data and ability of humans to maintain control decrease. The critical factors in communication are the volume of information being managed, controlled, transmitted, or interpreted and the effect of the increasing volume on response time.

The problem is to achieve adequate technical depth within reasonable flow times and to consider functional relationships required to achieve understanding of the total vehicle. The limiting factors in obtaining adequate technical depth lie in quick and exact communication of technical information and the ability to iterate on the design, including all essential disciplines, until the design quality is fully established.

The reference design process presented in section 6.0 of CR 2981 described the design process as a system of activity levels related to the aerospace product development cycle. These activity levels should be interpreted only as a basis for definition of the design process. They do not imply a rigid design process, either in current existence or proposed for IPAD. Some such process is always used to logically plan and guide the work.

The characterization of the design process by levels is shown in figure 2. These levels provided a subdivision of the design environment and were used to group related activities into integrated design networks for each design level. The existing computer programs and required new programs to support these networks were identified. (See volume 5 of reference 1.)

The needs for computer-supported process planning, project planning, schedule planning, data and computer program management; and for management information have been identified. The IPAD feasibility studies (refs. 1 and 2) showed these needs for the aerospace industry. Reference 3 identifies similar needs for large civil engineering projects with project-type data. The computer support is required in the following areas:

Computer program library

Data definition and organization

Data manipulation

Data integrity and tracking

Data display (on-line interactive and off-line, both modes in previously defined display formats or in formats defined interactively)

Design process definition (level, activity, job)

Design project definition (task, subtask)

Project scheduling and critical path identification

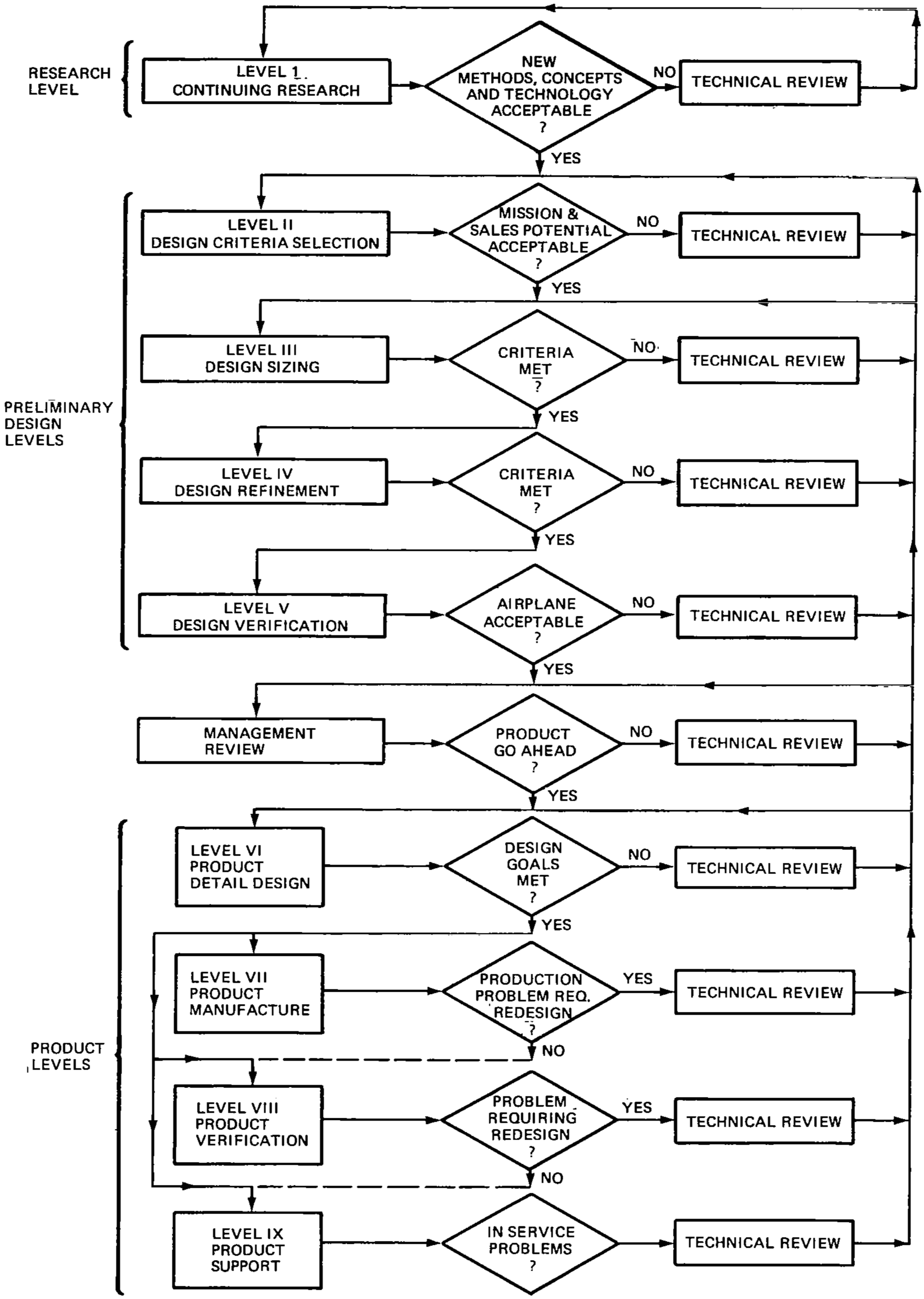

Figure 2.—Activity Levels

The capabilities described above must apply to classes of problems ranging from information retrieval to complex engineering analysis. It is therefore evident that a correspondingly wide range of information structures and data formats must be accommodated. One end of the user spectrum might be characterized by a request for a project status report showing relationship to stored plans, while at the other end an engineering analysis might take place involving mathematical operations such as matrix manipulation. Specifically, the data base must serve the entire class of users involved in the engineering design optimization effort.

In the above examples, the data structure and format required to support the project status report would be of a different nature than that of the engineering analysis. In the first case, the data structure might be a tree or hierarchy that models the project organization. The data elements would be formatted primarily as text or coded information. Access to the data would be directly via the named elements in the information structure, in which case, the user would explicitly address the elements of the data base structure. Adequate support of this class of data structure is available with existing data management systems (software).

In the engineering analysis case, the data might be more simply characterized as arrays of floating point numbers with no specific information structure other than the mathematical context in which they are to be used. In this case, the user implicitly provides the data structure via the logic of his program. The data is made available to the user at the level of files and records. There is no currently available data management system that concurrently supports both types of structures described above. The manipulation of this type of data must be performed entirely within the user program using conventional input/output and file management techniques. Therefore, an objective to provide support for both information and mathematical data types poses requirements that exceed the state of the art embodied in any one data management system. This wide variation in data types is illustrated in figure 3. The arrows pointing in opposite directions indicate a separation between data which is of a mathematical nature and that which is of an informational nature. Typically, the data contained in the sections labeled PART CONTROL and SUPPORT can be communicated to the user in the form of reports or in response to interactive queries. The reports and query responses must be informative for a wide variety of users ranging from high-level managers to warehouse clerks.

In contrast, data contained in the sections labeled NUMERICAL DEFINITION and DESIGN/ANALYSIS is most often used in mathematical algorithms. Most of this data is meaningful only in a mathematical sense to those engineers who are immediately involved in the overall design process. Even with divergent data types, communication and sharing of data is equally as important in the mathematical area as it is in the informational area. It follows that the structuring of data for common access is of equal importance in both areas.

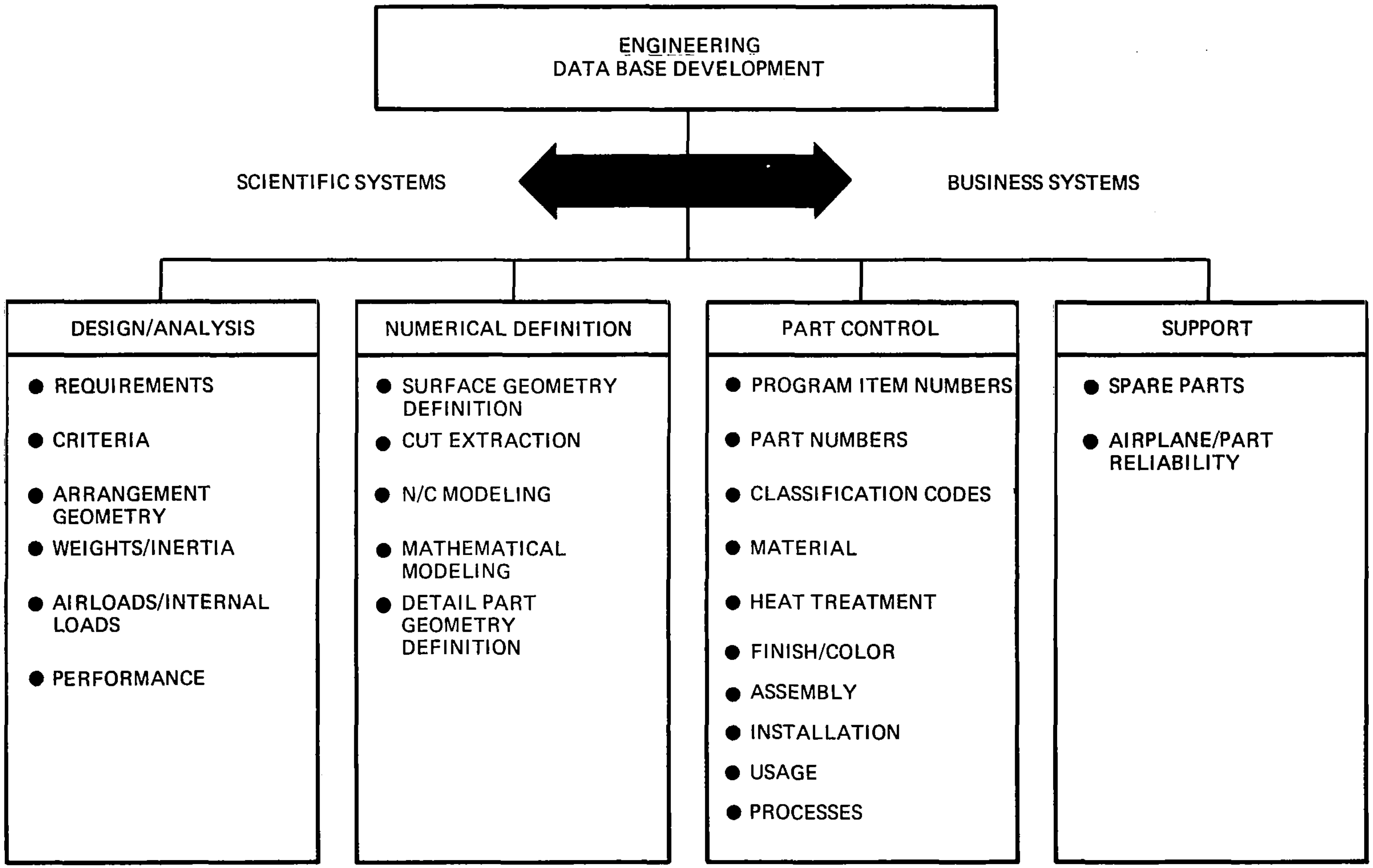

Figure 3.—Engineering Data Types

Historically, large investments have been made to support the development of informational systems. However, on the mathematical side, even though large investments have been made in the development of technical computer programs, little or no funding has been provided for data base development.

With the exception of engineering business data systems such as those for parts release, the predominent engineering computing practice is to obtain printed output of program execution and for some larger executions, such as lofting or structural analysis, a copy of the output will be stored on disk or tape for postprocessing. In the current situation, only a limited scientific computer data base exists and there is no formal organization. There are a few files set up with query capability, but these are generally limited to one discipline such as propulsion or geometry in design drafting systems.

The engineering computing environment can be characterized as:

Usually one user, one execution

Limited computing system records

Evolving to integrated processes

Using many language processors

Operating on many computing system configurations

The significant engineering computing problems can be summarized as:

Difficulty in tracking large quantities of data and programs

No capability to define scientific computing data outside of the language processor used to generate the data

Engineering is not using common data, resulting in duplication and inconsistencies

Poor computing facilities to transfer engineering data from programs to central storage and from central storage to other programs

Data is often not available in a format required by the next program, causing need for transformation and resulting in schedule slides

The apparent trends in engineering computing can be summarized as continued development of:

Integrated systems:

Involves several disciplines

No formal data base management

Limited consideration for expansion to include additional disciplines

Interactive capabilities:

Parts release

Product surface geometry

Input data preparation

Networks of satellite computers, each supporting several CAD/CAM work stations

Central data bases:

Parts release

Geometry

Design/analysis data

Implementation of distributed computing system with distributed data bases when computer operating systems can properly communicate

Effective communications are required to support the continued advancement of engineering computing. Standards in the following areas would improve communication of engineering data.

Data Definition Language--A national standard should be developed for a data definition language to support information management within scientific electronic data processing systems. The cooperation of the CODASYL Data Base Task Group (ref. 4) should be solicited so that the CODASYL standards for a FORTRAN oriented data definition language will incorporate the requirements to support scientific data processing.

FORTRAN--A national standard should be developed for a high level FORTRAN to reduce machine dependencies. For example, explicit precision should be supported so that the compiler will use double or triple precision on machines with various word sizes, i.e., 16, 32, 60 bit words. The work done by Control Data Corporation (ref. 1, volume IV, appendix C) in support of the IPAD feasibility study recommended an IPAD standard FORTRAN IPADF for current computers and IPADFV for computers with vector array processing capabilty. IPADF would be a subset of IPADFV. These FORTRAN compilers could be written in FORTRAN thus reducing machine dependencies.

Geometry--A national standard should be developed for generation, storage and communication of three-dimensional bounded geometry. This standard should support geometry modeling of surfaces and volumes (i.e., total vehicle and component parts), kinematics, and idealization for analysis (i.e., aerodynamics, structures, etc.). The American National Standard Institute (ref. 5) proposed standard is being developed to support communication of geometry data and should be extended to support geometry generation and storage.

Distributed Computing--A national standard is required for communications within a distributed computing system where computers of different manufacture and different word sizes can be linked in a common system. Control of the system would also be distributed so that the loss of one computer would result in shifting its work to the next available machine in the network which can handle the work.

The National Bureau of Standards work (ref. 6) in support of the Integrated Computer Aided Manufacturing (ICAM) being developed by the U.S. Air Force will identify existing standards applicable to computer aided manufacturing (CAM). This work should enhance development of communication between CAD and CAM systems.

3.0 ABBREVIATIONS

APU	Auxiliary power unit
AV EFF FL	Average effective field length
ICAM	Integrated computer-aided manufacturing
IPAD	Integrated Programs for Aerospace-Vehicle Design
IPADF	IPAD FORTRAN
IPADFV	IPAD FORTRAN - Vector processing
ID	Identification
I/O	Input/output
C	Computer (decision)
CAD	Computer-aided design
CALC	Calculated
CAM	Computer-aided manufacturing
CM	Central memory
CODASYL	Conference on data systems language
CP	Central processor
CRUS	Computer resources used
C/U	Computer/user (decision)
DDR	Drawing data record
DE	Data element
DR	Data relationship
EAMR	Engineering advance material release
EQ	Equal
KIT CH OUT	KRONOS interactive timesharing characters output
MS	Mass storage
MSA	Mass storage access

MSS	Mass storage sectors
MTU	Materials technology unit
OEW	Operating empty weight
ORIGIN TYP	Origin type
PIN	Program item number
RFP	Request for proposal
RUT	Resources utilization time
SAMM	Systematic activity modeling method
TTY CONNCT	Teletype connect
TTYCT	Teletype connect time
U	User (decision)
WBS	Work breakdown structure

4.0 DATA ANALYSIS

The purpose of this section is to define a data flow model that can serve as an estimate for frequency and volume of the data flow within a development program, typical of the aerospace industry and a typical computing resources model for scientific data processing. These models are presented as reference information only. The data flow model is based on a systematic activity modeling method (SAMM) developed by the Boeing Computer Services. The modeling was accomplished in a manual mode with no computer support. While this method would serve to meet the requirement to identify data flow paths established in section 5.3.2, it should not be construed as a user-specified solution for the data flow requirement. A rigorous evaluation of data flow modeling methods is required prior to selection of a method for implementation into the IPAD system. The resources model is described in terms of computing parameters which may be used by the information (data) bank administrator to indicate adjustments to improve overall efficiency. They can also be used to indicate when additional host system resources need to be added, i.e., peripheral equipment and/or additional computers.

4.1 DATA MODELING METHOD

The SAMM data modeling method begins with a top down hierarchical decomposition that is represented as a tree or node diagram of the type shown in figure 4. Each node represents a set of related activities that may or may not be supported by a computer process. The activity model layout shown in figure 5 is made for each node. Figure 6 illustrates a format to display external data flow at the boundary of the activity model. The format establishes a convention for forward input/output and feedback input/output. Similarly, figure 7 illustrates a format to identify internal data flow. In this example, data flow identified as 7 and 8 are forward output and become input to B and C respectively. Data 9 and 10 are feedback to A. Note that B has no forward output. Figure 8 illustrates the combined external and internal data flow. In this example, data flow should be interpreted as follows:

Data 1, 2 and 3	external forward input
Data 4 and 5	external feedback input
Data 20	external forward output
Data 19	external feedback output
Data 6-9 and 11-16	internal forward output
Data 10, 17 and 18	internal feedback output

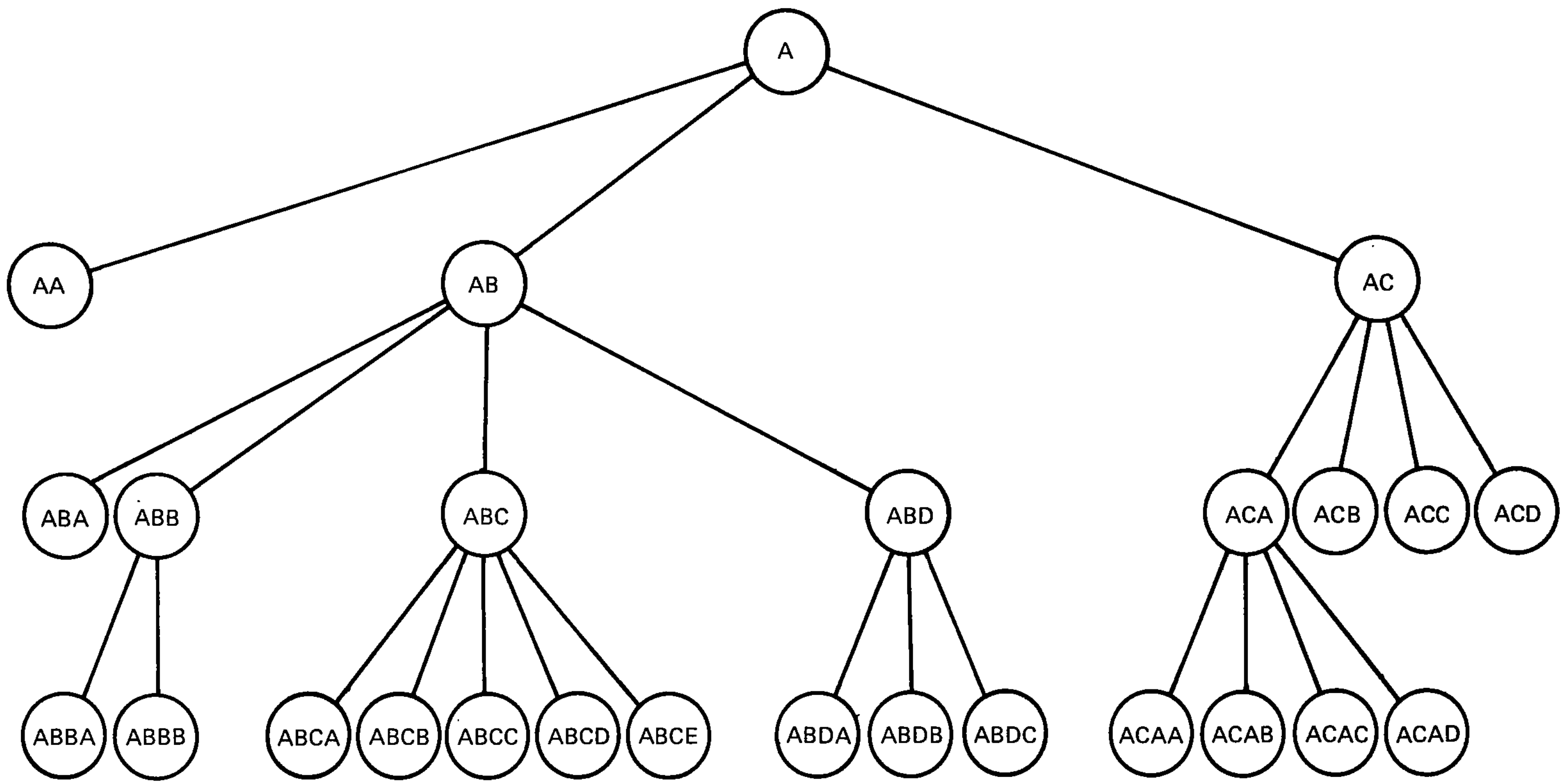

Figure 4.—Hierarchial Decomposition

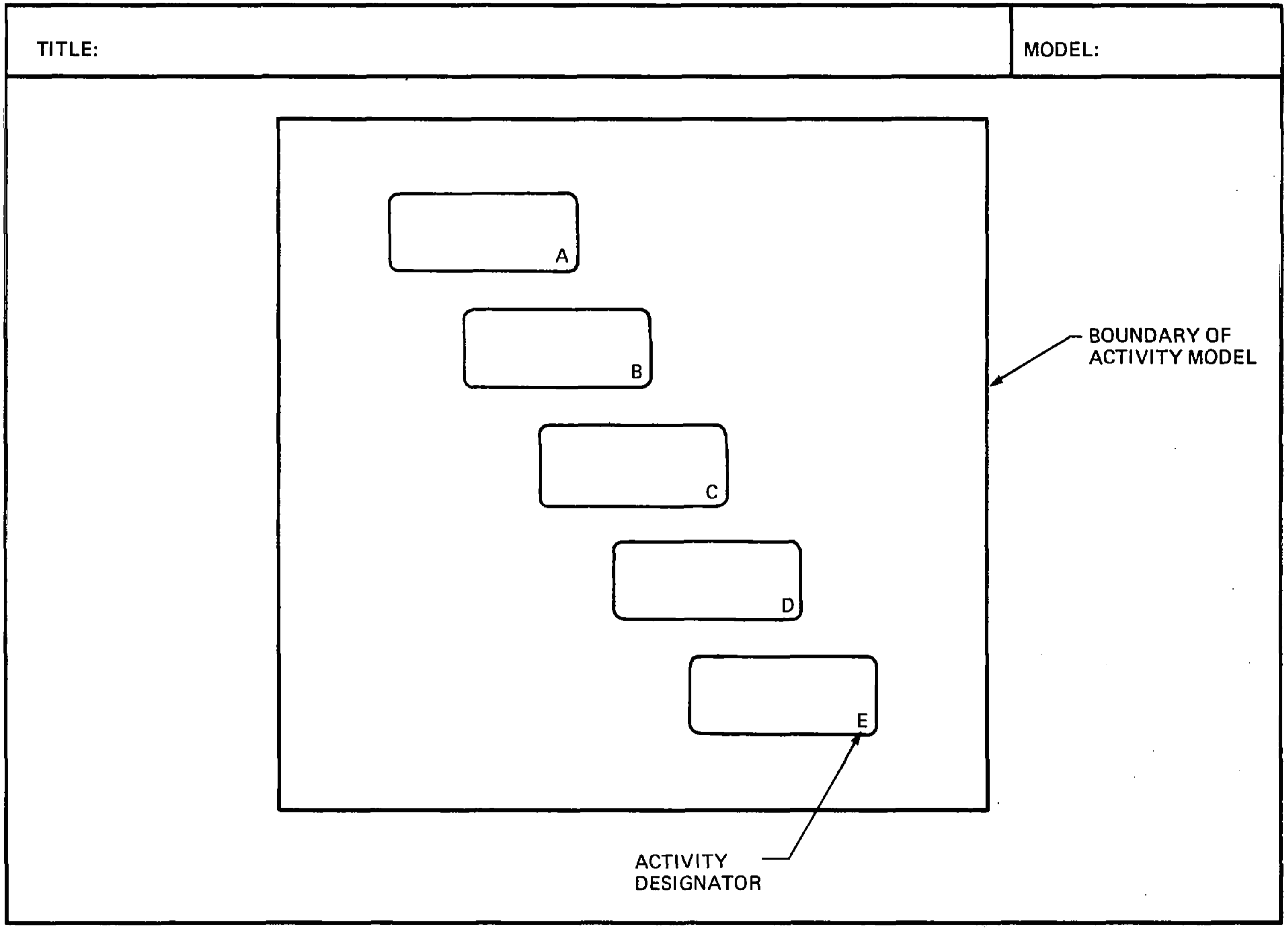

Figure 5.—Activity Model Layout

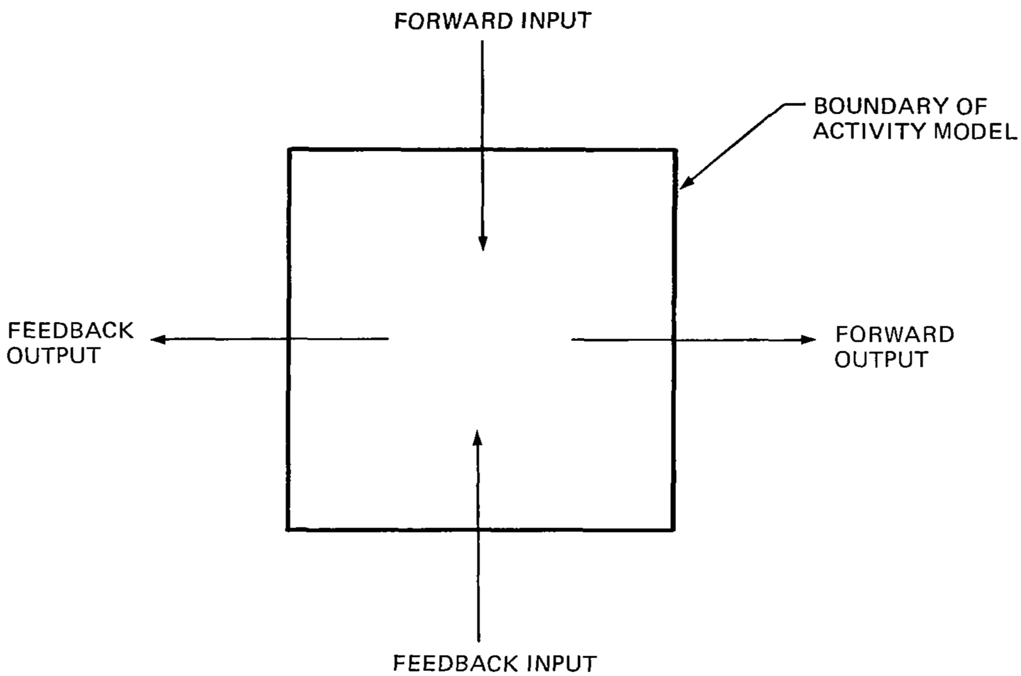

Figure 6.—Activity Model External Data Flow Format

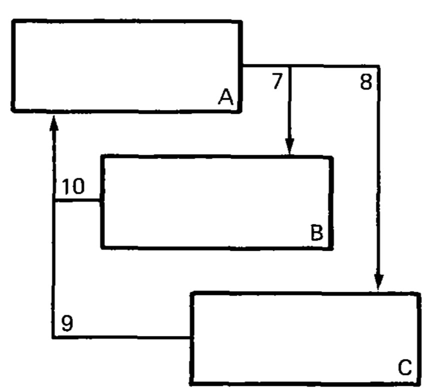

Figure 7.—Activity Model Internal Data Flow Format

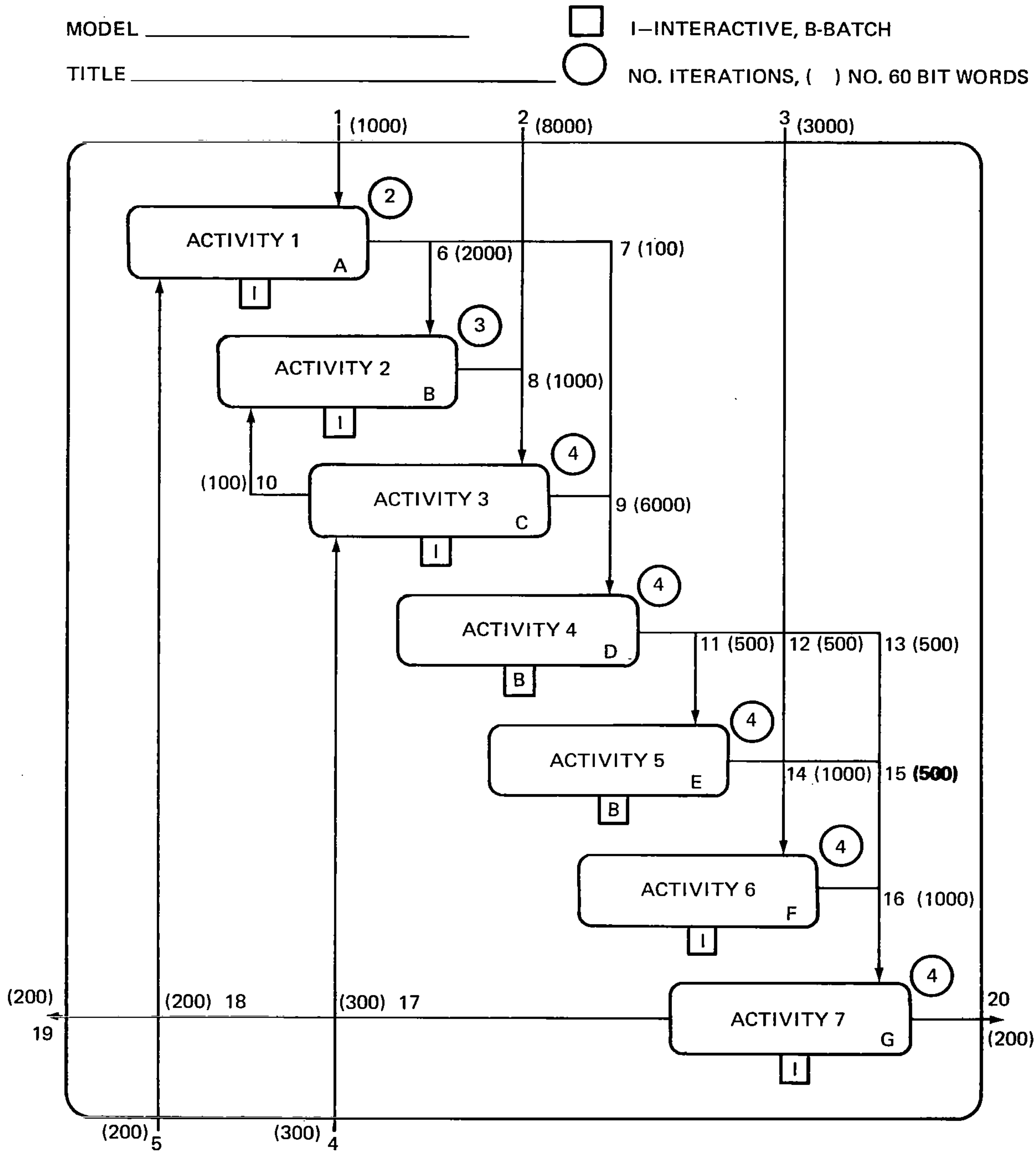

Figure 8.—Activity Model Data Flow and Volume Format

The data flow volume is identified by a number enclosed in parenthesis located adjacent to the data ID number. This represents the number of 60-bit words transferred on a computer of the CDC 6600 type. In addition, the number of iterations of each activity is enclosed in a circle and is estimated for an entire development program, i.e.,conceptual design, preliminary design, detail design and production phases of a product development cycle. The type of computing support is identified as predominently interactive or batch. (It should be assumed that data preparation will be interactive for the activities supported by batch computing.)

4.2 EXAMPLE DATA MODEL

A data model for a subsonic commercial transport has been developed based on Project 1 described in section 6.0 of D6-IPAD-70010-D. Figure 9 shows the hierarchical decomposition and the relationships to the nine IPAD design levels. IPAD levels I, II, VII, VIII, and IX were completed with only one SAMM model for each level. IPAD levels III, IV, V, and VI were decomposed into additional models.

The data models together with descriptive information of the data flow are presented in figures 10 through 35. The descriptive data includes the data identification and title. Also, if applicable, a decomposition trace shows relationship to the data flow identified on the preceding (higher) data model. In addition, the origin and destination are shown for data to identify lateral data transfers between data models. The data flow quantification is in terms of 60-bit data words and is based on the computer program input/output specified in volume V of reference 6 and the quantification of data sets for drawings identified in reference 4.

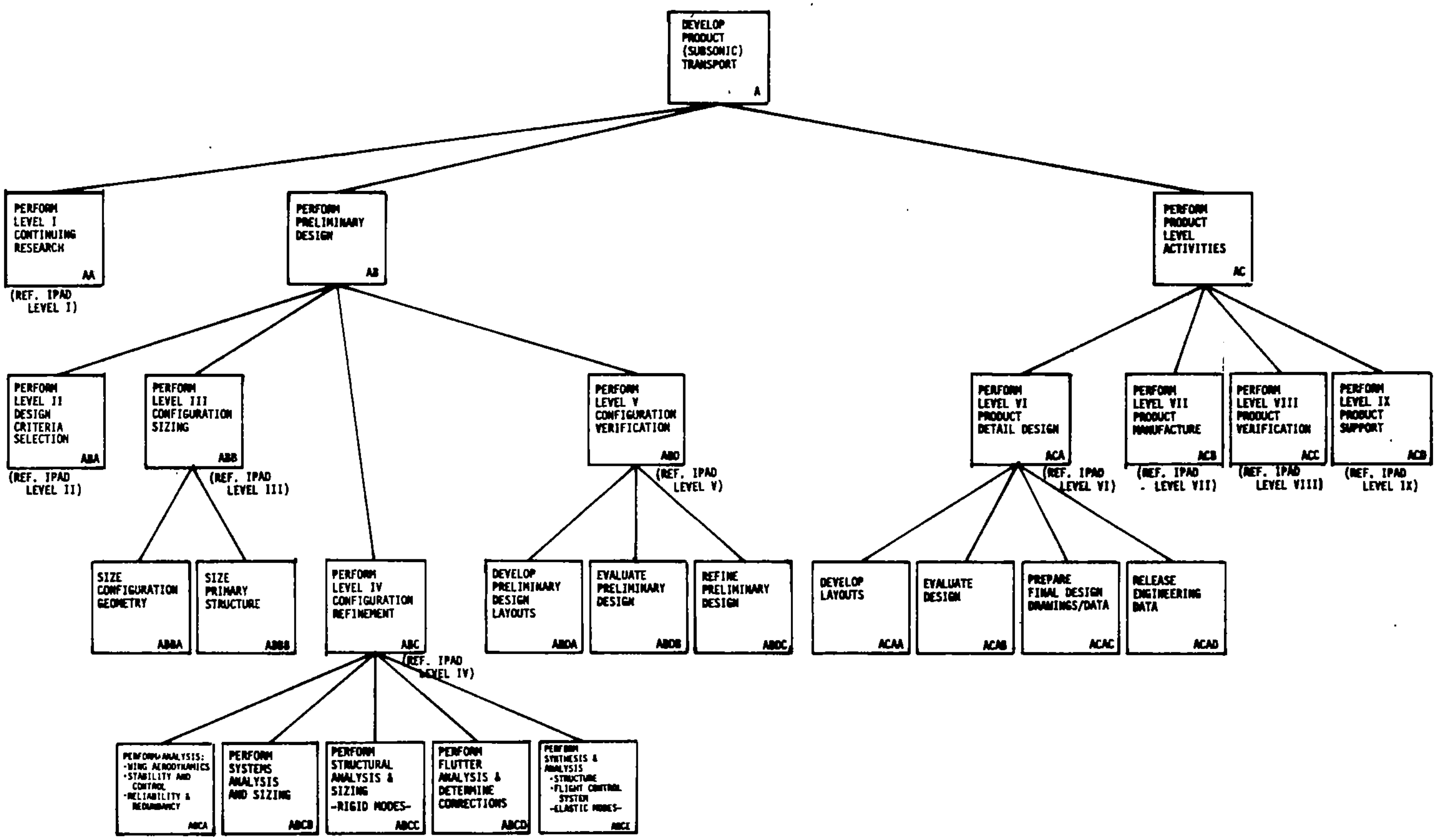

Figure 9.—Data Flow Hierarchial Decomposition (Subsonic Transport)

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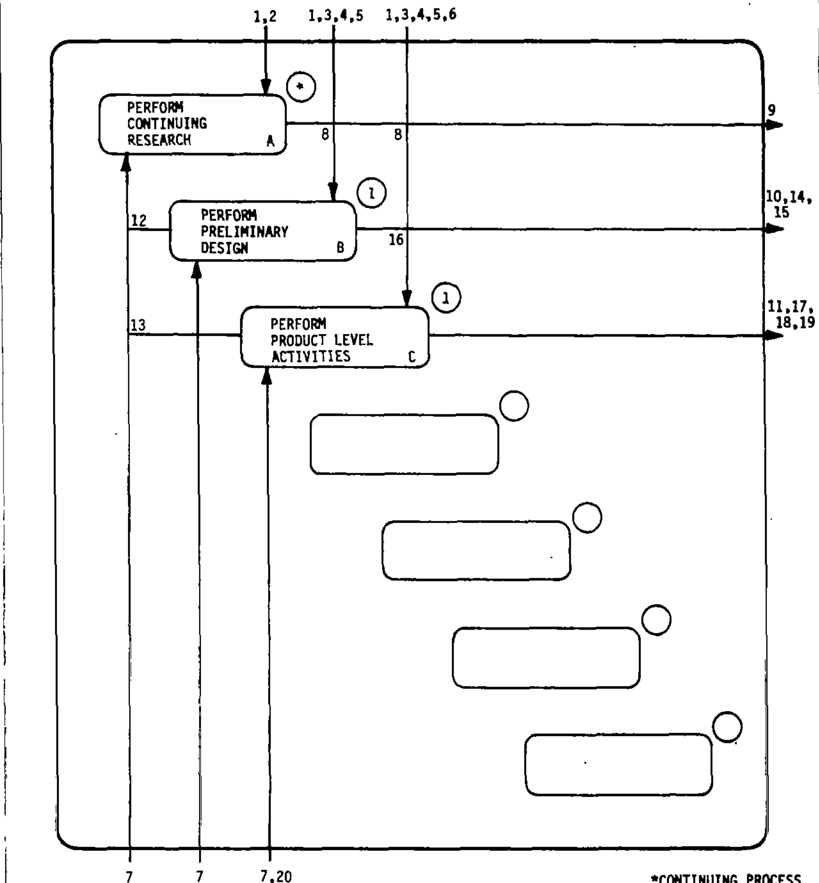
TITLE DEVELOP PRODUCT (SUBSONIC TRANSPORT) ◯ NO. ITERATIONS,

FIGURE 2.2-2
MODEL A

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1	EXT	-	CORPORATE POLICIES AND DIRECTIVES
2	EXT	-	CORPORATE RESEARCH GOALS
3	EXT	-	REGULATORY REQUIREMENTS
4	EXT	-	TECHNICAL DATA (UNIVERSITIES, INDUSTRY, AGENCIES, CUSTOMERS, ETC.)
5	EXT	-	MARKETING INFORMATION
6	EXT	-	CUSTOMER ORDERS
7	EXT	-	PRODUCT PERFORMANCE DATA
8	-	-	METHODS AND ADVANCED TECHNOLOGY
9	-	AA/EXT	TECHNICAL PUBLICATIONS, ETC.
10	-	AB/EXT	TECHNICAL PUBLICATIONS, ETC.
11	-	AC/EXT	TECHNICAL PUBLICATIONS, ETC.
12	-	-	REQUESTS FOR RESEARCH (NEW TECHNOLOGY, APPLICATION PROBLEMS, ETC.)
13	-	-	REQUESTS FOR RESEARCH
14	-	AB/EXT	POTENTIAL PRODUCTS
15	-	AB/EXT	LONG LEAD ITEMS
16	-	-	PRELIMINARY PRODUCT TECHNICAL DEFINITION
17	-	AC/EXT	FINISHED PRODUCT
18	-	AC/EXT	OPERATIONAL AND MAINTENANCE PROCEDURES
19	-	AC/EXT	SPARES
20	EXT	-	CERTIFICATION



*CONTINUING PROCESS

Figure 10.—Data Model A — Develop Product (Subsonic Transport)

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TITLE PERFORM LEVEL I CONTINUING RESEARCH ◯ NO. ITERATIONS, FIGURE 2.2-3 MODEL AA

DATA I.D.	DECOMP. TRACE	ORIG./ DEST.	DATA DESCRIPTION (DATA FLOW)
1	1	-	CORPORATE POLICIES AND DIRECTIVES
2	2	-	CORPORATE RESEARCH GOALS
3	4	-	TECHNICAL DATA (GENERAL RELATIONSHIPS, HYPOTHESIS, ETC.)
4	12	-	REQUESTS FOR RESEARCH (NEW TECHNOLOGY, APPLICATION PROBLEMS, ETC.)
5	7	-	PRODUCT PERFORMANCE DATA
6	9	AAA/EXT	TECHNICAL PUBLICATIONS - SCIENTIFIC RESEARCH
7	9	AAA/EXT	TECHNICAL PUBLICATIONS - APPLIED ARTS
8	-	-	THEORETICAL MODELS
9	8	-	METHODS AND ADVANCED TECHNOLOGY

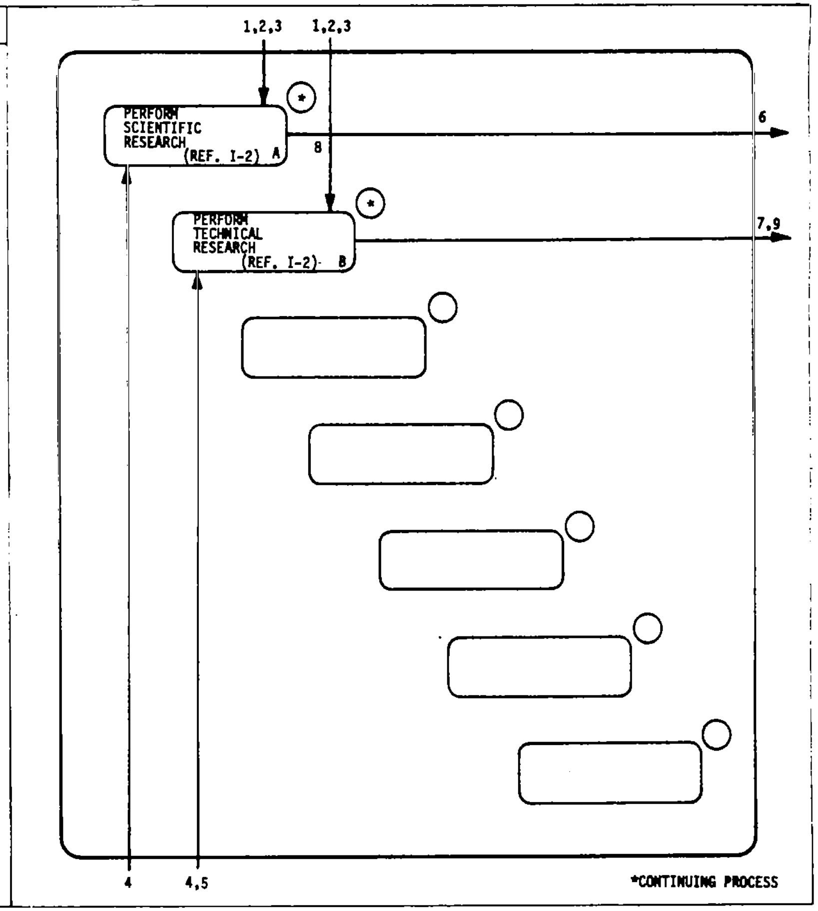

Figure 11.—Data Model AA — Perform Level I Continuing Research

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TITLE PERFORM LEVEL II DESIGN CRITERIA SELECTION

☐ I - INTERACTIVE, B - BATCH

◯ NO. ITERATIONS. ( ) NO. 60 BIT WORDS

FIGURE 2.2-5

MODEL ABA

DATA I.D.	DECOMP TRACE	ORIG/ DEST.	DATA DESCRIPTION (DATA FLOW)
1	1	-	CORPORATE POLICIES AND DIRECTIVES
2	2	-	TECHNICAL DATA (CUSTOMER)
3	3	-	MARKETING INFORMATION
4	4	-	REGULATORY REQUIREMENTS
5	5	-	PRODUCT PERFORMANCE DATA
6	6	-	METHODS AND ADVANCED TECHNOLOGY
7	22	-	POTENTIAL DEFICIENCIES - DESIGN CRITERIA (LEVEL III)
8	23	-	POTENTIAL DEFICIENCIES - DESIGN CRITERIA (LEVEL IV)
9	24	-	POTENTIAL DEFICIENCIES - DESIGN CRITERIA (LEVEL V)
10	-	ABAA/ ABBAF	TOTAL AIRCRAFT REQUIRED (FUNCTION OF SIZE RANGE AND OPERATING COSTS
11	-	ABAA/ ABBAF	MARKET ENVIRONMENT (FUNCTION OF LIMITATIONS, COMPETITION, GROWTH, TRAFFIC, ETC.)
12	-	ABAB/ ABBAA	DESIGN MISSION (PAYLOAD, RANGE, CRUISE ALTITUDE, APPROACH SPEED, FIELD LENGTH, ETC.)
13	-	ABAC/ ABBBA	PRODUCT CONFIGURATION DEFINITION (LEVEL II)
14	-	ABAC ABBBA	CONFIGURATION DESIGN SELECTION DATA
15	-	-	DEFICIENCY IN DESIGN MISSION (CONFIGURATION)
16	-	-	DEFICIENCY IN DESIGN MISSION (MARKET)
17	-	-	DEFICIENCY IN DESIGN MISSION (CRITERIA)
18	-	ABAD/ ABBBF	COSTS (NON-RECURRING, RECURRING, AND OPERATING)
19	-	ABAD/ ABBBF	RETURN ON INVESTMENT
20	-	ABAD/ ABBBF	TIME EFFECTS ON COST (PRICE VARIATIONS, PRODUCTION RATE VARIATIONS)
21	-	ABA/EXT	ROUTE SUITABILITY
22	-	-	POTENTIAL DEFICIENCIES IN PRODUCT (MARKET)
23	-	-	POTENTIAL DEFICIENCIES IN PRODUCT (CRITERIA)
24	7	ABA/EXT	DESIGN CRITERIA
25	8	ABA/EXT	TECHNICAL DOCUMENTATION (LEVEL II)

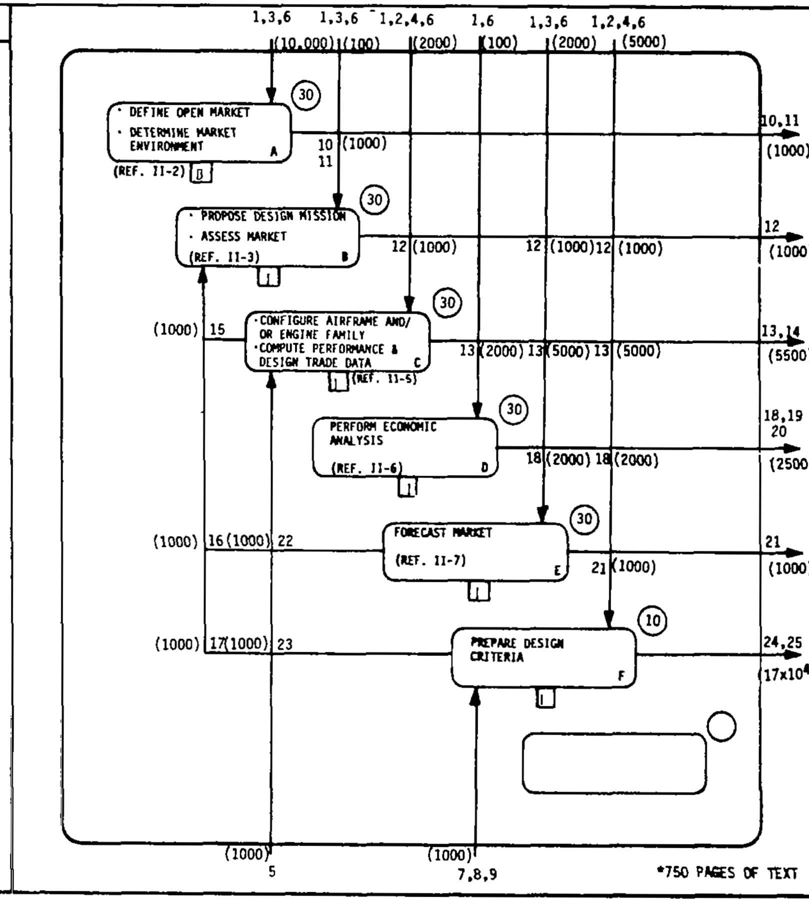

Figure 12.—Data Model AB – Perform Preliminary Design

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PERFORM PRELIMINARY DESIGN

NO. ITERATIONS,

FIGURE 2.2-4

AB

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1	1	-	CORPORATE POLICIES AND DIRECTIVES
2	4	-	TECHNICAL DATA (CUSTOMER)
3	5	-	MARKETING INFORMATION
4	3	-	REGULATORY REQUIREMENTS
5	7	-	PRODUCT PERFORMANCE DATA
6	8	-	METHODS AND ADVANCED TECHNOLOGY
7	-	ABA/EXT	DESIGN CRITERIA
8	-	ABA/EXT	TECHNICAL DOCUMENTATION (LEVEL II)
9	-	ABB/EXT	TECHNICAL DOCUMENTATION (LEVEL III)
10	-	ABC/EXT	TECHNICAL DOCUMENTATION (LEVEL IV)
11	-	ABD/EXT	TECHNICAL DOCUMENTATION (LEVEL V)
12	-	-	DESIGN/ANALYSIS DATA (LEVEL II)
13	-	-	DESIGN/ANALYSIS DATA (LEVEL III)
14	-	-	DESIGN/ANALYSIS DATA (LEVEL IV)
15	-	ABD/EXT	DESIGN/ANALYSIS DATA (LEVEL V)
16	-	-	MARKET/FINANCE DATA (LEVEL II)
17	-	-	MARKET/FINANCE DATA (LEVEL III)
18	-	-	MARKET/FINANCE DATA (LEVEL IV)
19	-	ABD/EXT	MARKET/FINANCE DATA (LEVEL V)
20	-	ABD/EXT	DEFINITION - DEVELOPMENT TESTING
21	-	-	RESULTS - DEVELOPMENT TESTING
22	-	-	POTENTIAL DEFICIENCIES - DESIGN CRITERIA (LEVEL III)
23	-	-	POTENTIAL DEFICIENCIES - DESIGN CRITERIA (LEVEL IV)
24	-	-	POTENTIAL DEFICIENCIES - DESIGN CRITERIA (LEVEL V)
25	-	-	POTENTIAL DEFICIENCIES - PRODUCT (LEVEL IV)
26	-	-	POTENTIAL DEFICIENCIES - PRODUCT (LEVEL IV)

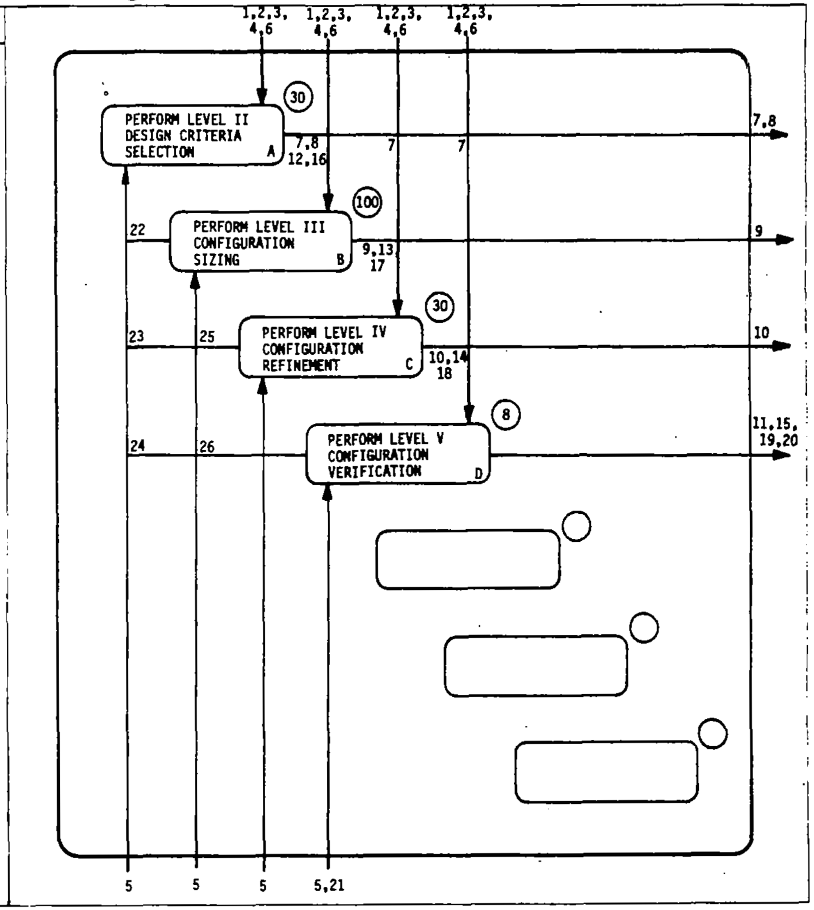


Figure 13.—Data Model ABA — Perform Level II Design Criteria Selection

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM LEVEL III CONFIGURATION SIZING

☐ I - INTERACTIVE, B - BATCH

◯ NO. ITERATIONS, ( ) NO. 60 BIT WORDS

FIGURE 2.2-6

MODEL ABB

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1	1	-	CORPORATE POLICIES AND DIRECTIVES
2	2	-	TECHNICAL DATA (CUSTOMER)
3	3	-	MARKETING INFORMATION
4	4	-	REGULATORY REQUIREMENTS
5	5	-	PRODUCT PERFORMANCE DATA
6	6	-	METHODS AND ADVANCED TECHNOLOGY
7	7	-	DESIGN CRITERIA
8	8	-	TECHNICAL DOCUMENTATION (LEVEL II)
9	12	-	DESIGN/ANALYSIS DATA (LEVEL II)
10	16	-	MARKET/FINANCE DATA (LEVEL II)
11	25	-	POTENTIAL DEFICIENCIES - PRODUCT (LEVEL IV)
12	26	-	POTENTIAL DEFICIENCIES - PRODUCT (LEVEL V)
13	9	ABBD/EXT	TECHNICAL DOCUMENTATION (LEVEL III)
14	13	ABBD/EXT	DESIGN/ANALYSIS DATA (LEVEL III)
15	17	ABBD/EXT	MARKET/FINANCE DATA (LEVEL III)
16	22	ABBD/ ABAF	POTENTIAL DEFICIENCIES - DESIGN CRITERIA (LEVEL III)
17	-	ABBA/ ABCCD	PRODUCT CONFIGURATION DEFINITION (LEVEL III)
18	-	-	AERODYNAMIC, WEIGHT, STABILITY AND CONTROL DATA (LEVEL III)
19	-	-	FINANCE AND MARKET DATA (LEVEL III)
20	-	ABBB/ ABCCD	PRIMARY STRUCTURE DEFINITION (LEVEL III)
21	-	-	NOISE CONTOURE DATA

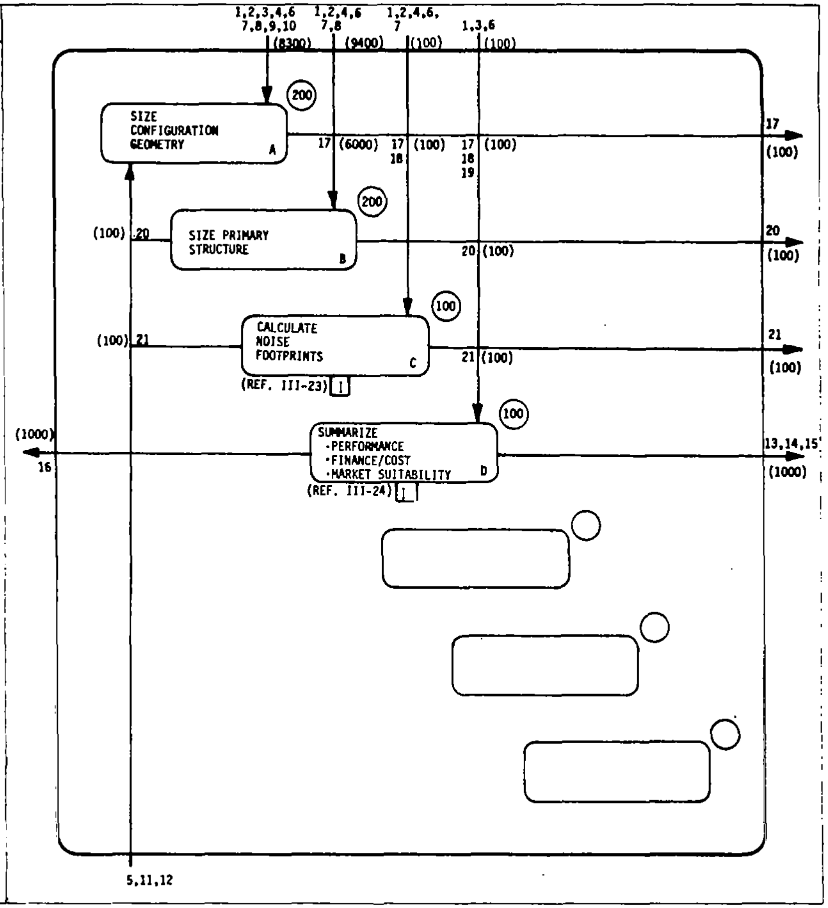


Figure 14.—Data Model ABB — Perform Level III Configuration Sizing

BCS BOEING COMPUTER SERVICES INC

TITLE SIZE CONFIGURATION GEOMETRY

I - INTERACTIVE, B - BATCH
◯ NO. ITERATIONS, ( ) NO. 60 BIT WORDS

FIGURE 2.2-7
MODEL ABBA

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1	1	-	CORPORATE POLICIES AND DIRECTIVES
2	2	-	TECHNICAL DATA (CUSTOMER)
3	3	-	MARKETING INFORMATION
4	4	-	REGULATORY REQUIREMENTS
5	5	-	PRODUCT PERFORMANCE DATA
6	6	-	METHODS AND ADVANCED TECHNOLOGY
7	7	-	DESIGN CRITERIA
8	8	-	TECHNICAL DOCUMENTATION (LEVEL II)
9	9	-	DESIGN/ANALYSIS DATA (LEVEL II)
10	10	-	MARKET/FINANCE DATA (LEVEL II)
11	11	-	POTENTIAL DEFICIENCIES - PRODUCT (LEVEL IV)
12	12	-	POTENTIAL DEFICIENCIES - PRODUCT (LEVEL V)
13	20	ABBBA/ ABBAA	PRIMARY STRUCTURE DEFINITION (LEVEL III)
14	21	ABBC/ ABBAE	NOISE CONTOURE DATA (LEVEL III)
15	-	ABBAA/ ABBBA	GENERAL ARRANGEMENT
16	-	ABBAB/ ABBD	CRUISE PERFORMANCE, FUEL BURNED AND ALLOWABLE OEW
17	-	ABBAB/ ABBD	INITIAL CRUISE ALTITUDE AND SPEED, AND BUFFET MARGINES
18	-	ABBAC/ ABBBE	WEIGHT AND BALANCE
19	-	-	CONFIGURATION DEFICIENCY (WING SIZE AND/OR POSITION, TAIL SIZE)
20	-	-	MAIN GEAR POSITION AND AERODYNAMIC C. G. LIMITS
21	-	-	CONFIGURATION DEFICIENCY (CONTROL SURFACE SIZE)
22	-	ABBAE/ ABBD	CLIMB PERFORMANCE, THRUST REQUIRED, APPROACH SPEED
23	-	-	CONFIGURATION DEFICIENCY (THRUST AND/OR WING SIZE)
24	-	ABBBF/ ABBD	ROUT SUITABILITY
25	-	ABBBF/ ABBD	COSTS (NON-RECURRING, RECURRING, AND OPERATING)
26	-	ABBBF/ ABBD	RETURN ON INVESTMENT
27	-	ABBBF/ ABBD	TIME EFFECTS ON COST (PRICE VARIATIONS, PRODUCTION RATE VARIATIONS)
28	-	ABBBA/ ABBAA	CONFIGURATION DEFICIENCY - PRIMARY STRUCTURE
29	-	ABBBE/ ABBAA	CONFIGURATION DEFICIENCY - WEIGHT AND BALANCE

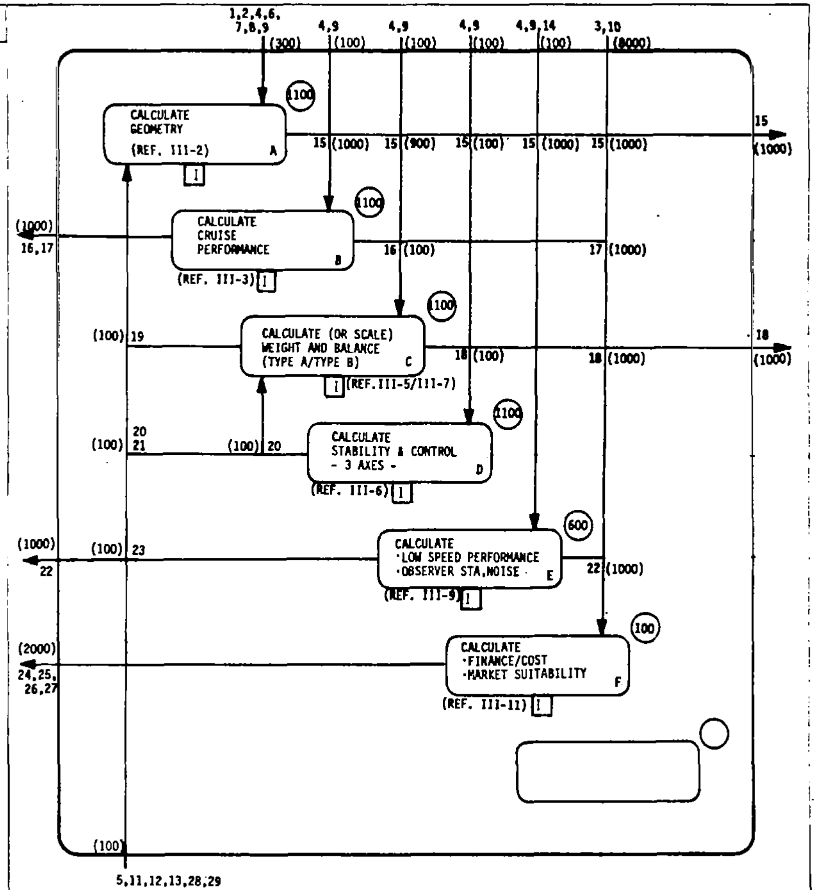


Figure 15.—Data Model ABBA — Size Configuration Geometry

BCS BOEING COMPUTER SERVICES INC

TITLE SIZE PRIMARY STRUCTURE

☐ I - INTERACTIVE, B - BATCH

◯ NO. ITERATIONS, ( ) NO. 60 BIT WORDS

FIGURE 2.2-8

MODEL ABBB

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1	1	-	CORPORATE POLICIES AND DIRECTIVES
2	2	-	TECHNICAL DATA (CUSTOMER)
3	7	-	DESIGN CRITERIA
4	4	-	REGULATORY REQUIREMENTS
5	8	-	TECHNICAL DOCUMENTATION (LEVEL II)
6	6	-	METHODS AND ADVANCED TECHNOLOGY
7	17	ABBAA/ ABBBA	PRODUCT CONFIGURATION DEFINITION (LEVEL III)
8	20	ABBBA/ ABCCD	STRUCTURAL CONCEPTS AND ARRANGEMENTS
9	9	ABBBB/ ABCCE	INERTIA AND WEIGHT DISTRIBUTIONS
10	9	-	STATIC LOADS (FORMULA GUST)
11	9	-	FLEXIBILITY CHANGE
12	-	-	DEFICIENCIES IN STRUCTURAL CONCEPT OR ARRANGEMENT
13	20	ABBBD/ ABCCB	PRIMARY STRUCTURE BENDING MATERIAL REQUIRED
14	9	ABBBE/ ABBAA	WEIGHT, BALANCE AND LOADABILITY DATA
15	9	-	FLUTTER MATRICES
16	9	ABBBG/ ABCBD	FLUTTER CLEARANCE
17	-	ABBBA/ ABBAA	POTENTIAL DEFICIENCY - PRIMARY STRUCTURE

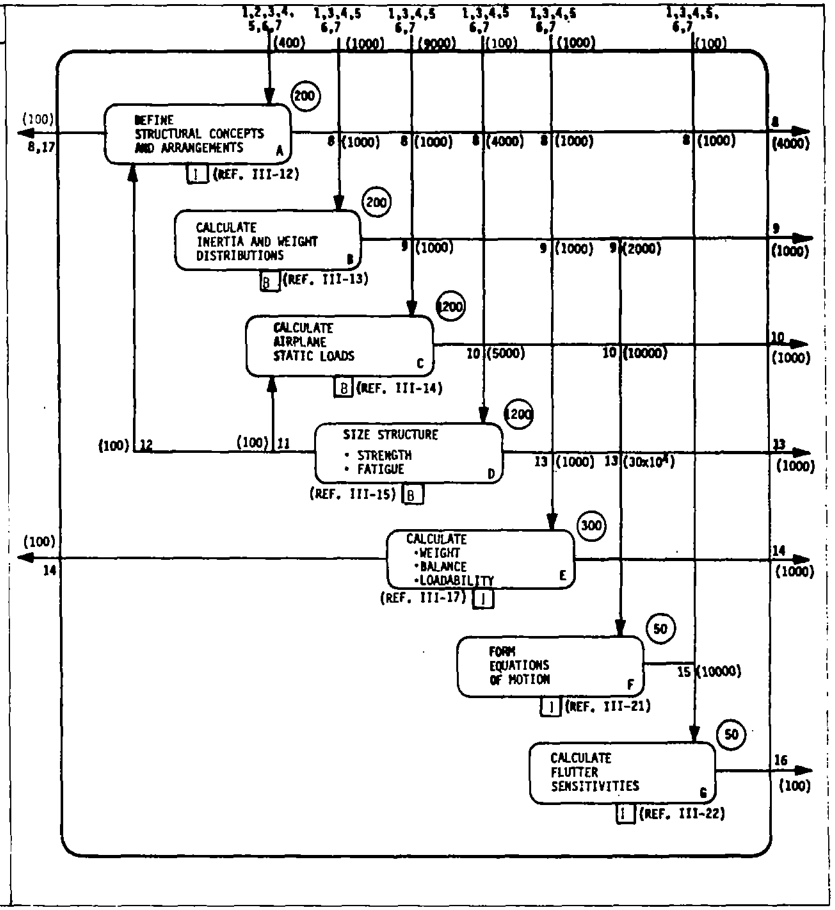


Figure 16.—Data Model ABBB – Size Primary Structure

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM LEVEL IV CONFIGURATION REFINEMENT ◯ NO. ITERATIONS, ( ) NO. 60 BIT WORDS

FIGURE 2.2-9
MODEL ABC

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1	1	EXT	CORPORATE POLICIES AND DIRECTIVES
2	2	EXT	TECHNICAL DATA (CUSTOMER)
3	3	EXT	MARKETING INFORMATION
4	4	EXT	REGULATORY REQUIREMENTS
5	5	EXT	PRODUCT PERFORMANCE DATA
6	6	EXT	METHODS AND ADVANCED TECHNOLOGY
7	7	EXT	DESIGN CRITERIA
8	9	EXT	TECHNICAL DOCUMENTATION (LEVEL III)
9	13	EXT	DESIGN/ANALYSIS DATA (LEVEL III)
10	17	EXT	MARKET/FINANCE DATA (LEVEL III)
11	16	ABCAA/ ABDAA	WIND TUNNEL MODEL DATA
11	16	ABCAB/ ABDAA	WIND TUNNEL MODEL DATA
12	18	ABCAD/ ABCBA	CONTROL SYSTEM INTERNAL LOADS
13	16	ABCBF/ ABCFA	UPDATED WEIGHT AND BALANCE DATA
14	17	ABCBD/ ABBAA	INSTALLED THRUST AND SPECIAL FUEL CONSUMPTION DATA (UNSATISFACTORY)
15	16	ABCBF/ ABCCA	UPDATED WEIGHT AND BALANCE DATA
16	15	ABCCD/ ABDAA	STRUCTURAL MEMBER CHANGES AND ADDITIONS
17a	24	ABCCA/ ABCDE	EXTERNAL LOADS
17b	25	ABCCB/ ABCDD	STRUCTURAL SIZING
17c	18	ABCCE/ ABCDA	WEIGHT DATA
18	23	ABCCE/ ABBAA	WEIGHT DATA
19	25	ABCDG/ ABBAA	WEIGHT DATA
20a	24	ABCDD/ ABCED	WEIGHT DATA
20b	26	ABCDF/ ABCEG	WEIGHT DATA
20c	20	ABCDG/ ABCEE	WEIGHT DATA
20d	20	ABCDG/ ABCEA	WEIGHT DATA
21a	24	ABCEC/ ABDA	STATIC LOADS DATA
21b	23	ABCED/ ABDA	STRUCTURAL SIZING DATA
21c	25	ABCEE/ ABDA	WEIGHT DATA
21d	22	ABCEG/ ABDA	FLIGHT CONTROL SYSTEM PERFORMANCE
22	20	ABCEE/ ABCDA	WEIGHTS DATA
23	20	ABCEE/ ABBAA	WEIGHTS DATA
24	19	ABCEG/ ABCAB	FLIGHT CONTROL SYSTEM PERFORMANCE
25	-	EXT	MATERIAL SPECIFICATION
26	-	-	MANAGEMENT DECISION DATA

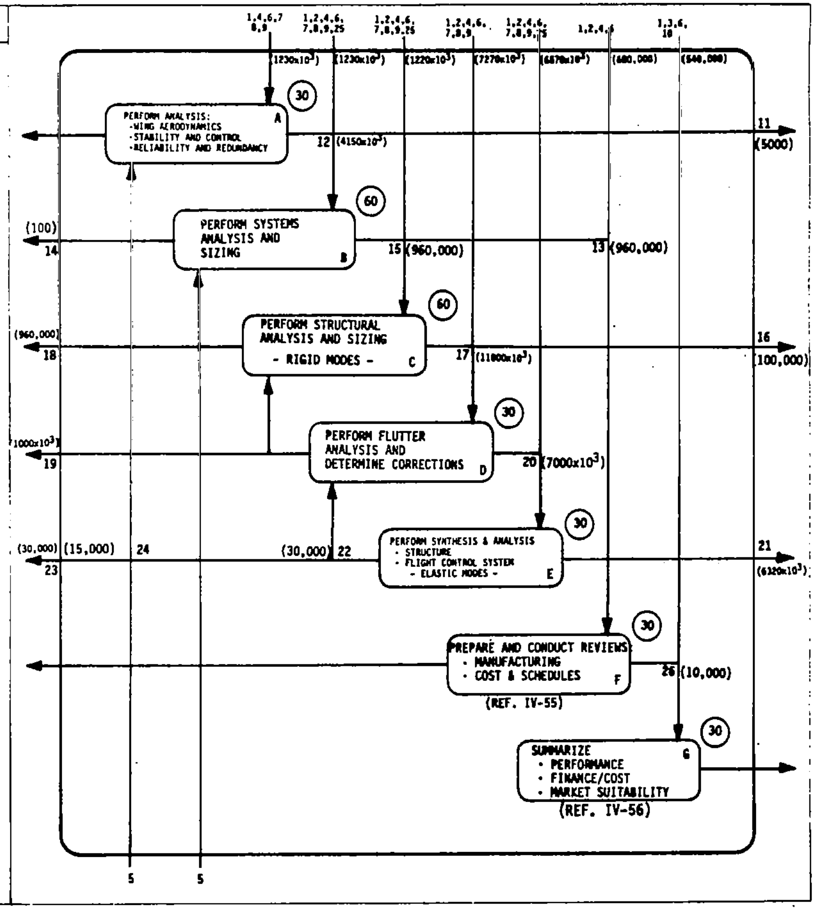


Figure 17.—Data Model ABC – Perform Level IV Configuration Refinement

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM ANALYSIS: WING AERODYNAMICS, STABILITY AND CONTROL, RELIABILITY AND REDUNDANCY

☐ I - INTERACTIVE, B - BATCH

◯ NO. ITERATIONS, ( ) NO. 60 BIT WORDS

FIGURE 2.2-10

MODEL ABCA

DATA I.D.	DECOMP. TRACE	ORIG/ DEST.	DATA DESCRIPTION (DATA FLOW)
1		EXT	CORPORATE POLICIES AND DIRECTIVES
2		EXT	REGULATORY REQUIREMENTS
3		EXT	DESIGN CRITERIA
4		EXT	METHODS AND ADVANCED TECHNOLOGY
5		-	
6		-	
7		-	NOT USED
8		-	NOT USED
9		-	AERODYNAMIC DATA
10		ABCAA/ ABBAA	PRODUCT PERFORMANCE DATA
11		ABCAB/ ABBAA	PRODUCT PERFORMANCE DATA
12	17	ABBAA/ ABCA	PRODUCT GEOMETRY DEFINITION (BLOCK III-2)
13	14	ABBBE/ ABCA	WEIGHT BALANCE AND LOADABILITY (BLOCK III-17)
14		-	MINOR PRODUCT CONFIGURATION CHANGES
15		-	WEIGHT DATA
16a		ABCAA/ ABDAA	AERODYNAMIC SHAPE DATA AND DATA FOR WIND TUNNEL MODEL
16b		ABCAA/ ABCCA	AERODYNAMIC SHAPE DATA AND DATA FOR WIND TUNNEL MODEL
17		-	CONTROL SURFACE PRESSURES, GEOMETRY AND KINEMATIC DATA
18		ABCAD/ ABCBA	CONTROL SYSTEM INTERNAL LOADS
19		ABCEG/ ABCAB	ELASTIC MODE DATA
20a		ABCAB/ ABDAA	AERODYNAMIC SHAPE DATA AND DATA FOR WIND TUNNEL MODEL
20b		ABCAB/ ABCCA	AERODYNAMIC SHAPE DATA AND DATA FOR WIND TUNNEL MODEL

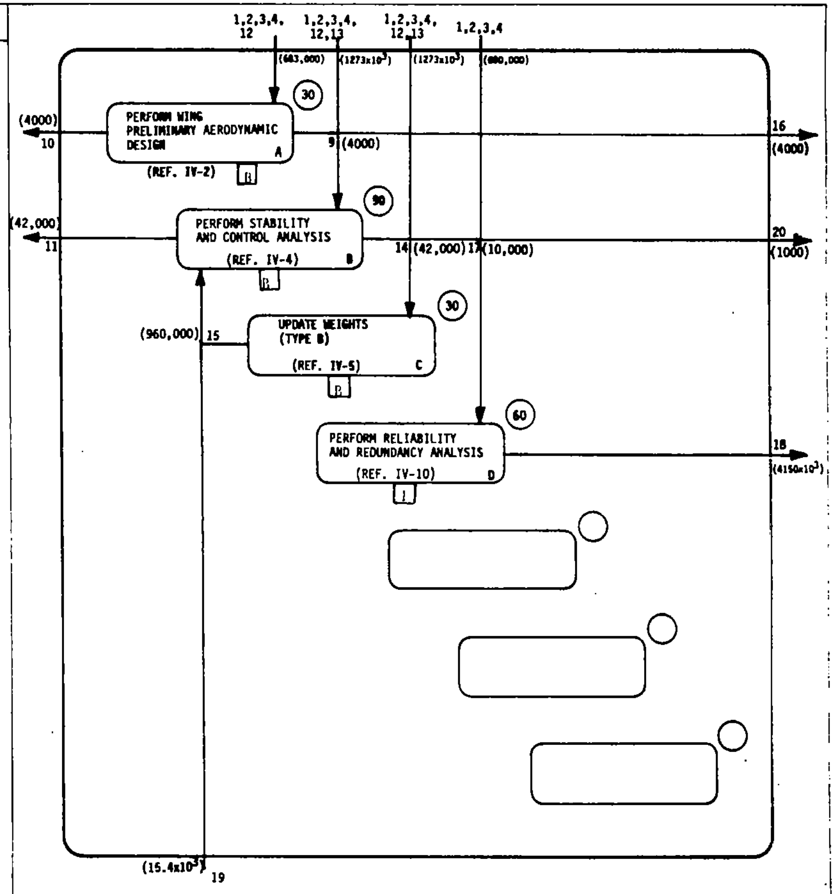


Figure 18.—Data Model ABCA — Perform Analysis: Wing Aerodynamic; Stability and Control; Reliability and Redundancy

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM SYSTEMS ANALYSIS AND SIZING

☐ I - INTERACTIVE, B - BATCH

◯ NO. ITERATIONS, ( ) NO. 60 BIT WORDS

FIGURE 2.2-11

MODEL ABCB

DATA I.D.	DECOMP. TRACE	ORIG./ DEST.	DATA DESCRIPTION (DATA FLOW)
1			CORPORATE POLICIES AND DIRECTIVES
2			REGULATORY REQUIREMENTS
3			DESIGN CRITERIA
4			METHODS AND ADVANCED TECHNOLOGY
5			MATERIAL SPECIFICATIONS
6			TECHNICAL DATA (CUSTOMER)
7	18	ABCAD/ ABCBA	RELIABILITY AND REDUNDANCY ANALYSIS OUTPUT
8			INLET, NOZZLES, THRUST REVERSER, ACOUSTICS, ACCESSORIES AND BARE ENGINE DATA
9		-	ACTUATOR AND CONTROL SYSTEMS DATA
10		-	CHANGES TO PROPULSION DATA
11		-	PROPULSION DATA AFFECTING SYSTEMS
12		-	SYSTEM DATA PRODUCING SIGNIFICANT WEIGHT CHANGE
13		-	PROPULSION DATA PRODUCING SIGNIFICANT WEIGHT CHANGE
14		-	FLIGHT CONTROL DATA PRODUCING SIGNIFICANT WEIGHT CHANGE
15		-	ACTUATOR DATA PRODUCING SIGNIFICANT WEIGHT CHANGE
16a		ABCBF/ ABCFA	UPDATED WEIGHT AND BALANCE DATA
16b		ABCBF/ ABCCA	UPDATED WEIGHT AND BALANCE DATA
17		ABCBD/ ABBAA	INSTALLED THRUST AND SPEC. FUEL CONSUMPTION DATA
18	14		LEVEL III WEIGHTS ANALYSIS

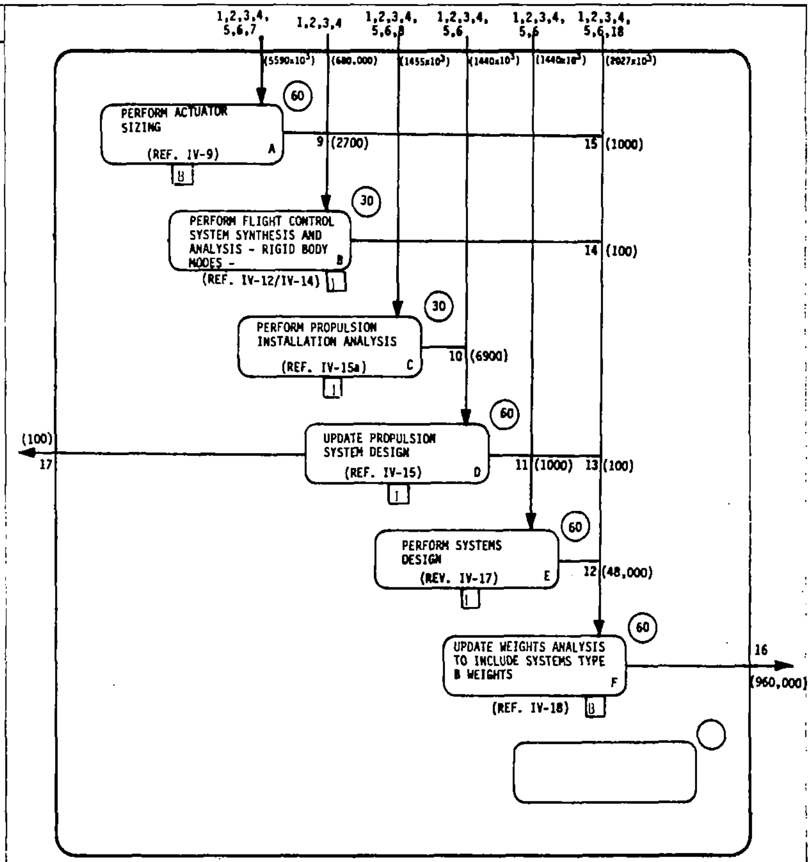


Figure 19.—Data Model ABCB —Perform Systems Analysis and Sizing

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM STRUCTURAL ANALYSIS AND SIZING - RIGID MODES -

□ - I - INTERACTIVE, B - BATCH

○ NO. ITERATIONS, (   ) NO. 60 BIT WORDS

FIGURE 2.2-12

MODEL ABCC

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1		EXT	CORPORATE POLICIES AND DIRECTIVES
2		EXT	REGULATORY REQUIREMENTS
3		EXT	DESIGN CRITERIA
4		EXT	METHODS AND ADVANCED TECHNOLOGY
5		EXT	MATERIAL SPECIFICATIONS
6		-	NOT USED
7	16	ABCBF/ ABCCA	PANEL WEIGHTS, CENTER OF GRAVITY, OVERALL WEIGHTS, ETC.
8	16b&20b	ABCA/ ABCCA	AERODYNAMIC DATA
9	13	ABBBD/ ABCCB	EXISTING LEVEL III STRUCTURAL SIZE
10	16	ABCBF/ ABCCC	EXISTING PRIMARY WEIGHT DATA
11		EXT	EXISTING STRUCTURAL DRAWINGS
12	16	ABCBF/ ABCCE	EXISTING TOTAL WEIGHT DATA
13		-	NOT USED
14		-	EXTERNAL LOADS (SHEARS, BENDING MOMENTS AND TORQUES)
15		-	MEMBER AREA CHANGES AND ADDITIONS
16		-	REVISED STRUCTURE DEFINITIONS
17		-	REVISED PRIMARY STRUCTURE WEIGHT
18		ABCCE/ ABCDA	REVISED WEIGHT DATA PACKAGE
19		-	REVISED WEIGHT DATA PACKAGE
20		-	NEW CONCEPT AND/OR CONFIGURATION DATA
21		-	REVISED FLEXIBILITY DATA
22		-	REVISED WEIGHT DATA, PANEL LOADS, C.G.'s, OVERALL WEIGHTS, ETC.
23		-	REVISED WEIGHT DATA PACKAGE
24		-	EXTERNAL LOADS (SHEARS, BENDING MOMENTS AND TORQUES)
25		-	STRUCTURAL SIZING

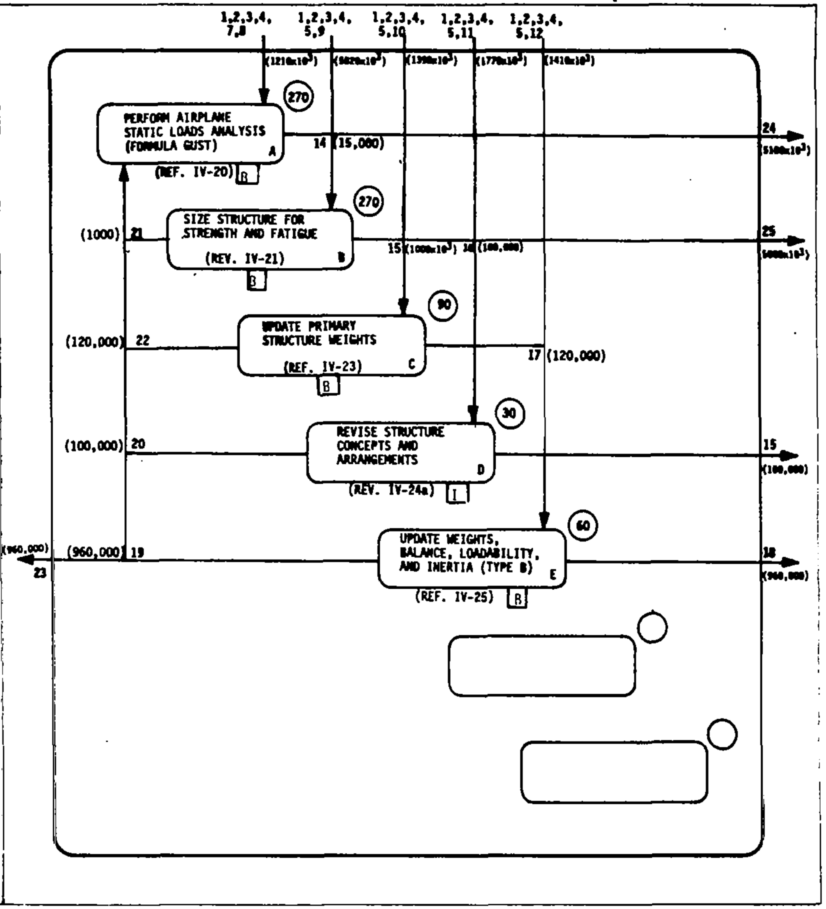


Figure 20.—Data Model ABCC — Perform Structural Analysis and Sizing — Rigid Modes

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM FLUTTER ANALYSIS AND DETERMINE CORRECTIONS

☐ I - INTERACTIVE, B - BATCH
◯ NO. ITERATIONS, ( ) NO. 60 BIT WORDS

FIGURE 2.2-13
MODEL ABCD

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1		EXT	CORPORATE POLICIES AND DIRECTIVES
2		EXT	REGULATORY REQUIREMENTS
3		EXT	DESIGN CRITERIA
4		EXT	METHODS AND ADVANCED TECHNOLOGY
5		EXT	MATERIAL SPECIFICATION
6		-	NOT USED
7		ABCCE/ ABCDA	MASS DATA
8	25	ABCCB/ ABCDA	FLEXIBILITY DATA
9	24	ABCCA/ ABCDD	EXTERNAL LOADS
10		EXT	INPUTS TO C.M.'s FCS-1 THROUGH FCS-7
11	22	ABCCE/ ABCDG	PREVIOUS WEIGHT DATA
12		-	EQUATIONS OF MOTION FOR FLUTTER ANALYSIS
13		-	DATA ON FLUTTER BOUNDARIES
14		-	MASS AND FLEXIBILITY DATA CHANGES RESULTING FROM FLUTTER ANALYSIS
15		-	DATA IDENTIFYING DEFICIENCIES IN FLUTTER REQUIREMENTS
16		-	WEIGHT DATA CHANGES AFFECTING FLIGHT CONTROLS
17		-	MASS CHANGES RESULTING FROM FLUTTER COMPLIANCE
18		-	CHANGES IN STRUCTURAL SIZING
19		-	FLIGHT CONTROL SYSTEM WEIGHT CHANGES
20		ABCDG/ ABCE	AIRPLANE WEIGHT DATA
21		-	REVISED CONTROL SYSTEM STRUCTURAL SIZING
22		-	REVISED FLUTTER SUPPRESSION DATA
23		-	REVISED CONFIGURATION GEOMETRY, MASS OR STIFFNESS DATA
24		ABCDD/ ABCED	REVISED STRUCTURAL SIZING
25		ABCDG/ ABBAA	WEIGHT DATA TO RE-EVALUATE OEW/LOADABILITY CRITERIA
26		ABCDF/ ABCEG	FLIGHT CONTROL SYSTEM DATA
27	25	ABCCB/ ABCDD	STRUCTURAL SIZING

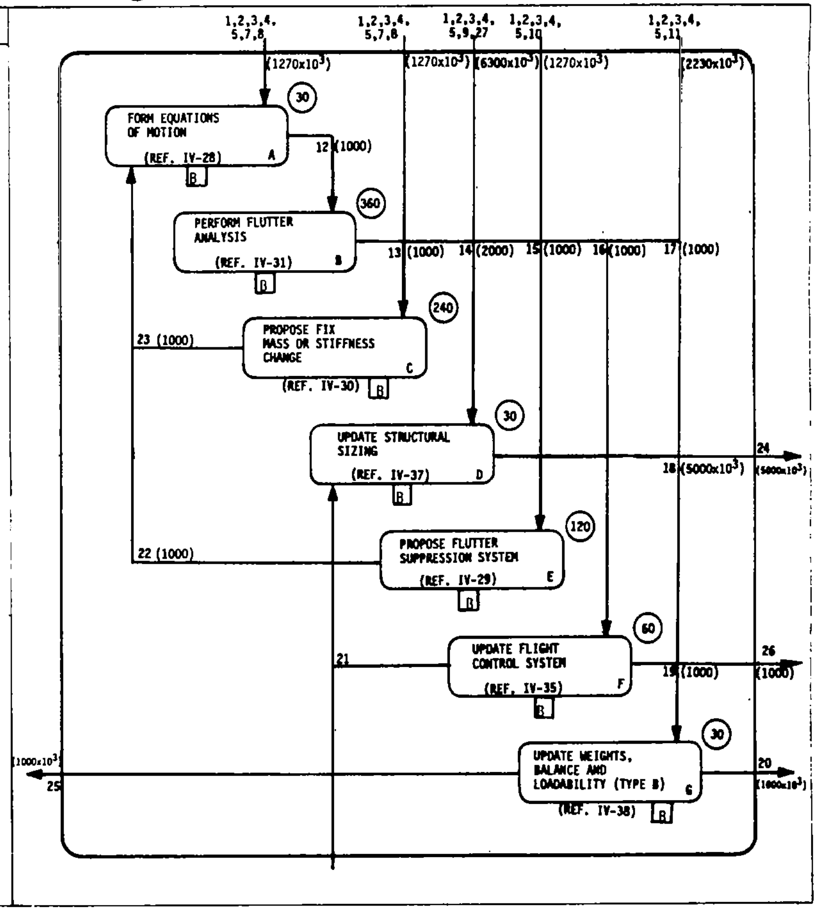


Figure 21.—Data Model ABCD — Perform Flutter Analysis and Determine Corrections

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM SYNTHESIS AND ANALYSIS - STRUCTURE AND FLIGHT CONTROL SYSTEM - ELASTIC MODES -

☐ I - INTERACTIVE, B - BATCH

◯ NO. ITERATIONS, ( ) NO. 60 BIT WORDS

FIGURE 2.2-14

MODEL ABCE

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1		EXT	CORPORATE POLICIES AND DIRECTIVES
2		EXT	REGULATORY REQUIREMENTS
3		EXT	DESIGN CRITERIA
4		EXT	METHODS AND ADVANCED TECHNOLOGY
5		EXT	MATERIAL SPECIFICATION
6		-	NOT USED
7	24	ABCDD/ ABCEA	FLEXIBILITY DATA
8	20	ABCDG/ ABCEA	PREVIOUS WEIGHT DATA
9		EXT	FLEXIBILITY, AERODYNAMIC AND GEOMETRIC DATA
10		-	EQUATIONS OF MOTION
11		-	SELECTED CRITICAL (QUASI STATIC) LOAD CONDITIONS
12		-	NOT USED
13		-	CRITICAL STATIC PLUS DYNAMIC LOAD CONDITIONS
14		-	REVISIONS TO STRUCTURAL SIZING
15		-	REVISIONS TO STRUCTURAL STIFFNESS
16		-	REVISED EQUATIONS OF MOTION
17		-	FLIGHT CONTROL SYSTEM PERFORMANCE
18		-	REVISED WEIGHTS DATA
19		ABCEG/ ABCAB	FLIGHT CONTROL SYSTEM PERFORMANCE
20a		ABCEE/ ABBAA	REVISED WEIGHTS DATA
20b		ABCEE/ ABCDA	REVISED WEIGHTS DATA
21	24	ABCDD/ ABCED	EXISTING STRUCTURAL SIZING DATA
22		ABCEG/ ABDA	FLIGHT CONTROL SYSTEM PERFORMANCE
23		ABCEE/ ABDAG	STRUCTURAL SIZING DATA
24		ABCEC/ ABDA	STATIC LOADS DATA
25		ABCEE/ ABDA	MASS DATA REVISIONS

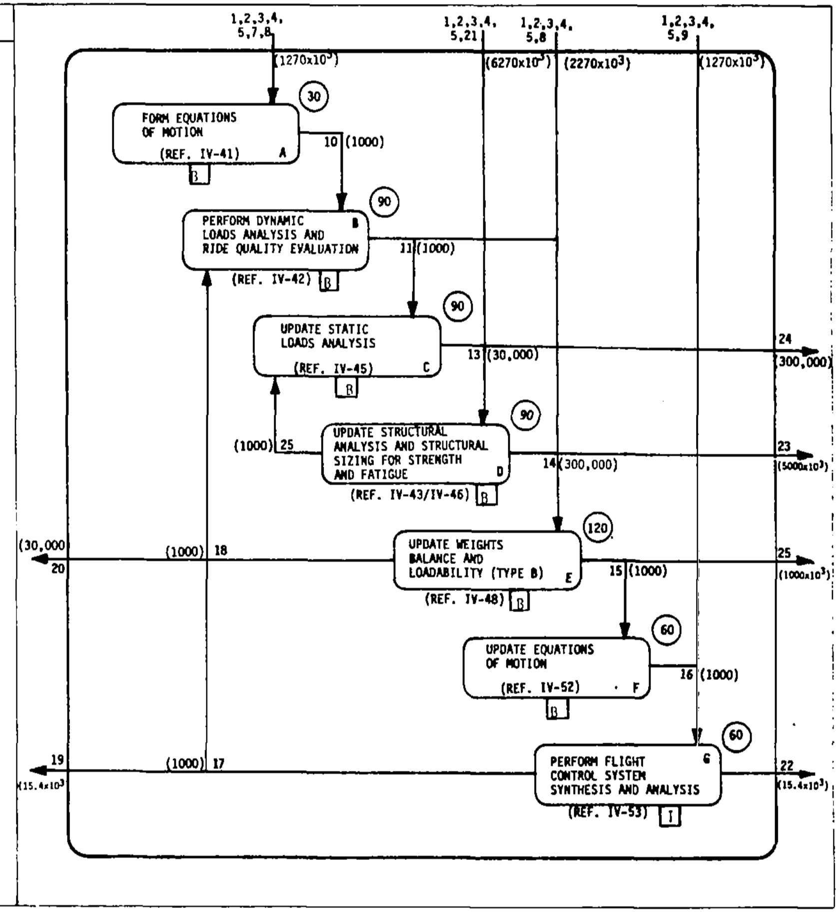


Figure 22.—Data Model ABCE — Perform Synthsis and Analysis of Structure and Flight Control System — Elastic Modes

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM LEVEL V CONFIGURATION VERIFICATION ◯ NO. ITERATIONS,

FIGURE 2.2-15
MODEL ABD

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1	1	AB	CORPORATE POLICIES AND DIRECTIVES
2	2	AB	TECHNICAL DATA CUSTOMER
3	3	AB	MARKETING INFORMATION
4	4	AB	REGULATORY REQUIREMENTS
5	5	AB	PRODUCT PERFORMANCE DATA
6	6	AB	METHODS AND ADVANCED TECHNOLOGY
7	7	AB	DESIGN CRITERIA
8	10	AB	TECHNICAL DOCUMENTATION LEVEL IV
9	14	AB	DESIGN/ANALYSIS DATA LEVEL IV
10	18	AB	MARKET/FINANCE DATA LEVEL IV
11	21	AB	RESULTS - DEVELOPMENTAL TESTING
12	23	AB	POTENTIAL DEFICIENCIES - DESIGN CRITERIA
13	25	AB	POTENTIAL DEFICIENCIES - PRODUCT
14	-	-	PRELIMINARY DESIGNS CONCEPT
15		A	PRELIMINARY DESIGN CONCEPT

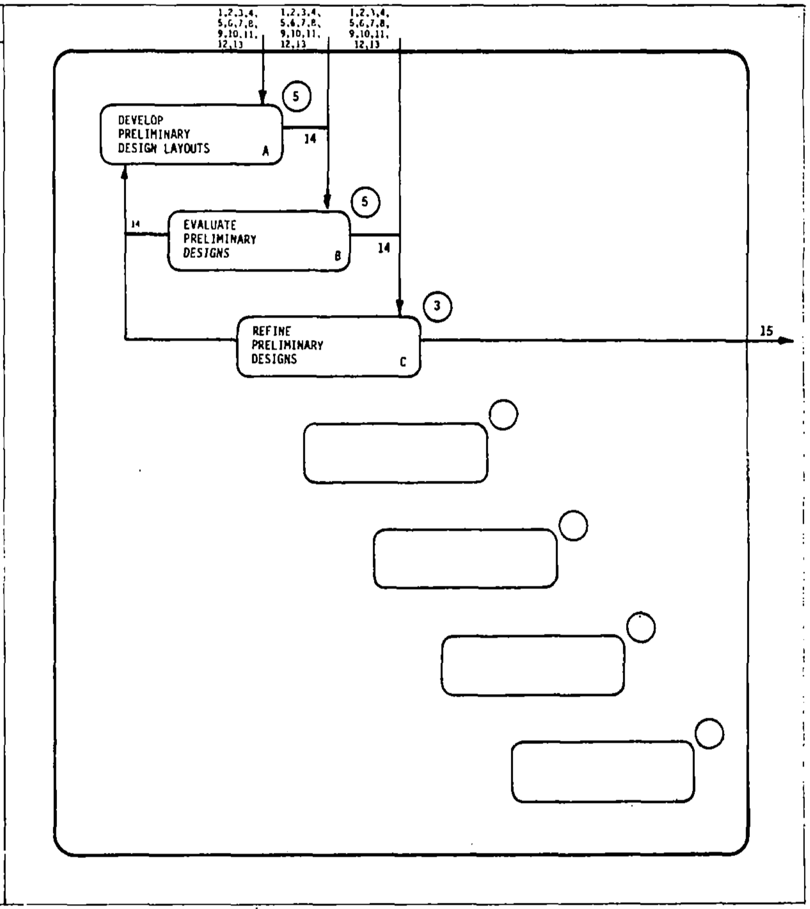


Figure 23.—Data Model ABD – Perform Level V Configuration Verification

BCS BOEING COMPUTER SERVICES INC

TITLE DEVELOP PRELIMINARY DESIGN LAYOUTS (LEVEL V)

☐ I - INTERACTIVE, B - BATCH
◯ NO. ITERATIONS.

FIGURE 2.2-16
MODEL ABDA

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1			GENERAL ANALYSIS METHODS
2			CUSTOMER ORDERS
3			REGULATORY REQUIREMENTS
4	17	ABBAA/	GEOMETRY
5			KINEMATICS
6	25	ABCEE/	WEIGHTS - SCIENTIFIC ANALYSIS AND TESTS
7a	16	ABCAA/	AERODYNAMICS - SCIENTIFIC ANALYSIS & TESTS
7b	16	ABCAB/	AERODYNAMICS - SCIENTIFIC ANALYSIS & TESTS
8	24	ABCEC/	LOADS - SCIENTIFIC ANALYSIS & TESTS
9	23	ABCED/	STRESS - SCIENTIFIC ANALYSIS & TESTS
10			DESIGN PHILOSOPHY (DIRECTIVES - DESIGN MANUAL - DURABILITY - ALLOWABLES)
11			PROCESS SPECS (REQUIREMENTS MTU)
12			PRODUCT PERFORMANCE TARGET (RANGE - PAYLOAD - WEIGHT - LIFE - MAINTENANCE)
13			MATERIAL - STANDARDS SPECS
14			COMPONENT SPECS (PRELIMINARY) ENGINE - VALVES - MOTORS - APU - ELECTRONICS
15	20	ABCCD/	GENERAL ARRANGEMENT
16	23	ABCED/	DESIGN CONCEPT
17			ENVIRONMENT
18	23	ABCED/	JOINT CONCEPT
19	23	ABCED/	INTERFACE (SYSTEMS-STRUCTURES) CONCEPT
20			MANUFACTURING PLANS - CAPABILITIES - SCHEDULES
21		ABC/	PRODUCIBILITY REVIEW RESULTS
22	25	ABCEE/	WEIGHTS REVIEW RESULTS
23	21	ABDBE/	PRODUCIBILITY REVIEW RESULTS
24	22	ABDBC/	MATERIALS & PROCESS REVIEW RESULTS
25	23	ABDBA/	STRUCTURES STAFF REVIEW RESULTS
26	24	ABDBB/	WEIGHTS STAFF REVIEW RESULTS
27	25	ABDBD/	AERODYNAMICS STAFF REVIEW RESULTS
28	34	/ABDB	STATUS (PERFORMANCE - PROBLEMS)
29	28	/ABDB	DESIGN DEFINITION LAYOUT
30	16	/ABDB	MEMBER CONFIGURATION
31a	19	/ABDB	INTERFACE CONFIGURATION
31b	19	ABDC/	INTERFACE CONCEPT

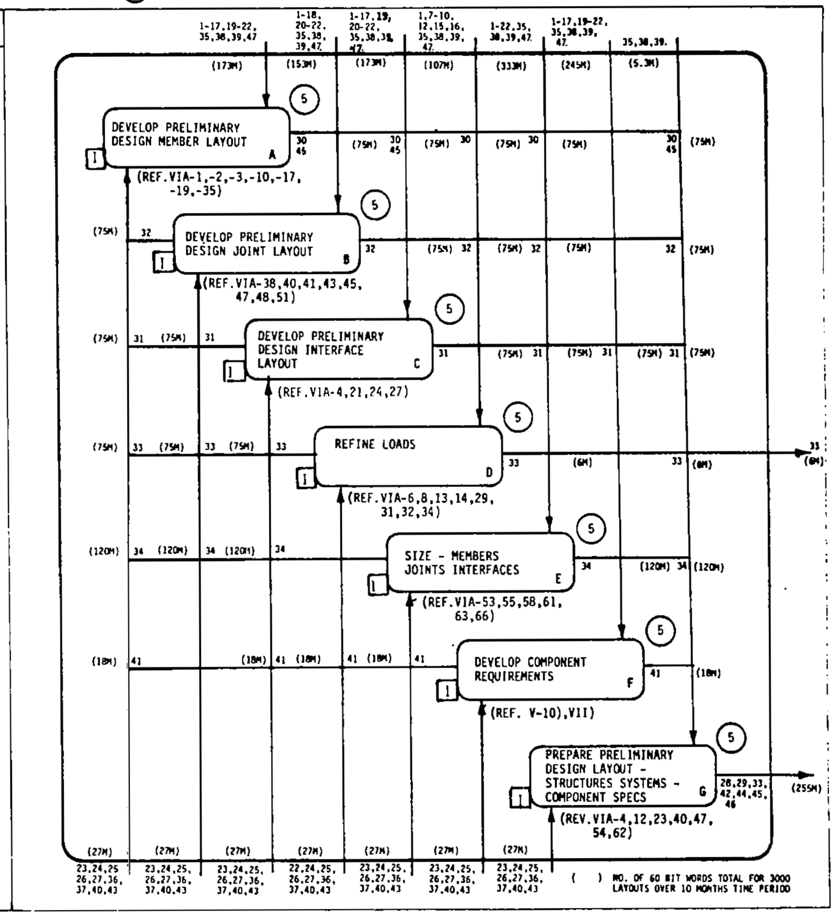


Figure 24.—Data Model ABDA — Develop Preliminary Layouts (Level V)

BCS BOEING COMPUTER SERVICES INC

TITLE DEVELOP PRELIMINARY DESIGN LAYOUTS (LEVEL V)

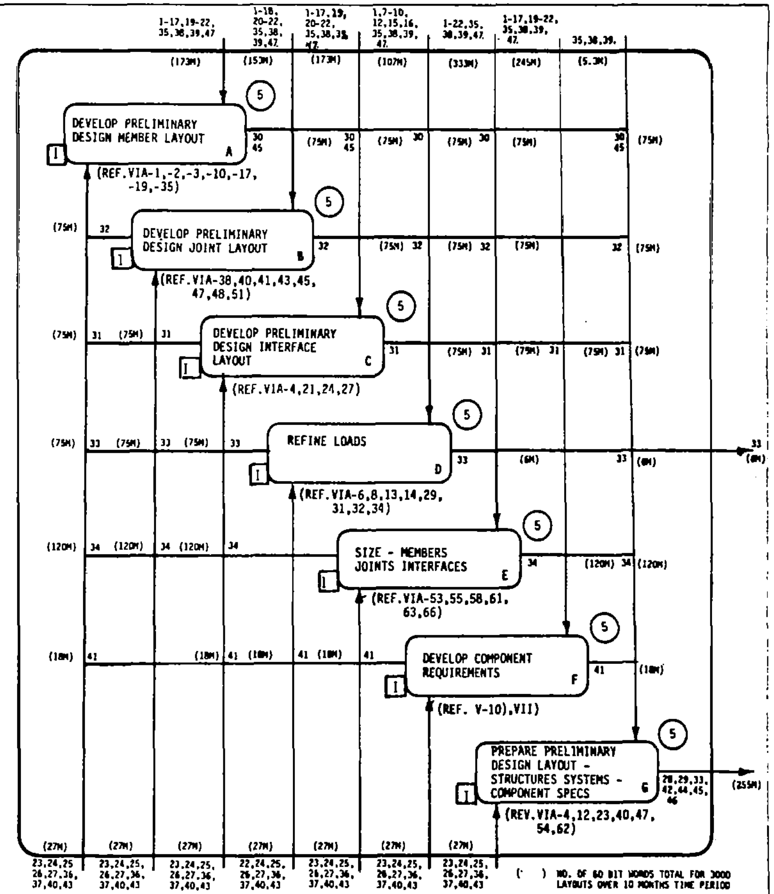
☐ I - INTERACTIVE, B - BATCH

◯ NO. ITERATIONS,

FIGURE 2.2-16

MODEL ABDA

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
32a	12	/ABDB	JOINT CONFIGURATION
32b	18	ABDC/	JOINT CONCEPT
33	31	/ABDB	REFINED LOADS
34	39	/ABDB	JOINT/MEMBER SIZE
35		ABC/	DESIGN FUNCTION TARGET
36	26	ABDBD/	DESIGN FUNCTION REVIEW RESULTS (AERODYNAMICS GEOMETRY)
37	29	ABDBG/	EVALUATION DOCUMENTATION
38		ABC/	MASTER SCHEDULE
39		ABC/	DETAIL SCHEDULE
40	35	ABDBF/	COMPONENT REVIEW/TEST RESULTS
41	-	-	REFINED COMPONENT REQUIREMENTS
42	14	/ABDB	COMPONENT SPECS
43	30	/ABDBG	STATUS (PERFORMANCE - PROBLEMS)
44	36	/ABDB	WORK BREAKDOWN STRUCTURE (WBS)
45	4	/ABDB	GEOMETRY (REFINED)
46	33	/ABDB	DETAIL SCHEDULE
47	22	ABCEG/	FLIGHT CONTROLS - KINEMATICS



REF DOCUMENT BCS 10167 (SAMM)

Figure 24.—Develop Preliminary Design Layouts—Level V (Concluded)

BCS BOEING COMPUTER SERVICES INC

TITLE EVALUATE PRELIMINARY DESIGN (LEVEL V)

☐ I - INTERACTIVE, B - BATCH

◯ NO. ITERATIONS,

FIGURE 2.2-17

MODEL ABDB

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1			GENERAL ANALYSIS METHODS
2			CUSTOMER ORDERS
3			REGULATORY REQUIREMENTS
4	45	ABDAA/	GEOMETRY
5			KINEMATICS
6	25	ABCEE/	WEIGHTS - SCIENTIFIC ANALYSIS & TESTS
7a	16	ABCAA/	AERODYNAMICS - SCIENTIFIC ANALYSIS & TESTS
7b		ABCAB/	AERODYNAMICS - SCIENTIFIC ANALYSIS & TESTS
8	24	ABCEC/	LOADS - SCIENTIFIC ANALYSIS & TESTS
9	23	ABCED/	STRESS - SCIENTIFIC ANALYSIS & TESTS
10			DESIGN PHILOSOPHY (DIRECTIVES - DESIGN MANUAL - DURABILITY - ALLOWABLES)
11			PROCESS SPECS
12			PRODUCT PERFORMANCE TARGET (RANGE - PAYLOAD - WEIGHT - LIFE - MAINTENANCE)
13			MATERIAL SPECS (FASTENERS)
14			COMPONENT SPECS (ENGINE - VALVES - MOTORS - APU - ELECTRONICS)
15	20	ABCCD/	GENERAL ARRANGEMENT
16	30	ABDAA/	MEMBER CONCEPT
17			ENVIRONMENT
18	32	ABDAB/	JOINT CONCEPT
19	31	ABDAE/	INTERFACE (SYSTEMS STRUCTURE) CONCEPT
20			MANUFACTURING PLANS - CAPABILITIES - SCHEDULES
21a	23	/ABDA	PRODUCIBILITY REVIEW RESULTS
21b	21	/ABDC	PRODUCIBILITY REVIEW RESULTS
22a	24	/ABDA	MATERIALS & PROCESS REVIEW RESULTS
22b	22	/ABDC	MATERIALS & PROCESS REVIEW RESULTS
23a	25	/ABDA	STRUCTURES STAFF REVIEW RESULTS
23b	23	/ABDC	STRUCTURES STAFF REVIEW RESULTS
24a	26	/ABDA	WEIGHTS STAFF REVIEW RESULTS
24b	24	/ABDC	WEIGHTS STAFF REVIEW RESULTS
25a	27	/ABDA	AERODYNAMICS STAFF REVIEW RESULTS
25b	25	/ABDC	AERODYNAMICS STAFF REVIEW RESULTS

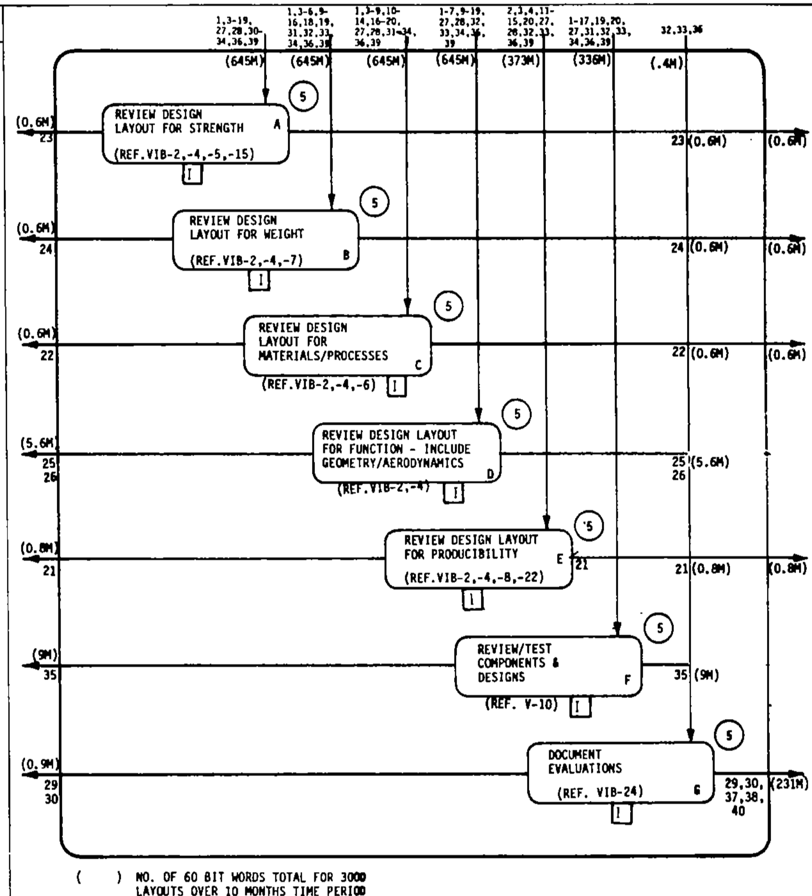


Figure 25.—Data Model ABDB — Evaluate Preliminary Design (Level V)

BCS BOEING COMPUTER SERVICES INC

TITLE EVALUATE PRELIMINARY DESIGN (LEVEL 5)

☐ I - INTERACTIVE, B - BATCH
◯ NO. ITERATIONS,

FIGURE 2.2-17
MODEL ABDB

DATA I.D.	DECOMP. TRACE	ORIG./ DEST.	DATA DESCRIPTION (DATA FLOW)
26a	36	/ABDA	DESIGN FUNCTION REVIEW RESULTS
26b	26	/ABDC	DESIGN FUNCTION REVIEW RESULTS
26c	4	/ABDC	DESIGN FUNCTION REVIEW RESULTS (GEOMETRY)
27			DESIGN FUNCTION TARGET
28	29	ABDAG/	DESIGN DEFINITION LAYOUT
29a	28	/ABDC	EVALUATION DOCUMENTATION
29b	37	/ABDA	EVALUATION DOCUMENTATION
30a	43	/ABDC	STATUS (PERFORMANCE - PROBLEMS)
30b	43	/ABDA	STATUS (PERFORMANCE - PROBLEMS)
31	33	ABDAD/	REFINED LOADS
32			MASTER SCHEDULE
33	46	ABDAG/	DETAIL SCHEDULE
34	28	ABDAG/	STATUS (PERFORMANCE - PROBLEMS)
35	40	/ABDA	REVIEW/TEST COMPONENTS DESIGNS RESULTS
36	44	ABDAG/	WORK BREAKDOWN STRUCTURE (WBS)
37	38	/ABDC	WORK BREAKDOWN STRUCTURE (WBS)
38	29	/ABDC	DESIGN DEFINITION LAYOUT
39	34	ABDAE/	JOINT MEMBER SIZE
40	36	/ABDC	REVISED DETAIL SCHEDULE

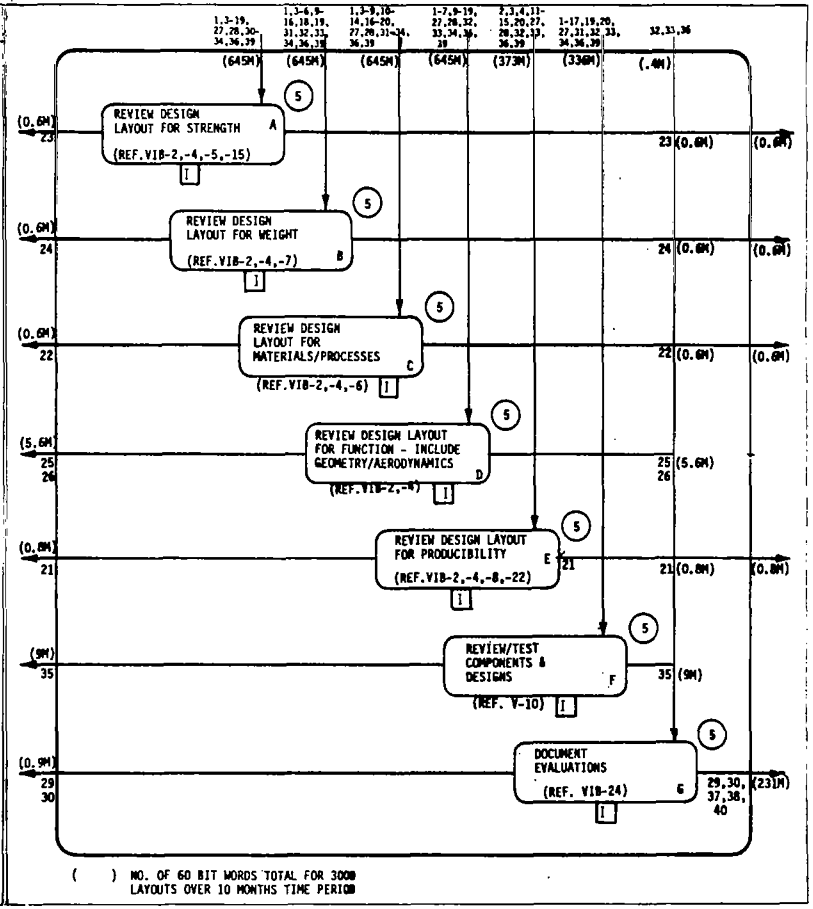


Figure 25.—Evaluate Preliminary Design—Level V (Concluded)

BCS BOEING COMPUTER SERVICES INC

TITLE REFINE PRELIMINARY DESIGN (LEVEL V)

☐ I - INTERACTIVE, B - BATCH

◯ NO. ITERATIONS,

FIGURE 2.2-18

MODEL ABDC

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1			GENERAL ANALYSIS METHODS
2			CUSTOMER ORDERS
3			REGULATORY REQUIREMENTS
4	26	ABDBD/	GEOMETRY
5			KINEMATICS
6	24	ABDBB/	WEIGHTS - UPDATED SCIENTIFIC ANALYSIS & TESTS
7	25	ABDBD/	AERODYNAMICS - UPDATED SCIENTIFIC ANALYSIS & TESTS
8	25	ABDBD/	LOADS - UPDATED SCIENTIFIC ANALYSIS & TESTS
9	23	ABDBA/	STRESS - UPDATED SCIENTIFIC ANALYSIS & TESTS
10			DESIGN PHILOSOPHY (DIRECTIVES - DESIGN MANUAL - DURABILITY - ALLOWABLES, ETC.)
11			PROCESS SPECS
12			PRODUCT PERFORMANCE TARGET (RANGE - PAYLOAD - WEIGHT - LIFE - MAINTENANCE)
13			MATERIAL SPECS (SHEET - BAR - TUBING - EXT - FORGING - FASTENERS)
14			COMPONENT SPECS - ENGINE - VALVES - MOTORS - APU - ETC.)
15	20	ABCCD/	GENERAL ARRANGEMENT
16	30	ABDAA/	DESIGN CONCEPT
17			ENVIRONMENT
18	32	ABDAB/	JOINT CONCEPT
19	31	ABDAC/	INTERFACE CONCEPT (SYSTEMS - STRUCTURE)
20			MANUFACTURING PLANS, CAPABILITIES, SCHEDULES
21	21	ABDBE/	PRODUCIBILITY & REVIEW RESULTS
22	22	ABDBC/	MATERIALS & PROCESS REVIEW RESULTS
23	23	ABDBA/	STRUCTURES STAFF REVIEW RESULTS
24	24	ABDBB/	WEIGHTS STAFF REVIEW RESULTS
25	25	ABDBD/	AERODYNAMICS STAFF REVIEW RESULTS
26	26	ABDBD/	DESIGN FUNCTION REVIEW RESULTS
27			DESIGN FUNCTION TARGET
28	29	ABDBG/	EVALUATION DOCUMENTATION
29	38	ABDBG/	DESIGN DEFINITION LAYOUT
30	20	/ACAA	DESIGN DEFINITION LAYOUT
31	17	/ACAC	REFINED COMPONENT SPECS (ENGINE, VALVES, MOTORS, APU, ETC.)

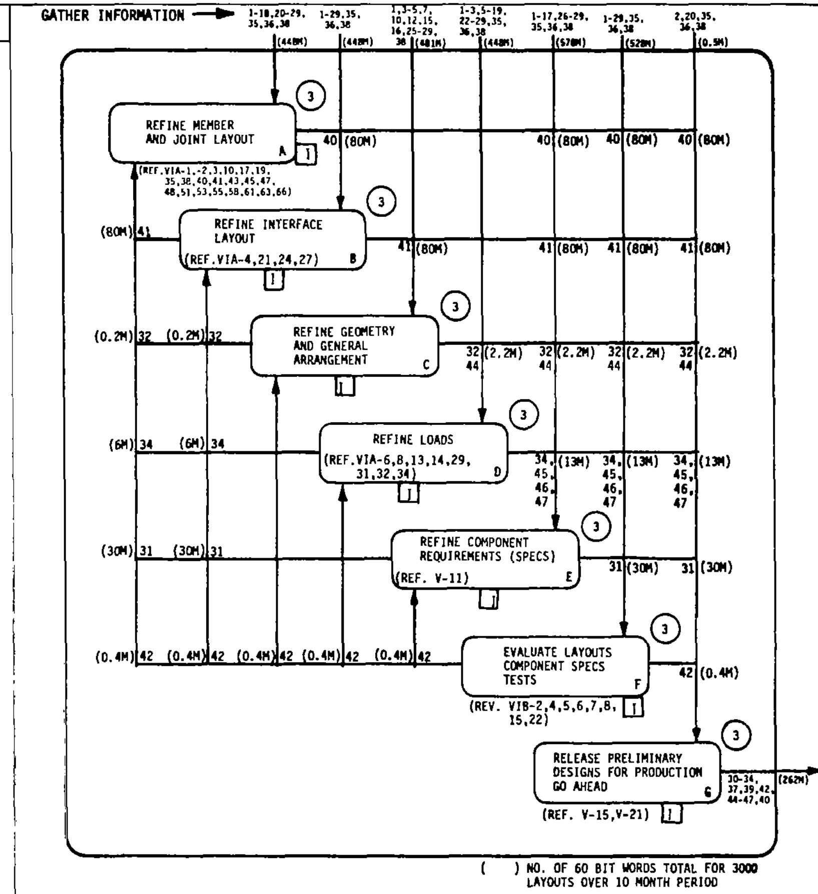


Figure 26.—Data Model ABDC — Refine Preliminary Design (Level V)

BCS BOEING COMPUTER SERVICES INC

TITLE REFINE PRELIMINARY DESIGN (LEVEL V)

☐ I - INTERACTIVE, B - BATCH
◯ NO. ITERATIONS,

FIGURE 2.2-18
MODEL ABDC

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
32a	7	/ACAA	REFINED GEOMETRY
32b	5	/ACAD	REFINED GEOMETRY
32c	7	/ACAB	REFINED GEOMETRY
32d	7	/ACAC	REFINED GEOMETRY
33	34	/ACAA	STATUS (PERFORMANCE - PROBLEMS)
34a	12	/ACAA	REFINED LOADS
34b	12	/ACAA	UPDATED LOADS
35			MASTER SCHEDULE
36	40	ABDBG/	DETAIL SCHEDULE
37	5	/ACAA	DETAIL SCHEDULE UPDATED
38	37	ABDBG/	WORK BREAKDOWN STRUCTURE
39a	3	/ACAA	WORK BREAKDOWN STRUCTURE UPDATED
39b	3	/ACAB	WBS
40	22	/ACAA	REFINED MEMBER - JOINT LAYOUT
41	23	/ACAAB	REFINED INTERFACE LAYOUT
42a	27	/ACAA	EVALUATION DOCUMENTATION (PRODUCIBILITY)
42b	28	/ACAA	EVALUATION DOCUMENTATION (WEIGHTS)
43	30	ABDBG/	STATUS (PERFORMANCE - PROBLEMS)
44	19	/ACAA	UPDATED GENERAL ARRANGEMENT
45a	10	/ACAA	UPDATED WEIGHTS
45b	10	/ACAC	UPDATED WEIGHTS
46a	11	/ACAA	UPDATED AERODYNAMICS
46b	11	/ACAC	UPDATED AERODYNAMICS
47a	13	/ACAA	UPDATED STRESS EVALUATION
47b	13	/ACAA	UPDATED STRESS EVALUATION

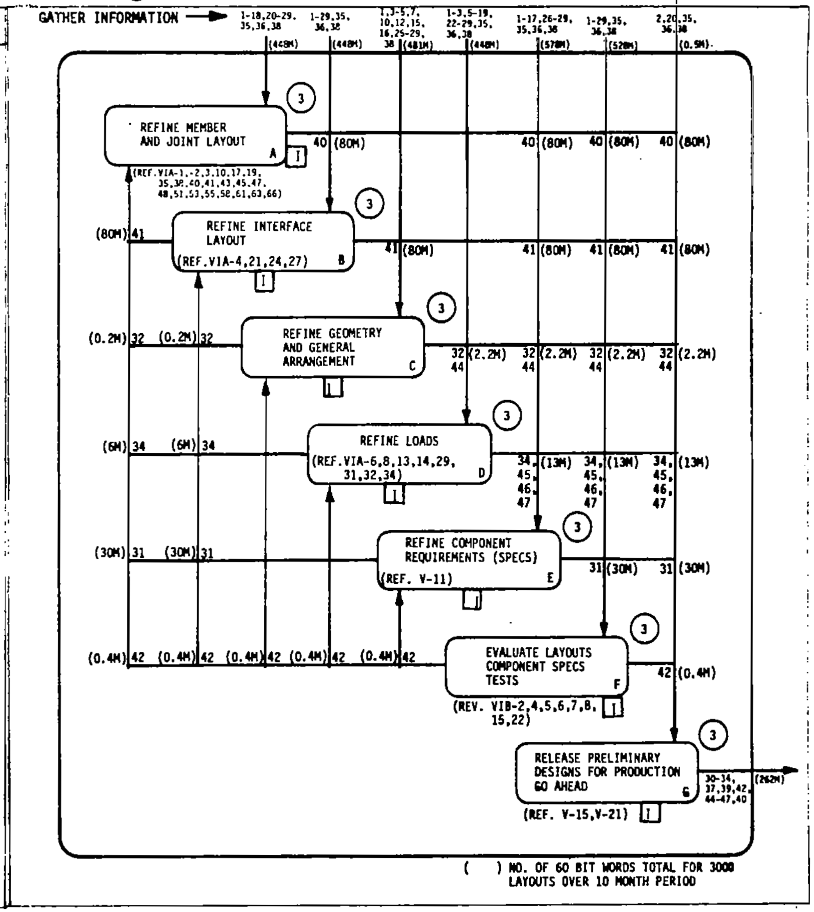


Figure 26.—Refine Preliminary Design Level V (Concluded)

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM PRODUCT LEVEL ACTIVITIES ◯ NO. ITERATIONS,

FIGURE 2.2-19
MODEL AC

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1			GO AHEAD
2			CUSTOMER ORDERS
3			MASTER SCHEDULE
4			DESIGN CONCEPT (PD)
5			GEOMETRY
6			GENERAL ARRANGEMENT
7			COST/WEIGHT STATUS
8			WBS
9a	5	ACA	DETAIL SCHEDULE
9b	5	ACAA	DETAIL SCHEDULE
9c	5	ACAB	DETAIL SCHEDULE
9d	5	ACAD	DETAIL SCHEDULE
10			REGULATORY REQUIREMENTS
11			DESIGN PHILOSOPHY & DIRECTIVES & ANALYSIS METHODS
12			PRODUCT PERFORMANCE TARGETS
13			MOCK-UP DESIGN/REQUEST
14			RESEARCH RESULTS
15			DESIGN CHANGE REQUESTS
16			DESIGN DEFINITION DOCUMENTATION
17			MANUFACTURING CAPABILITIES - PLANS - SCHEDULES
18			MOCK-UP
19			CHANGE REQUESTS (MANUFACTURING)
20			PRODUCT
21			TEST PLANS
22			STATIC TEST
23			PERFORMANCE TEST (COMPONENTS - SYSTEM)
24			FLIGHT TEST
25			CERTIFICATION
26			CHANGE REQUEST (VERIFICATION)
27			SUPPORT PLANS
28			SPARES
29			KITS
30			CHANGE REQUEST (SUPPORT)
31			CUSTOMER PROBLEMS

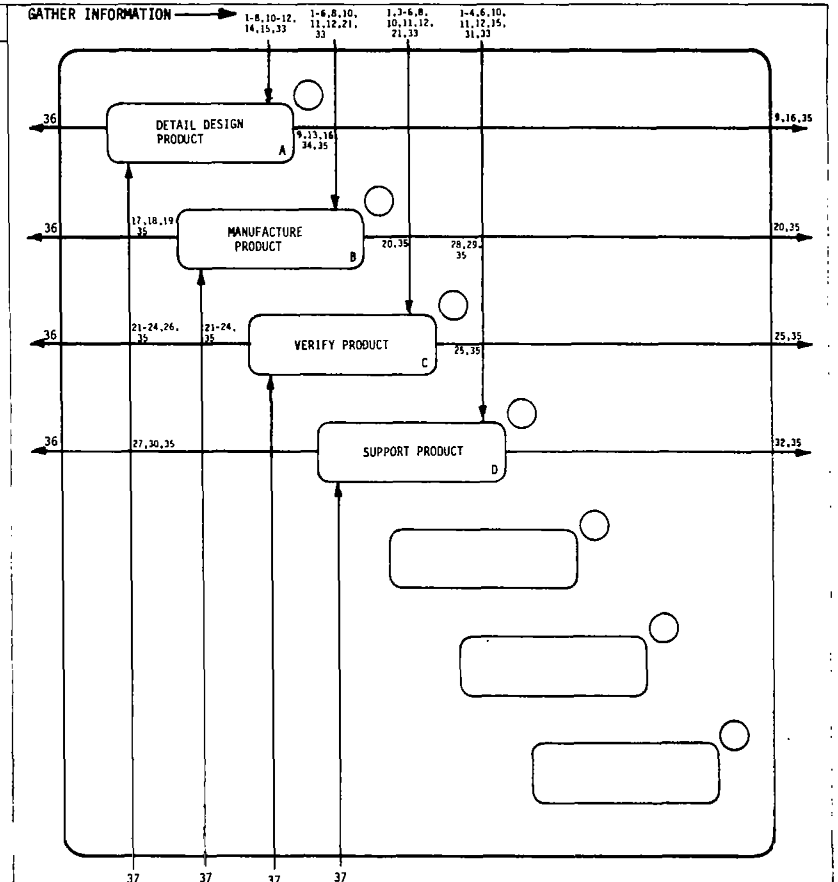


Figure 27.—Data Model AC — Perform Product Level Activities

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM PRODUCT LEVEL ACTIVITIES ◯ NO. ITERATIONS,

FIGURE 2.2-19
MODEL AC

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
32			OPERATION/MAINTENANCE PROCEDURES
33		A/	STATUS (PERFORMANCE - PROBLEMS)
34			DESIGN APPROVAL
35	22	/ACA	STATUS (PERFORMANCE - PROBLEMS)
36		/A	STATUS (PERFORMANCE - PROBLEMS)
37	33	ACA/	STATUS (PERFORMANCE - PROBLEMS)

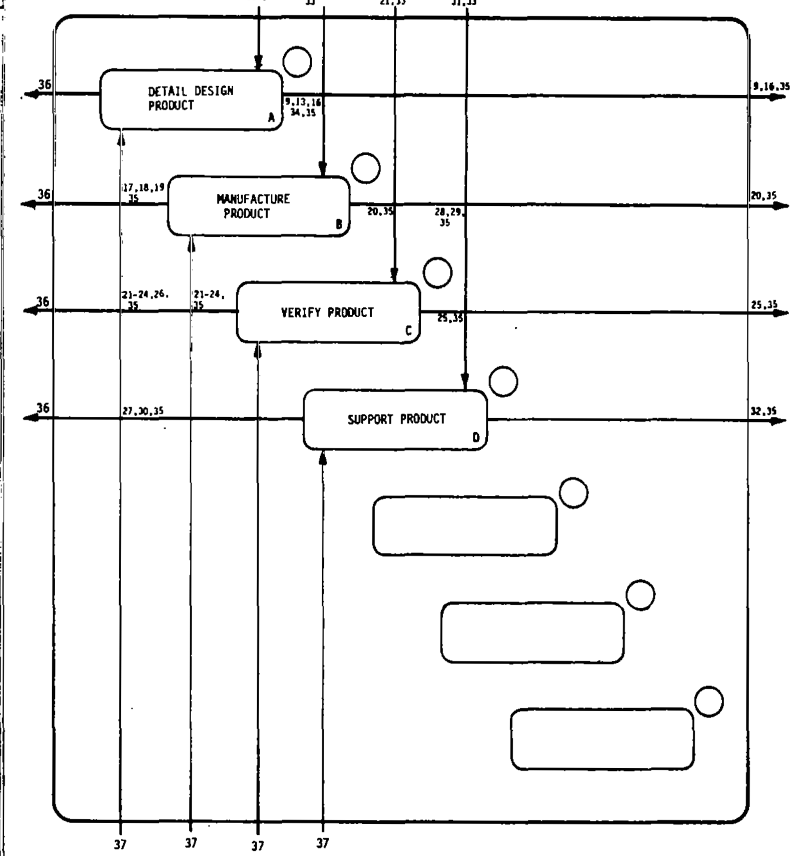


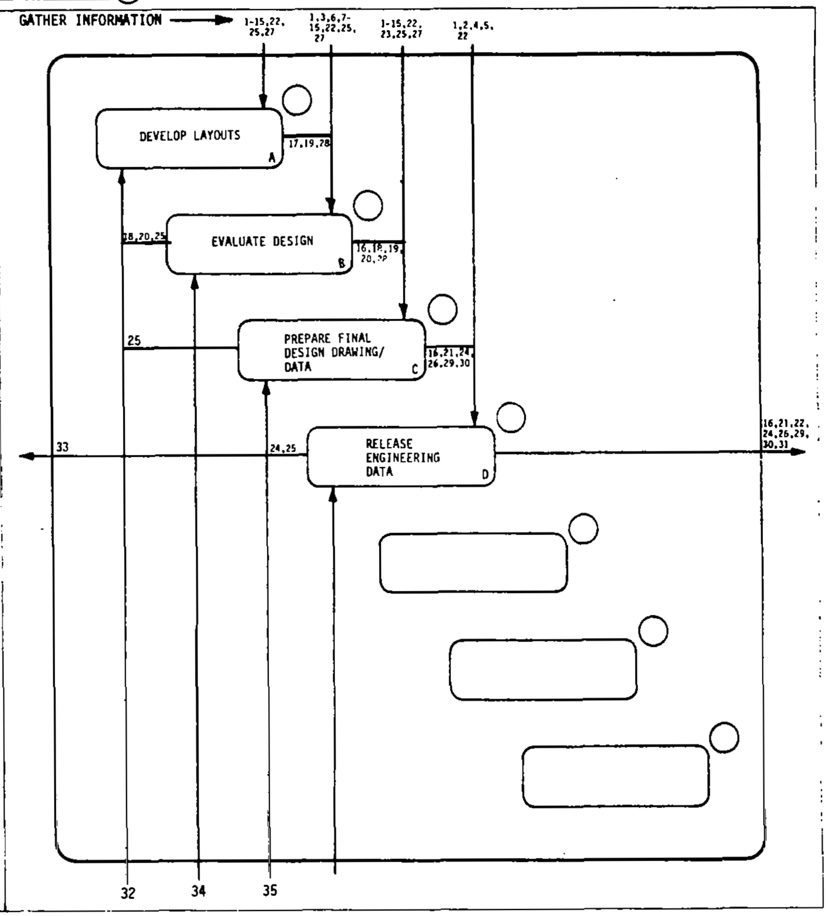
Figure 27.—Perform Product Level Activities (Concluded)

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM LEVEL VI PRODUCT DETAIL DESIGN ◯ NO. ITERATIONS,

FIGURE 2.2-20
MODEL ACA

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1	2	AC/	CUSTOMER ORDERS
2	3	AC/	MASTER SCHEDULE
3	4	AC/	DESIGN CONCEPT
4	8	AC/	WBS
5	9	AC/	DETAIL SCHEDULE
6	12	AC/	PRODUCT PERFORMANCE TARGET
7	5	AC/	GEOMETRY
8	6	AC/	GENERAL ARRANGEMENT
9	11	AC/	COMPONENT & MATERIAL SPECIFICATIONS
10	11	AC/	GENERAL ANALYSIS METHODS
11	11	AC/	DESIGN PHILOSOPHY
12	10	AC/	REGULATORY REQUIREMENTS
13	11	AC/	SCIENTIFIC ANALYSIS (WTS, AERODYNAMICS, LOADS, STRESS)
14	11	AC/	MATERIALS TECHNOLOGY REQUIREMENTS
15	11	AC/	DEVELOPMENTAL TESTS, PROPULSION, STRUCTURE, SYSTEMS, WIND TUNNEL
16		/ACB	ADVANCE MATERIAL ORDERS (EAMR)
17			MOCK-UP DESIGNS
18			MOCK-UP EVALUATION
19			DESIGN LAYOUT
20			EVALUATION RESULTS (PRODUCIBILITY, WEIGHTS, MATERIALS TECHNOLOGY, SUPPORT)
21		/ACB	DESIGN DEFINITION (DRAWING - DOCUMENTATION)
22	35	/AC	STATUS (PERFORMANCE - PROBLEMS)
23	34	AC/	DESIGN APPROVAL
24		/ACB	DESIGN RELEASE PAPER (EPR DDR DUE LIST)
25	15	AC/	DESIGN CHANGE REQUEST (PRODUCTION, EVALUATION, SUPPORT)
26		/ACB	DESIGN CHANGE (DEFINITION DRAWING DOCUMENTATION)
27	15	AC/	KITS & SPARES DESIGN REQUEST
28			KITS & SPARES DESIGN LAYOUT
29a		ACB	KITS & SPARES DESIGN DEFINITION
29b		ACD	KITS & SPARES DESIGN DEFINITION
30		/ACD	OPERATION & MAINTENANCE PROCEDURE
31	34	/ACAA	STATUS (PERFORMANCE, PROBLEMS)
32	49	ACAA	STATUS (PERFORMANCE, PROBLEMS)



SAMM

Figure 28.—Data Model ACA – Perform Level VI Product Detail Design

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM LEVEL VI PRODUCT DETAIL DESIGN

FIGURE 2.2-20

MODEL ACA

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
33	37	AC	STATUS (PERFORMANCE, PROBLEMS)
34	42	ACAB	STATUS (PERFORMANCE, PROBLEMS)
35	45	ACAC	STATUS (PERFORMANCE, PROBLEMS)

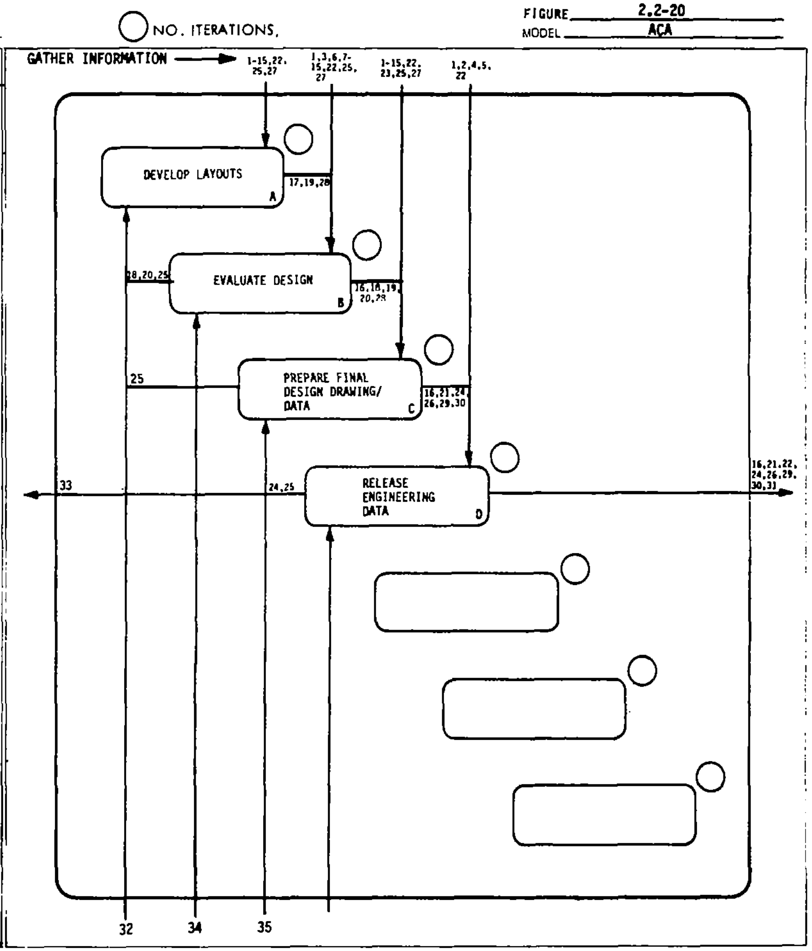


Figure 28.—Perform Level VI Product Detail Design (Concluded)

BCS BOEING COMPUTER SERVICES INC

TITLE DEVELOP LAYOUTS (LEVEL VI)

☐ I - INTERACTIVE, B - BATCH
◯ NO. ITERATIONS,

FIGURE 2.2-21
MODEL ACAA

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1			GENERAL ANALYSIS METHODS
2			CUSTOMER ORDERS
3	39	ABDCG/	WBS
4			MASTER SCHEDULE
5	37	ABDCG/	DETAIL SCHEDULE
6			REGULATORY REQUIREMENTS
7	32	ABDCC/	GEOMETRY
8a	8	/ACAB	PART GEOMETRY
8b	8	/ACAC	PART GEOMETRY
9			KINEMATICS
10	45	ABDCG/	WEIGHTS - SCIENTIFIC ANALYSIS
11	46	ABDCG/	AERODYNAMICS - SCIENTIFIC ANALYSIS
12	34	ABDCG/	LOADS - SCIENTIFIC ANALYSIS
13	47	ABDCG/	STRESS - SCIENTIFIC ANALYSIS
14			PROCESS SPECIFICATIONS (REQUIREMENTS MTU)
15			DESIGN PHILOSOPHY (DIRECTIVES, DESIGN MANUAL, DURABILITY, ALLOWABLES)
16			PRODUCT PERFORMANCE TARGET (AIRPLANE SPEC, RANGE, PAYLOAD, LIFE, MAINTENANCE)
17	31	ABDCG/	COMPONENT SPECS (ENGINE, VALVES, MOTORS, APU, ETC.)
18			MATERIAL SPECS (SHEET, BAR, TUBING, EXT, FORGING, FASTENERS)
19	44	ABDCG/	GENERAL ARRANGEMENT
20	30	ABDCG/	DESIGN DEFINITION LAYOUT
21			ENVIRONMENT
22	40	ABDCG/	JOINTS CONCEPT
23	41	ABDCG/	INTERFACE (SYSTEMS - STRUCTURE)
24			CUSTOMER VARIABLES
25			DESIGN CHANGE REQUESTS
26			MANUFACTURING PLANS - SCHEDULES - CAPABILITIES)
27	42	ABDCG/	PRODUCIBILITY REVIEW
28	42	ABDCG/	WEIGHTS REVIEW
29	25	/ACABD	OPERATIONS & MAINTENANCE PROCEDURES
30	30	ACABG/	PRODUCIBILITY REVIEW RESULTS

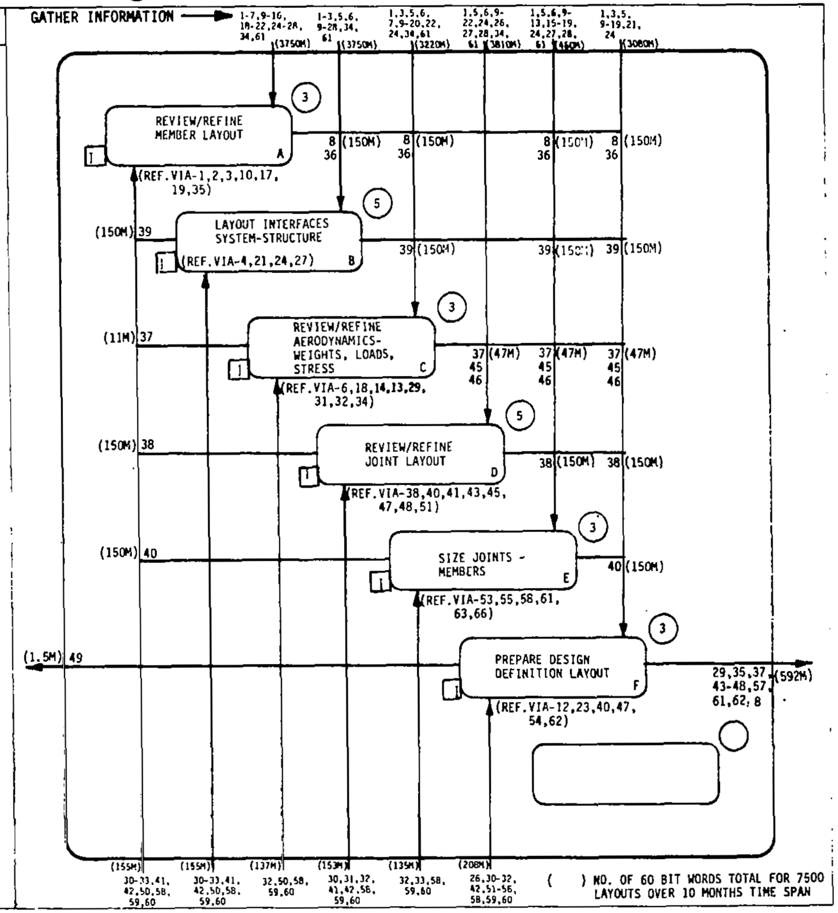


Figure 29.—Data Model ACAA — Develop Layouts (Level VI)

BCS BOEING COMPUTER SERVICES INC

TITLE DEVELOP LAYOUTS (LEVEL VI)

☐ I - INTERACTIVE, B - BATCH
◯ NO. ITERATIONS,

FIGURE 2.2-21
MODEL ACAA

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
31	28	ACAB /	MATERIALS & PROCESS STAFF REVIEW RESULTS
32	26	ACABA/	STRUCTURES STAFF REVIEW RESULTS
33	27	ACABB/	WEIGHTS STAFF REVIEW RESULTS
34	33	ABDCG/	STATUS (PERFORMANCE PROBLEMS)
35a	32	/ACAB	DESIGN DEFINITION LAYOUT (INCLUDES REDESIGN KITS SPARES)
35b	2	/ACAC	DESIGN DEFINITION (INCLUDES REDESIGN KITS LAYOUT SPARES)
36			MEMBER CONFIGURATION LAYOUT
37	12	/ACABA	UPDATED LOADS
38			JOINT LAYOUT
39			MEMBER - INTERFACE COMPOSITE LAYOUT
40			JOINT MEMBER LAYOUT
41	29	ACABD/	DESIGN FUNCTION REVIEW RESULTS
42	31	ACABF/	MOCK-UP REVIEW RESULTS
43	8	/ACADC	MOCK-UP CONSTRUCTION REQUEST
44a	5	/ACAB	DETAIL SCHEDULE UPDATE
44b	5	/ACAC	DETAIL SCHEDULE UPDATE
45	10	/ACAB	UPDATE WEIGHTS
46	11	/ACABA	UPDATED AERODYNAMICS
47	13	/ACAB	UPDATED STRESS
48a	37	/ACAB	STATUS (PERFORMANCE PROBLEMS)
48b	40	/ACAC	STATUS (PERFORMANCE PROBLEMS)
49	32	/ACA	STATUS (PERFORMANCE PROBLEMS)
50	42	ACABG/	STATUS (PERFORMANCE PROBLEMS)
51	28	ACACG/	DESIGN FUNCTION REVIEW RESULTS
52	29	ACACF/	STRESS STAFF REVIEW RESULTS
53	30	ACACF/	WEIGHTS STAFF REVIEW RESULTS
54	31	ACACF	MATERIALS TECHNOLOGY REVIEW RESULTS
55	32	ACACF/	PRODUCIBILITY REVIEW RESULTS
56	33	ACACF/	MOCK-UP REVIEW RESULTS
57	7	/ACADC	MOCK-UP DESIGN DEFINITION
58	41	ACAC/	DESIGN CHANGE REQUEST (MANAGEMENT)
59	42	ACACG/	DESIGN CHANGE REQUEST (CUSTOMER SUPPORT)
60	50	ACACG/	DESIGN CHANGE REQUEST (PRODUCTION)

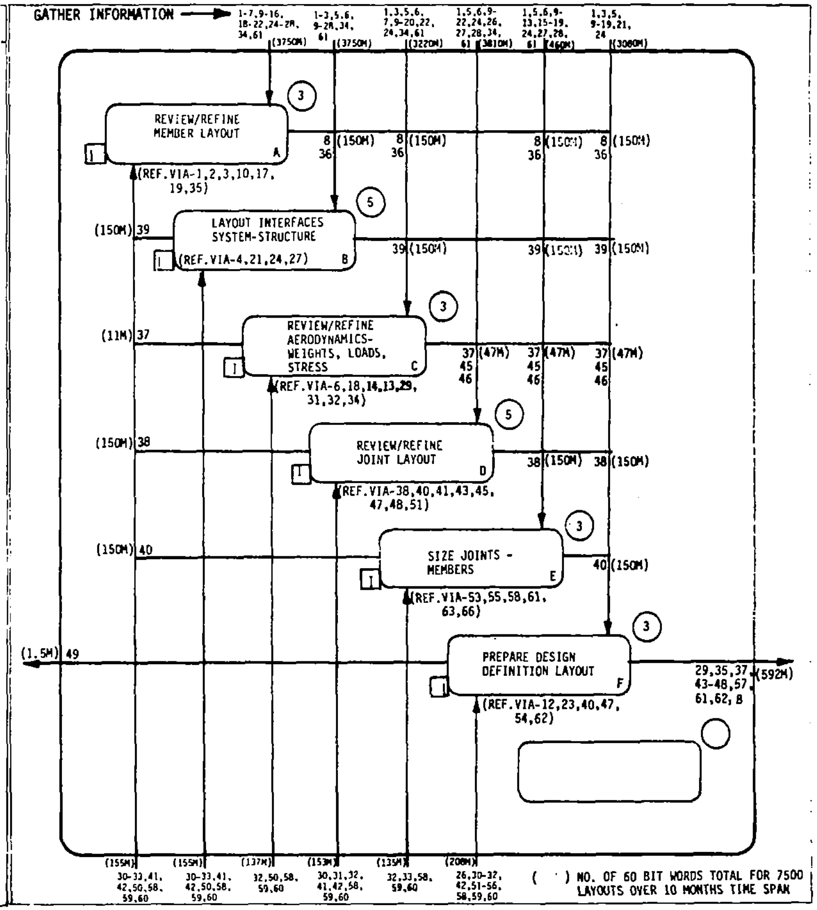


Figure 29.—Develop Layouts—Level VI (Continued)

BCS BOEING COMPUTER SERVICES INC

I - INTERACTIVE, B - BATCH

NO. ITERATIONS,

TITLE DEVELOP LAYOUTS (LEVEL VI)

FIGURE 2.2-21

MODEL ACAA

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
61a	17	/ACAB	COMPONENT SPEC
61b	17	/ACAC	COMPONENT SPEC
62a	19	/ACAB	GENERAL ARRANGEMENT
62b	19	/ACAC	GENERAL ARRANGEMENT

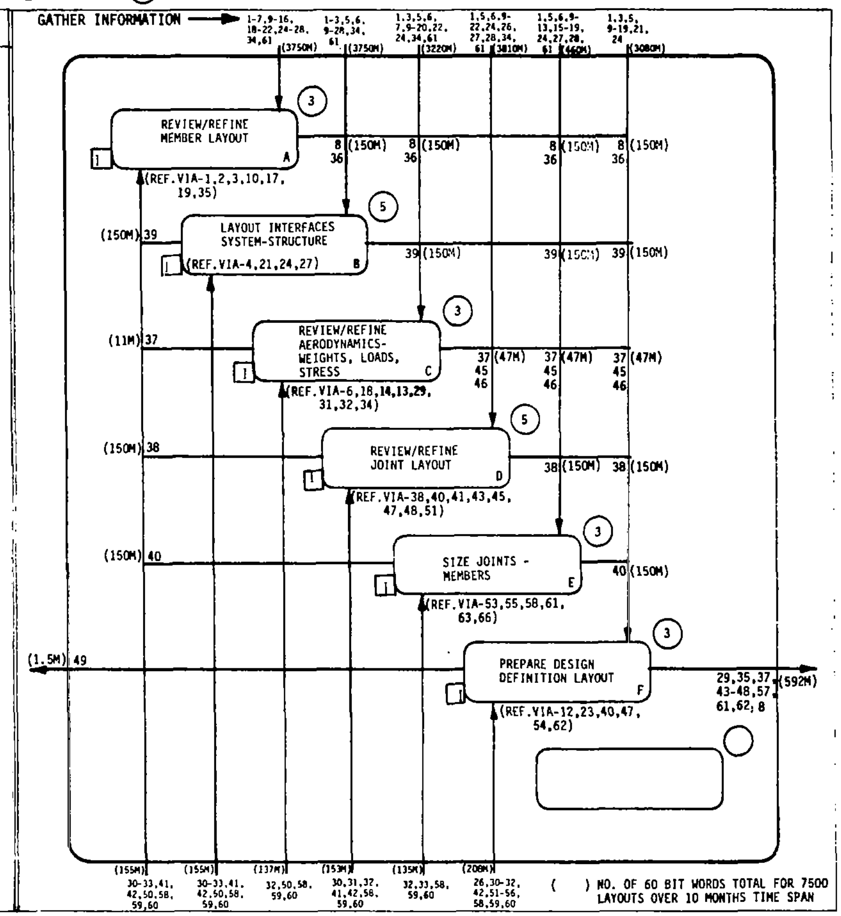


Figure 29.—Develop Layouts—Level VI (Concluded)

BCS

TITLE EVALUATE DESIGN (LEVEL VI)

☐ I - INTERACTIVE, B - BATCH
◯ NO. ITERATIONS,

FIGURE 2.2-22
MODEL ACAB

DATA I.D.	DECOMP. TRACE	ORIG/ DEST.	DATA DESCRIPTION (DATA FLOW)
1			GENERAL ANALYSIS METHODS
2			CUSTOMER ORDERS
3	39	ABDCG/	WBS
4			MASTER SCHEDULE
5	44	ACAAF/	DETAIL SCHEDULE
6			REGULATORY REQUIREMENTS
7	32	ABDCC/	GEOMETRY
8	8	ACAAF/	PART GEOMETRY
9			KINEMATICS
10	45	ACAAF/	WEIGHTS - SCIENTIFIC ANALYSIS
11	46	ACAAF/	AERODYNAMICS - SCIENTIFIC ANALYSIS
12	37	ACAAF/	LOADS - SCIENTIFIC ANALYSIS
13	47	ACAAF/	STRESS - SCIENTIFIC ANALYSIS
14			PROCESS SPECIFICATION
15			DESIGN PHILOSOPHY
16			PRODUCT PERFORMANCE TARGETS
17	61	ACAAF/	COMPONENT SPECS
18			MATERIAL SPECS
19	62	ACAAF/	GENERAL ARRANGEMENT
20			ENVIRONMENT
21			NOT USED
22			CUSTOMER VARIABLES
23			DESIGN CHANGE REQUESTS
24			MANUFACTURING, PLANS SCHEDULES, CAPABILITIES
25	29	ACAAF/	OPERATIONS & MAINTENANCE (AIRPLANE) INPUT DATA
26	32	/ACAA	STRESS STAFF REVIEW RESULTS
27	33	/ACAA	WEIGHTS STAFF REVIEW RESULTS
28	31	/ACAA	MATERIALS & PROCESS REVIEW RESULTS
29	41	/ACAA	DESIGN FUNCTION REVIEW RESULTS
30	30	/ACAA	PRODUCIBILITY REVIEW RESULTS
31	42	/ACAA	MOCK-UP REVIEW RESULTS
32	35	ACAAF/	DESIGN DEFINITION (INCLUDES REDESIGN, KITS, SPARES)
33a	4	/ACAC	UPDATED WBS
33b	1	/ACAD	UPDATED WBS

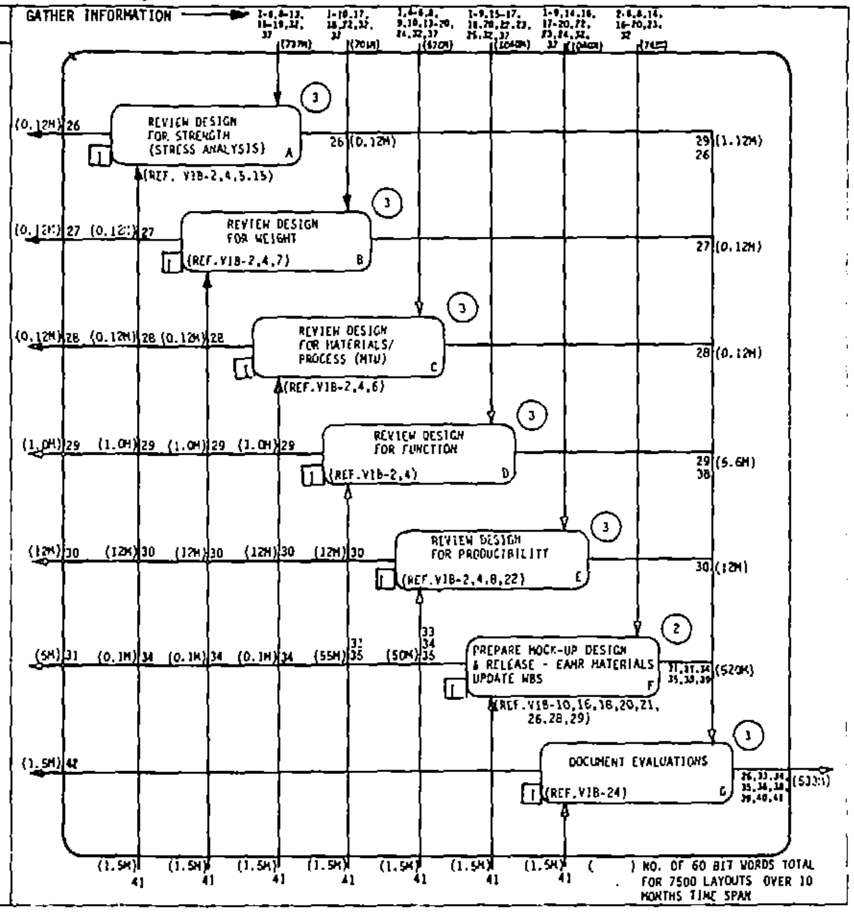


Figure 30.—Data Model ACAB – Evaluate Design (Level VI)

BCS

TITLE EVALUATE DESIGN (LEVEL VI)

I - INTERACTIVE, B - BATCH
NO. ITERATIONS

FIGURE 2.2-22
MODEL ACAB

DATA I.D.	DECOMP. TRACE	ORIG/ DEST.	DATA DESCRIPTION (DATA FLOW)
34	47	/ACAC	EAMR RELEASE
35		/ACB	MOCK-UP DESIGN & RELEASE
36	51	/ACAC	REVIEW RESULTS DOCUMENTATION
37	48	ACAA/	STATUS (PERFORMANCE - PROBLEMS)
38	25	/ACAC	OPERATIONS & MAINTENANCE OUTPUT DATA
39	26	/ACAC	DESIGN DEFINITION (INCLUDES REDESIGN, KITS, SPARES)
40	46	/ACAC	STATUS (PERFORMANCE - PROBLEMS)
41	45	/ACACG	STATUS (PERFORMANCE - PROBLEMS)
42a	50	/ACAA	STATUS (PERFORMANCE - PROBLEMS)
42b	34	/ACA	STATUS (PERFORMANCE - PROBLEMS)

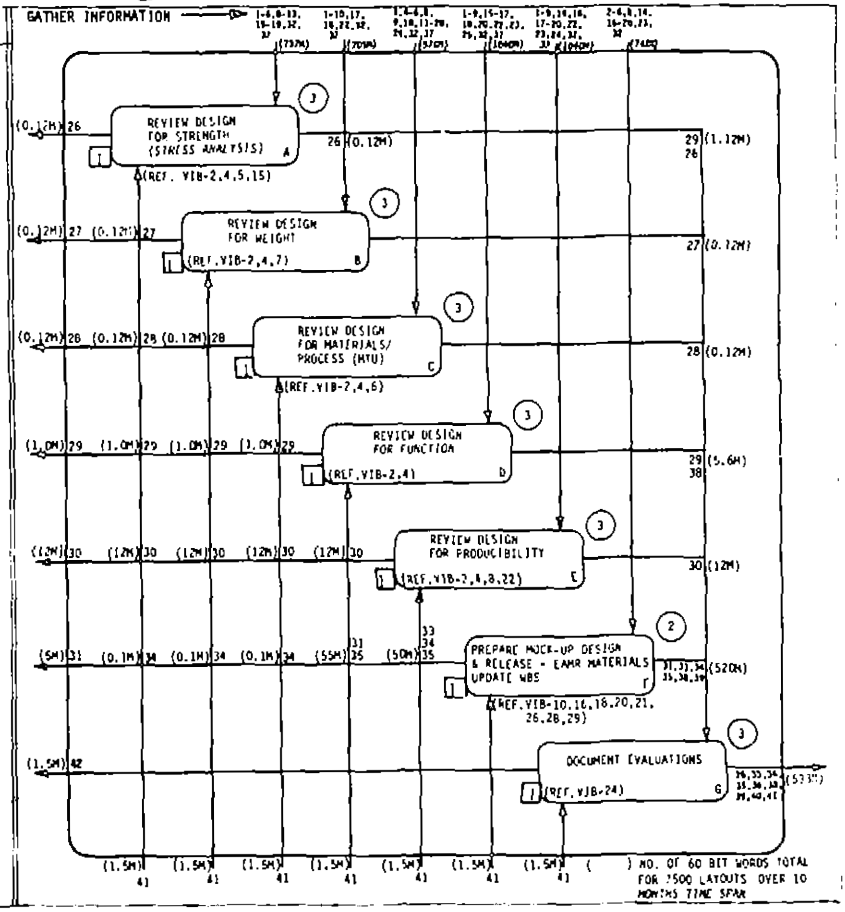


Figure 30.—Evaluate Design Level VI (Concluded)

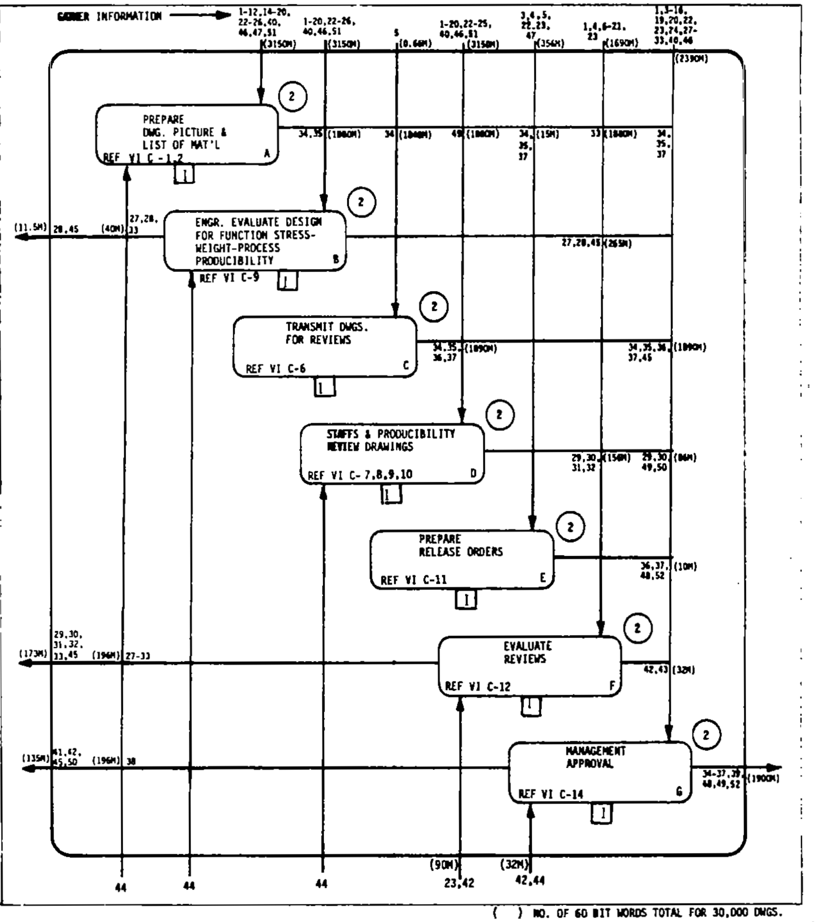
BCS BOEING COMPUTER SERVICES INC

TITLE PREPARE FINAL DESIGN DRAWINGS / DATA (LEVEL VI)

☐ I - INTERACTIVE, B - BATCH
◯ NO. ITERATIONS,

FIGURE 2.2 - 23
MODEL ACAC

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1			GENERAL ANALYSIS METHODS
2	35	ACAAE/	DESIGN LAYOUT
3			CUSTOMER ORDERS
4	33	ACABG/	WBS
5	44	ACAAF/	DETAIL SCHEDULE
6			REGULATORY REQUIREMENTS
7	32	ABDCC/	GEOMETRY
8	8	ACAAF/	PART GEOMETRY
9			KINEMATICS
10	45	ABDCG/	WEIGHTS SCIENTIFIC ANALYSIS
11	46	ABDCG/	AERO
12	34	ABDCG/	LOADS
13	47	ABDCG/	STRESS
14			PROCESS SPECIFICATIONS
15			DESIGN PHILOSOPHY
16			PRODUCT PERFORMANCE TARGETS (RANGE-PAYLOAD LIFE - MAINT)
17	61	ACAAF/	COMPONENT SPECS (ENGINE, VALUES, PUMPS, MOTOR, SWITCHES, ETC.)
18			MATERIAL SPECS (SHEET-BAR-TUBING-EXT-FORGING-FAST)
19	62	ACAAF/	GENERAL ARRANGEMENT
20			ENVIRONMENT
21			NOT USED
22			CUSTOMER VARIABLES
23			DESIGN CHANGE REQUESTS (PRODUCTION)
24			MANUFACTURING-PLANS-SCHEDULES-CAPABILITIES
25	38	ACABG/	OPERATIONS & MAINTENANCE (PRODUCT)
26	39	ACABG/	DESIGN DEFINITION-DRAWING/DATA (INCLUDES REDESIGN-KITS-SPARES)
27			DRAWING-PROCEDURE/GEOMETRY/ACCURACY-REVIEW RESULTS
28	51	ACAAF/	DESIGN FUNCTION REVIEW RESULTS
29	52	ACAAF/	STRESS STAFF REVIEW RESULTS
30	53	ACAAF/	WEIGHTS STAFF REVIEW RESULTS
31	54	ACAAF/	MATERIALS TECHNOLOGY STAFF REVIEW RESULTS
32	55	/ACAAF	PRODUCIBILITY REVIEW RESULTS
33	56	ACAAF/	MOCK UP REVIEW RESULTS
34	10	/ACAD	DESIGN DEFINITION - FINAL DWG/DATA (INCLUDES REDESIGN-KITS-SPARES)



( ) NO. OF 60 BIT WORDS TOTAL FOR 30,000 DWGS. (PICTURE SHEETS & PARTS LISTS FOR 100,000 PARTS) OVER 18 MONTH TIME SPAN

Figure 31.—Data Model ACAC – Prepare Design Releases (Level VI)

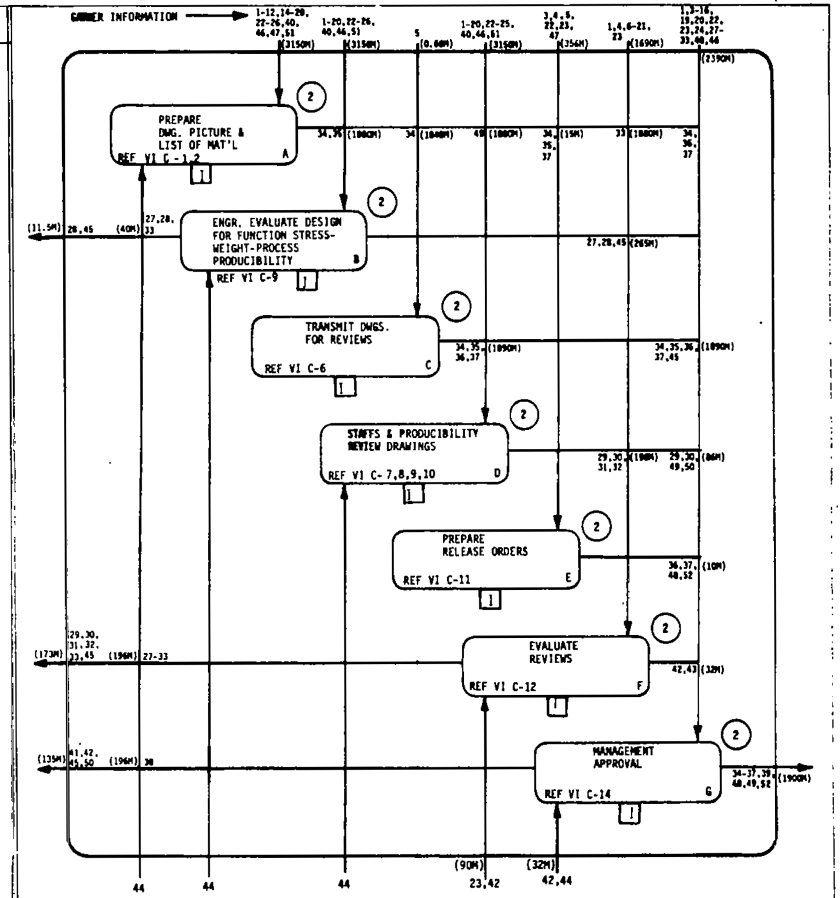
BCS

PREPARE FINAL DESIGN DRAWINGS / DATA (LEVEL VI)

☐ I - INTERACTIVE, B - BATCH
◯ NO. ITERATIONS,

FIGURE 2.2 - 23
MODEL ACAC

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
35	11	/ACAD	OPERATION & MAINTENANCE PROCEDURES (PRODUCT)
36	6	/ACADE	DRAWING RELEASE & PART RELEASE AUTHORIZATION (EPR)
37	3	/ACADA	EAMR (UPDATED)
38			MANAGEMENT EVALUATION
39	17	/ACAD	MANAGEMENT APPROVAL
40	48	ACAAE/	STATUS (PERFORMANCE PROBLEMS)
41	58	/ACAA	DESIGN CHANGE REQUEST (MANAGEMENT)
42a	10	ACD/	DESIGN CHANGE REQUEST (CUSTOMER/SUPPORT)
42b	59	/ACAA	DESIGN CHANGE REQUEST (CUSTOMER SUPPORT)
43	15	/ACAD	STATUS (PERFORMANCE PROBLEMS)
44	14	ACAD/	STATUS (PERFORMANCE PROBLEMS)
45a	41	/ACAB	STATUS (PERFORMANCE PROBLEMS)
45b	35	/ACA	STATUS (PERFORMANCE PROBLEMS)
46	40	ACABG/	STATUS (PERFORMANCE PROBLEMS)
47	34	ACABF/	EAMR
48	4	/ACAD	DRAWING DATA RECORD (DDR)
49	9	ACADD	GAGE DATA INFORMATION
50	60	/ACAA	DESIGN CHANGE REQUEST (PRODUCTION)
51	36	ACABG/	DESIGN EVALUATION
52	12	/ACAD	OPERATIONS & PROCEDURES TRANSMITTAL



( ) NO. OF 60 BIT WORDS TOTAL FOR 30,000 DWGS. (PICTURE SHEETS & PARTS LISTS FOR 100,000 PARTS) OVER 18 MONTH TIME SPAN

Figure 31.—Prepare Final Design Drawings/Data—Level VI (Concluded)

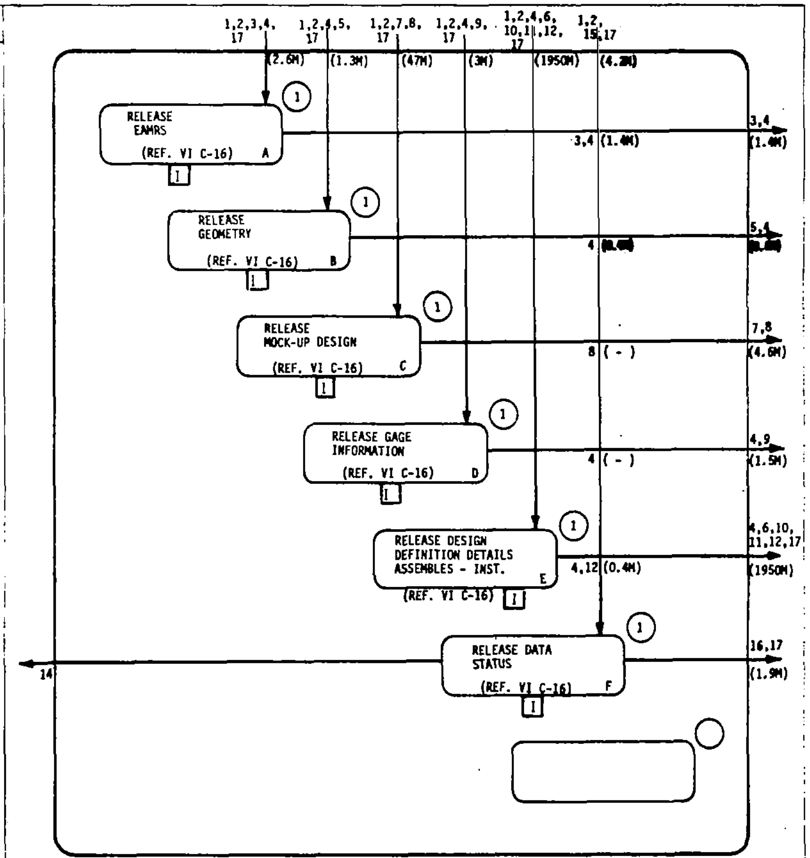
BCS BOEING COMPUTER SERVICES INC

TITLE RELEASE ENGINEERING DATA (LEVEL VI)

[ ] - INTERACTIVE, B - BATCH
○ NO. ITERATIONS,

FIGURE 2.2-24
MODEL ACAD

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1	33	ACABG/	WBS
2	44	ACAAF/	DETAIL SCHEDULE
3	37	ACACG/	EAMR
4	48	ACACG/	DDR (DRAWING DATA RECORD)
5	32	ABDCG/	GEOMETRY
6	36	ACACG/	EPR (ENGINEERING PARTS RELEASE)
7	57	ACAAF/	MOCK-UP DESIGN (II)
8	43	ACAAF	MOCK-UP RELEASE TRANSMITTAL
9	49	ACACG/	GAGE DATA DEFINITION
10	34	ACACG/	DESIGN DEFINITION (DETAILS - ASSEMBLIES - COMPONENT SPECS - INSTALLATIONS)
11	35	ACACG/	OPERATION & MAINTENANCE PROCEDURES DATA
12	52	ACACG/	O & M PROCEDURES TRANSMITTAL
13			NOT USED
14	44	/ACAC	STATUS (PERFORMANCE - PROBLEMS)
15	43	ACACG/	STATUS (PERFORMANCE - PROBLEMS)
16	37	/ACB	STATUS (PERFORMANCE - PROBLEMS)
17	39	ACACG/	MANAGEMENT APPROVAL



( ) NO. OF 60 BIT WORDS TOTAL FOR 30,000 DRAWINGS (PICTURE SHEETS & PARTS LISTS FOR 100,000 PARTS) OVER 18 MONTHS TIME SPAN

Figure 32.—Data Model ACAD — Release Designs (Level VI)

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM LEVEL VII PRODUCT MANUFACTURE

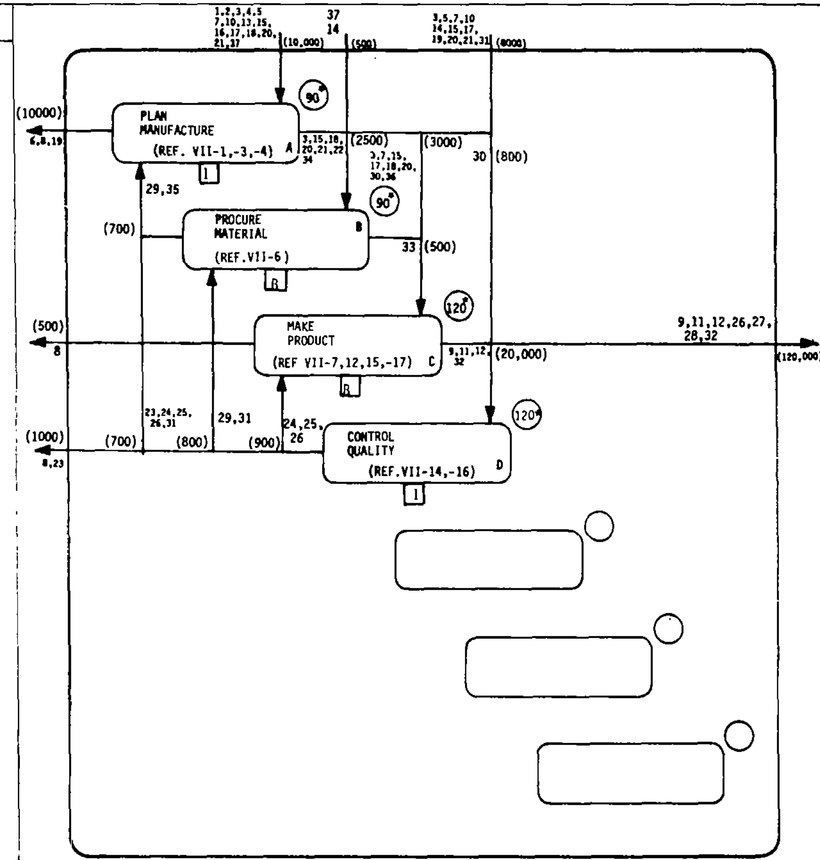
☐ I - INTERACTIVE, B - BATCH

◯ NO. ITERATIONS, ( ) NO. 60 BIT WORDS

FIGURE 2.2-25

MODEL ACB

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1			MASTER SCHEDULE
2		ACA/ACB	DESIGN CONCEPT
3		ACA/ACB	GEOMETRY
4		ACA/ACB	GENERAL ARRANGEMENT
5			DESIGN CHANGE REQUESTS
6		ACB/ACA	MANUFACTURING CAPABILITIES
7		ACA/ACB	MOCK-UP DESIGN
8		ACB/ACA	CHANGE REQUESTS (MANUFACTURING)
9		ACB/ACC	PRODUCT
10			TEST PLANS
11		ACB/ACD	SPARES
12		ACB/ACD	KITS
13			DESIGN APPROVAL
14		ACA/ACB	ADVANCE MATERIAL ORDERS
15		ACA/ACB	DESIGN DEFINITION
16		ACA/ACB	DESIGN RELEASE PAPER
17		ACA/ACB	SPARES AND KITS DEFINITIONS
18		ACA/ACB	PROCESS SPECIFICATIONS
19		ACB/ACA	PRODUCIBILITY REVIEW RESULTS
20		ACA/ACB	COMPONENT SPECIFICATIONS
21		ACA/ACB	MATERIAL SPECIFICATIONS
22			MATERIAL QUANTITY REQUIREMENTS
23			MATERIAL REVIEW RECOMMENDATIONS
24			PART REJECTIONS
25			ASSEMBLY AND INSTALLATION DISCREPANCIES
26			PRODUCT BUY-OFF
27		ACB/ACC	PRODUCT MANUFACTURE DOCUMENTATION
28		ACB/ACC	TEST RESULTS DOCUMENTATION
29			MATERIAL REJECTIONS
30			SHOP ORDERS
31			MATERIAL REVIEW DISPOSITION
32			MOCK-UP
33			MATERIAL AND PURCHASED COMPONENTS
34			PURCHASE ORDERS
35			PROCUREMENT STATUS AND PROBLEMS
36			NUMERICAL CONTROL MEDIA
37	16	ACAD/ ACBA	STATUS (PERFORMANCE - PROBLEMS ENGINEERING)



* ITERATIONS REQUIRED FOR EACH AIRPLANE MANUFACTURED

Figure 33.—Data Model ACB – Perform Level VII Product Manufacture

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM LEVEL VIII PRODUCT VERIFICATION

☐ I - INTERACTIVE, B - BATCH
◯ NO. ITERATIONS, (   ) NO. 60 BIT WORDS

FIGURE 2.2-26
MODEL ACC

DATA I.D.	DECOMP. TRACE	ORIG./ DEST.	DATA DESCRIPTION (DATA FLOW)
1	6	ACA	PRODUCT PERFORMANCE TARGET
2	7	ACA	GEOMETRY
3	9	ACA	COMPONENT AND MATERIAL SPECIFICATIONS
4	10	ACA	GENERAL ANALYSIS METHODS
5	12	ACA	REGULATORY REQUIREMENTS
6	13	ACA	SCIENTIFIC ANALYSIS (WTS, AERO, LOADS, ETC.)
7	20	ACA	EVALUATION RESULTS
8	21	ACA	DESIGN DEFINITION
9	22	ACA	STATUS (PERFORMANCE, PROBLEMS)
10	24	ACA	DESIGN RELEASE PAPER
11	26	ACA	DESIGN CHANGE
12			MASTER SCHEDULE
13	9	ACB	PRODUCT
14	10	ACB	TEST PLANS
15	27	ACB	PRODUCT MANUFACTURE DOCUMENTATION
16	28	ACB	TEST RESULTS DOCUMENTATION
17			DESIGN CHANGE REQUEST
18			PRODUCT CERTIFICATION
19			HISTORICAL DATA

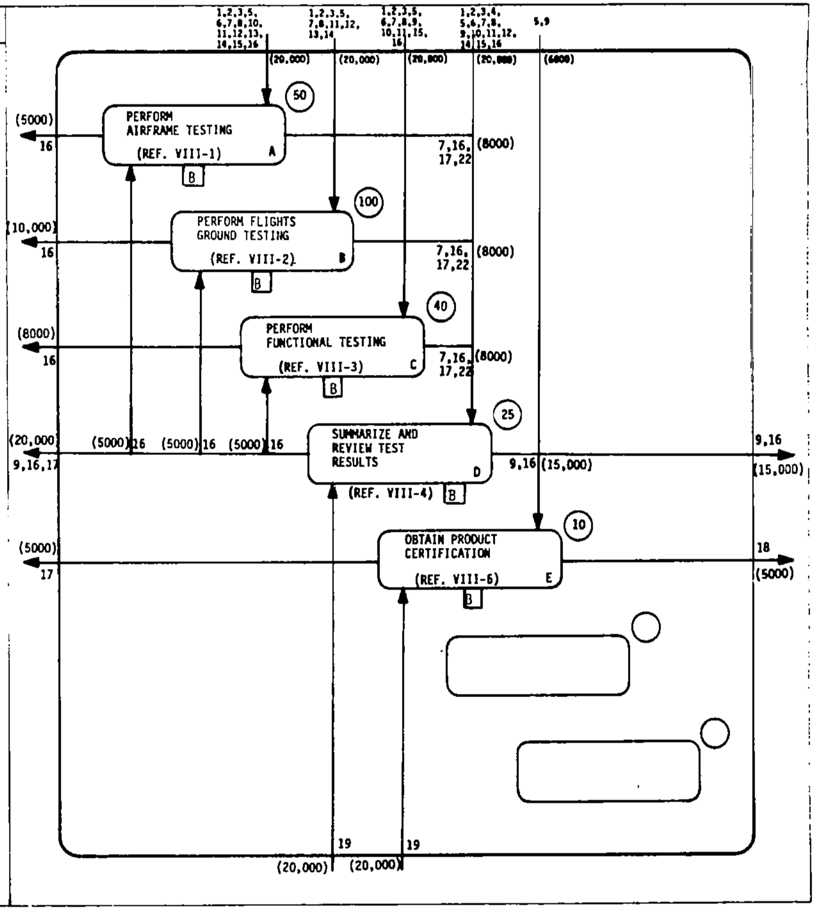


Figure 34.—Data Model ACC – Perform Level VIII Product Verification

BCS BOEING COMPUTER SERVICES INC

TITLE PERFORM LEVEL IX PRODUCT SUPPORT

☐ I - INTERACTIVE, B - BATCH

◯ NO. ITERATIONS, (   )   NO. 60 BIT WORDS

FIGURE 2.2-27

MODEL ACD

DATA I.D.	DECOMP. TRACE	ORIG/. DEST.	DATA DESCRIPTION (DATA FLOW)
1			HISTORICAL DATA
2			INSERVICE EXPERIENCE ANALYSES
3			CUSTOMER ORDERS
4			PRODUCT PERFORMANCE TARGET
5			COMPONENT AND MATERIAL SPECIFICATIONS
6			REGULATORY REQUIREMENTS
7			EVALUATION RESULTS
8			STATUS (PERFORMANCE, PROBLEMS)
9			TEST RESULTS DOCUMENTATION
10	43	ACAC	DESIGN CHANGE REQUEST
11			KITS AND SPARES DESIGN DEFINITION
12			OPERATION AND MAINTENANCE METHODS
13			SERVICE BULLETINS
14			RETROFIT KITS
15			SPARE PARTS LISTS
16			FLIGHT SUPPORT
17			MAINTENANCE AND GROUND SUPPORT
18			SPARES ANALYSES
19			MAINTENANCE AND OPERATIONS MANUALS
20			FIELD SERVICE SUPPORT
21			INSERVICE EXPERIENCE

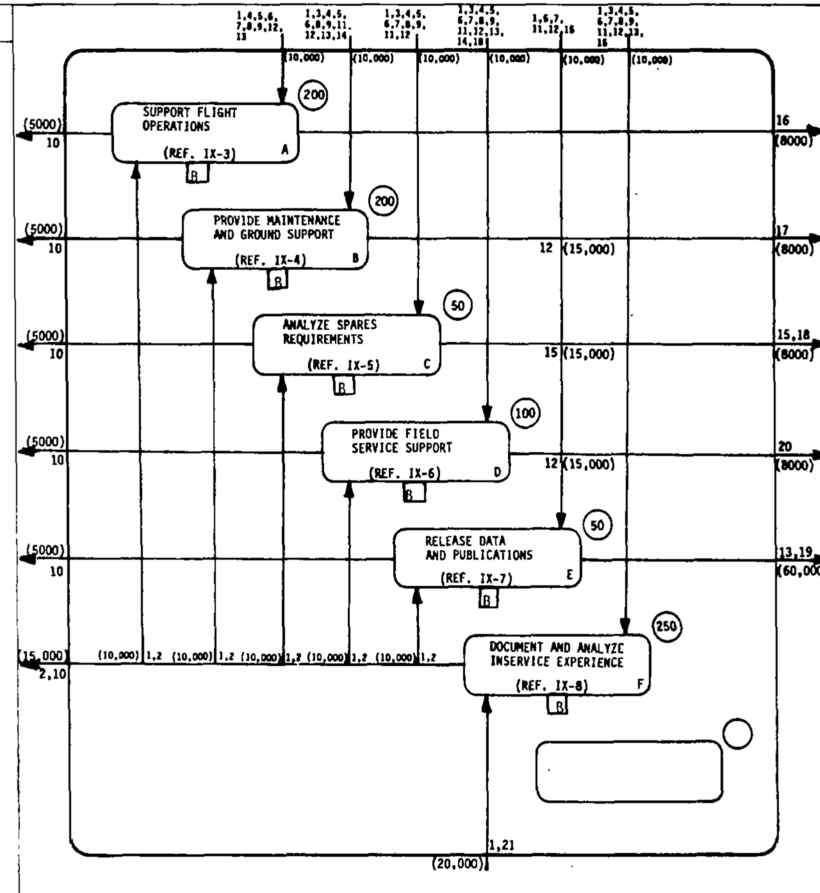


Figure 35.—Data Model ACD – Perform Level IX Product Support

4.3 DESIGN PROCESS DATA CATEGORIES

An analysis was made of data categories within the design process. Figure 36 illustrates these categories. The general character of data within each category is described in the following sections.

Product Requirements--Corporate. Corporate requirements for new products are based on marketing research, customer orders, corporate financial resources, etc. For defense contracts, corporate determines what bid proposals will be prepared. The parameters for conceptual design projects are size, range, operating costs and cost targets for product development. The data for corporate requirements consist of memoranda, marketing reports, general product parameters, etc. These represent volumes of text, graphs, sketches and drawings which can be cataloged for access from files--the infrequency of use may preclude the need for other than manual access.

Product Requirements--Regulatory. Government regulations impose product requirements concerning safety, noise, performance, etc. This information is in the form of several volumes of documentation which are subject to revisions as they are released. The design projects must have access to this information, but it is not essential that it be available at a moments notice, such as at a terminal. It is used to measure requirements at critical design reviews.

Product Requirements--Customer. The military, or Government, customer imposes the requirements for a product through a request for proposal (RFP) which describes the mission, cost targets, etc. The RFP consists of several documents, generally. The commercial customer imposes variances from a standard design, usually, such as preferences in seating arrangements, instrument groupings, etc. These are in the form of specification documents, drawings, sketches, color schemes, etc. These are used for the initial design and critical design reviews and customer acceptance.

Product Description--Design Work Package Descriptions. Design work package descriptions are developed to guide all design work and to provide a primary interface with all funtional departments. The design work packages are the result of a coordinated work package team which include team members from all involved functional disciplines. Design work packages are used to cost design elements and to quickly acquaint the personnel assigned to the task with all aspects of the task to be accomplished and the applicable design requirements. They also provide early visibility of the component design approach and give technology and manufacturing specialists an opportunity to make suggestions for cost and weight improvements.

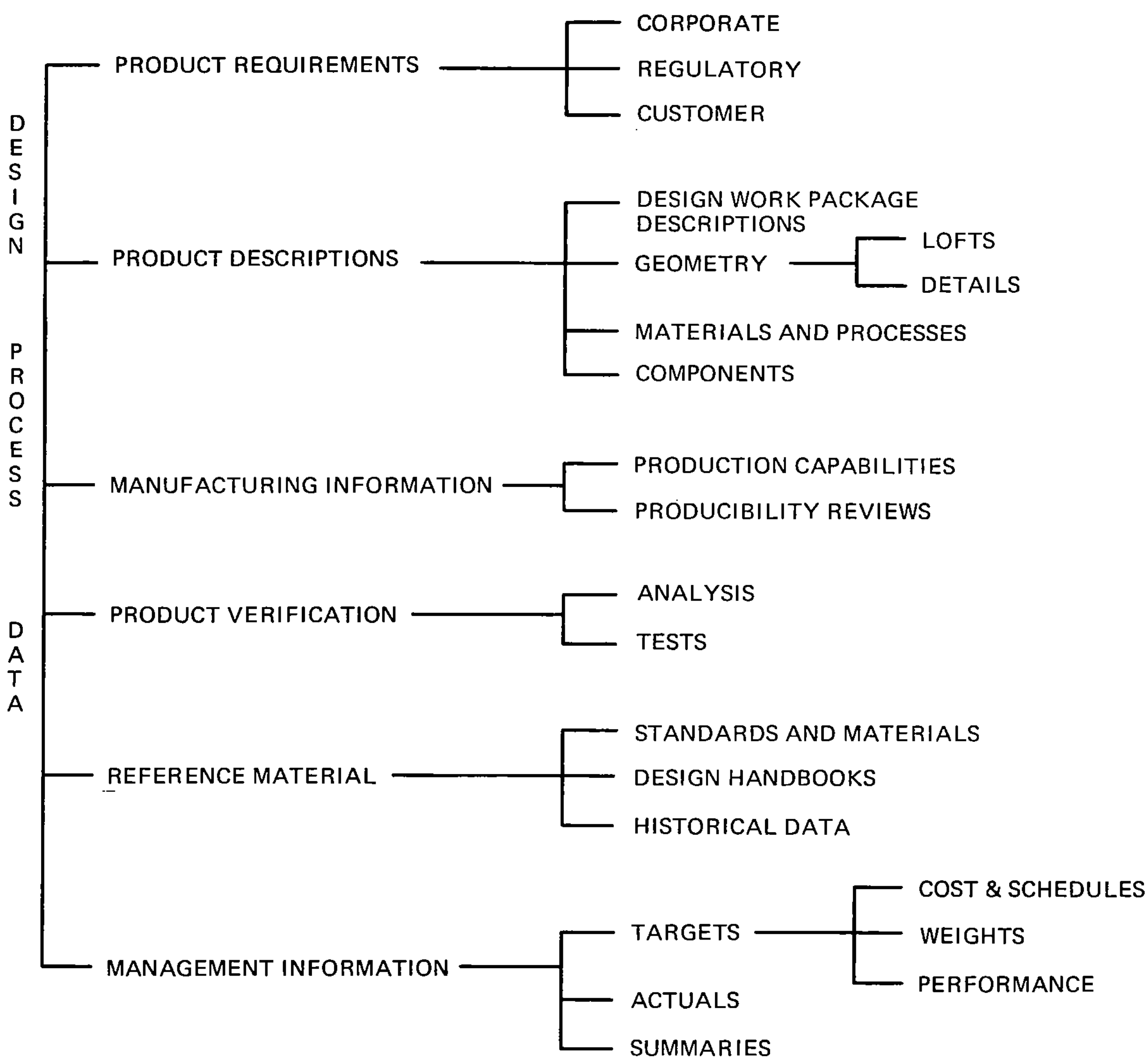


Figure 36.—Design Process Data Categories

The total product hardware is subdivided into discrete packages at Work Breakdown Structure (WBS) levels 4 and 5, and are organized as volumes of a document. Each volume is identified by a unique program item number (PIN) and contains PIN description for the lowest level of the WBS required to insure that the cost and development schedules for the work package are clearly established. Each work package defines the hardware, schedule, critical events, and the established targets for the designer. Their purpose is to provide basic information for the design, development, and manufacture of the product and are used as the prime tool for:

Development of the complete component

Identifying potential product improvements including cost reduction

An up-to-date design description

Visibility of concept

Establishing and tracking targets

The design work packages serve to define the product until the final engineering technical definition is released, e.g., drawings, documents, data sets, etc. The work packages consist of text and sketches.

Product Descriptions—Geometry. The geometry of the product is represented by several media and methods. One of the primary purposes is to communicate the product geometry to manufacturing in order to fabricate or purchase the various components and to assemble the product and install the systems. Other users of geometry include aerodynamics (for wind tunnel models), structural analysis, quality assurance, and product support.

Loft Geometry is used to generate the shape of the product and some off-surface features (e.g., stringer centerlines), beginning with rough shapes in preliminary design and developing the final product lines which control the component geometry. Lofts include computer definitions (points, lines and cross section logic) and extractions from the definitions which can be plotted, printed (coordinate points) or produced on magnetic tapes or disks. This information can be used by design for detail geometry control and by manufacturing for tool design and numerical control input data.

Detail Geometry is used to define product components, systems, assemblies, and installations. These are in the form of computer output (plots, tapes, etc.), dimensioned drawings, and undimensioned full-scale drawings. The volume of this information has been described in CR 2982, section 6.0.

Product Descriptions--Materials and Processes. Specifications for physical properties of materials that are used for specific purposes in the product are used by the designer when designating material callouts on the list of materials. These are also used by procurement when ordering the material.

Process specifications describe requirements for heat treat, surface finish, surface treatment, etc. Manufacturing develops the production processes that will meet these specifications, based on formability, machineability, etc.

The material and processes specifications are generally in several volumes of handbooks but can reside in a computer data base for convenient accessibility by the user of such information.

Product Descriptions--Components. Specifications for purchased components and those manufactured in-house describe the criteria for size, strength, weight, function, and durability. These are used to request bids from suppliers and to develop criteria for acceptance testing of the completed components. These components may consist of complete systems.

The specifications are in the form of documents for each component, consisting of descriptions of the criteria, sketches, drawings, and geometric parameters. These documents can be adapted to computer storage.

Manufacturing Information--Production Capabilities. Manufacturing provides feedback information to the design engineer to provide guidelines for cost-effective production. The information is in various forms (memoranda, inserts to design handbooks, etc.) and covers various subjects (minimum corner radii for formed sheet metal parts, standard fillet radii for machined parts, etc.). Cost impacts may be provided concerning tolerance or surface finish, for example.

This information could be accessed from a computer data base, using key words. The designer user would then be able to compare various geometries and the associated costs for production.

Manufacturing Information--Producibility Reviews. Manufacturing reviews designs in rough layout form and in final form, either informally or as part of a critical design review. There is a continual interaction between the design and manufacturing engineers to develop an efficient design that can be produced cost effectively. The information produced informally will be incorporated in the design. The review during a critical design review is in the form of memoranda and can be documented with sketches and recommendations, similar to design change requests that are initiated after design release.

Product Verification—Analyses. Various aspects of the product are analyzed, beginning with conceptual design and continuing to final acceptance by the customer and for certification. The analyses include cost, weight, performance, systems, and structure. Computer programs support the bulk of these, although a design engineer may perform some interim analyses manually. The output of the analytical computer programs may include printouts, graphs, etc., and in many cases becomes input for other programs.

Existing computer programs will continue to be used in the IPAD environment but will probably be integrated with or interfaced to the IPAD system in some manner.

Product Verification--Tests. Various tests are used to verify that the product meets the requirements of design intent, performance, customer acceptance, etc. These tests utilize computer programs to collect and analyze the test data. Wind tunnel tests are used by aerodynamics early in the design phase and are followed by system functional tests, structural static and dynamic tests, and ultimately by flight tests. There are also laboratory tests to determine properties of materials, component acceptance tests, etc.

The test results are summarized and documented, using tables, graphs, text, etc. This documentation becomes part of the historical data for follow-on programs. Some of the test data may be used in the analytical programs.

Reference Material--Standards and Materials. Reference information for design engineers is available for standard hardware (fasteners), extrusions, and raw material (sheet, plate, etc.) Data on size, strength, and condition is included, as well as possible substitutions. This information is primarily in table form in several document volumes. This data could be stored in a computer data base in conjunction with a current inventory, so the design engineer could check on availability. This would be advantageous when considering substitutions of material, etc.

Reference Material--Design Handbooks. Design handbooks contain guidelines for design engineers for all aspects of design. This requires several volumes of documenation including texts, tables, graphs and drawings. The design criteria include fastener patterns, forming radii, tolerance analysis, structural analysis techniques, etc. Much of the information concerns the manufacturing feedback with production capabilties and limitations. Cost criteria are also discussed.

Much of the design handbook data is adaptable to computer files that can be assessed at a termianl by the use of key words. The information for which computer storage would not be feasible could be indexed for a search by the user.

Reference Material--Historical Data. Historical information is available in many forms from various sources. This information concerns experience on existing and past products that can be used on new product design. Much of the data has been relegated to archives and can be retrieved in a matter of hours or several days. This information may be in the form of drawings and documents and test reports. Much of the data appears in the handbooks for current use. New information is being gathered by product support and spares organizations as actual performance experience is documented.

Historical data is readily usable only when it is organized and cataloged for quick access by potential users. If a search is slow and cumbersome, it will be abandoned. Here again is a potential application for computer files of information accessible by the design engineer. Classification coding systems are in use to index existing parts which may be selected for a current design application. Using manual retrieval methods, classification coding systems have been demonstrated to produce 10 percent of the parts required for current design application. This has proved very cost effective.

Management Information--Targets. Planning of a new product results in targets for costs and schedules, weights, and performance. The targets are assigned to program item numbers (PIN) which are related to a comprehensive work breakdown structure (WBS). The management of a product line then uses these targets to measure the progress of the attainment of the targets.

A management information system can be integrated in the IPAD system to provide progress reports and isolate problem areas.

Management Information--Actuals. Actual results are collected against the target costs and schedules, weights, and performance to determine progress. Charts and graphs are produced to provide management with this information, on which decisions will be based.

Management Information--Summaries. Target versus actual summary reports are used to measure performance, determine problem areas and to support critical design reviews. Summaries can be provided to top management, while more detailed reports are provided to lower levels of management for day-to-day progress reviews. The results of the summary reports must be available both at a terminal and on hardcopy reports.

4.4 EXAMPLE COMPUTING RESOURCES MODEL

A computing resources model has been developed to characterize typical engineering users. Computing usage parameters were based on three weeks considered typical of the computing work load for a large scientific computing complex. One week was selected from each of three months (March, June, and October 1976). Selective data was extracted from the three weeks for the following work groupings:

Structures staff

All other staffs (aerodynamics, weights, etc.)

Detail design structure

All other detail design

Preliminary design

All other engineering

Total: all engineering

Sixteen basic parameters were evaluated for each of the above work groups. A logarithmic or linear distribution was plotted for each parameter. The distributions were based on the number of jobs which fall into a specific range, such as central processor seconds having an upper limit of 1 sec, 2 sec, 4 sec, 8 sec, etc. The following is a list of the parameters evaluted:

CP SEC (central processor seconds)

RUT SEC (resources utilization time)

CM UNITS (central memory units)

MS ACCESS (mass storage access)

MS SECTORS (mass storage sectors)

KIT CH OUT (KRONOS interactive timesharing character output)

TTY CONCT (teletype connect time)

CALC CRUS (calculated computer resource units)

CP/RUT (ratio of central processor seconds to total seconds of resources used)

MSS/MSA (ratio of sectors of data per each disk request)

CRUS/TTYCT (ratio of resources used per second of terminal connect time)

AV EFF FL (average effective field length)

CP/TTYCT (ratio of central processor seconds used per second of terminal connect time)

MSA/TTYCT (ratio of disk requests per second of terminal connect time)

MSS/TTYCT (ratio of mass storage sectors obtained per second of terminal connect time)

ORIGIN/TYP (origin type i.e., local batch, remote job entry or timesharing)

The log sum distribution was also plotted for several parameters. The plotted data were further divided by 1) timesharing jobs, 2) batch jobs and 3) all jobs. This generated a total of 245 plotted distributions, i.e., 35 distributions for each of the seven work groupings. Figures 37 through 58 show the 35 distributions for the total of all engineering work. The work represented by these distributions is typical of the commercial airplane scientific computing environment and would be similar for military aircraft. The work includes preliminary design, a major product development effort for a new subsonic commercial transport, a major product development effort for a derivative subsonic commercial transport, and sustaining for four subsonic commercial airplanes in current production. The work does not include engineering business systems such as parts release. The complete distributions are contained in computer listing SM-L-0001 (ref. 7). Tables 1 through 4 show a comparison of the mean value for each of the 16 parameters and their standard deviation. These tables characterize the average or typical timesharing and batch users. The sixteen parameters used in the analysis of computing resources should be considered examples and are reference data to aid the computing staff in selecting the parameters to be used to meet the requirements for computing system performance, monitoring, and control specified in section 5.3.5.3. It may be necessary during the computing day to make adjustments in basic computing system resources available for jobs such as central memory, central processor time slice, etc., in order to maintain acceptable overall system response time.

CP SEC UPPER LIMIT	NO. JOBS	%	
1.00	3187	44	.XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
2.00	701	10	.XXXXXXXXXX
4.00	757	10	.XXXXXXXXXX
8.00	727	10	.XXXXXXXXXX
16.00	674	9	.XXXXXXXXX
32.00	490	7	.XXXXXXX
64.00	372	5	.XXXXX
128.00	195	3	.XXX
256.00	88	1	.X
512.00	32	0	.
1024.00	8	0	.
2048.00	1	0	.
4096.00	0	0	.
8192.00	0	0	.
16384.00	0	0	.

CP SEC UPPER LIMIT	TOTAL CP SEC	%	
1.00	726.60	1	.X
2.00	1011.90	1	.X
4.00	2191.57	2	.XX
8.00	4198.87	4	.XXXX
16.00	7598.24	8	.XXXXXXXX
32.00	11418.29	12	.XXXXXXXXXXXX
64.00	16594.89	18	.XXXXXXXXXXXXXXXXXX
128.00	17126.85	18	.XXXXXXXXXXXXXXXXXX
256.00	15206.58	16	.XXXXXXXXXXXXXXXX
512.00	11026.61	12	.XXXXXXXXXXXX
1024.00	5776.39	6	.XXXXXX
2048.00	1813.19	2	.XX
4096.00	.00	0	.
8192.00	.00	0	.
16384.00	.00	0	.

*Figure 37.—Total Engineering Time-Sharing Jobs—
Distribution of CP Sec (Units—Sec)*

RUT SEC UPPER LIMIT	NO. JOBS	%	
1.00	1189	16	.XXXXXXXXXXXXXXXX
2.00	1085	15	.XXXXXXXXXXXXXXX
4.00	1023	14	.XXXXXXXXXXXXXX
8.00	927	13	.XXXXXXXXXXXXX
16.00	937	13	.XXXXXXXXXXXXX
32.00	771	11	.XXXXXXXXXXX
64.00	655	9	.XXXXXXXXX
128.00	375	5	.XXXXX
256.00	188	3	.XXX
512.00	56	1	.X
1024.00	22	0	.
2048.00	2	0	.
4096.00	2	0	.
8192.00	0	0	.
16384.00	0	0	.

RUT SEC UPPER LIMIT	TOTAL RUT SEC	%	
1.00	824.13	0	.
2.00	1574.13	1	.X
4.00	2934.98	2	.XX
8.00	5317.67	3	.XXX
16.00	11026.35	6	.XXXXXX
32.00	17414.52	10	.XXXXXXXXXX
64.00	29719.46	17	.XXXXXXXXXXXXXXXXX
128.00	33828.91	19	.XXXXXXXXXXXXXXXXXXX
256.00	33018.11	19	.XXXXXXXXXXXXXXXXXXX
512.00	19427.16	11	.XXXXXXXXXXX
1024.00	15455.29	9	.XXXXXXXXX
2048.00	3318.83	2	.XX
4096.00	4520.98	3	.XXX
8192.00	.00	0	.
16384.00	.00	0	.

Figure 38.—Total Engineering Time-Sharing Jobs—Distribution of RUT Sec (Units—Sec)

CM UNITS UPPER LIMIT	NO. JOBS	%	
1.00	3776	52	.XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
2.00	597	8	.XXXXXXXX
4.00	671	9	.XXXXXXXXX
8.00	661	9	.XXXXXXXXX
16.00	612	8	.XXXXXXXX
32.00	449	6	.XXXXXX
64.00	270	4	.XXXX
128.00	127	2	.XX
256.00	48	1	.X
512.00	17	0	.
1024.00	2	0	.
2048.00	2	0	.
4096.00	0	0	.
8192.00	0	0	.
16384.00	0	0	.
32768.00	0	0	.

CM UNITS UPPER LIMIT	TOTAL CM UNITS	%	
1.00	829.72	1	.X
2.00	862.54	1	.X
4.00	1932.97	3	.XXX
8.00	3808.48	6	.XXXXXX
16.00	7095.07	11	.XXXXXXXXXXX
32.00	10152.87	15	.XXXXXXXXXXXXXXX
64.00	12048.93	18	.XXXXXXXXXXXXXXXXXX
128.00	10992.55	17	.XXXXXXXXXXXXXXXXX
256.00	8548.81	13	.XXXXXXXXXXXXX
512.00	6232.13	9	.XXXXXXXXX
1024.00	1504.11	2	.XX
2048.00	2401.53	4	.XXXX
4096.00	.00	0	.
8192.00	.00	0	.
16384.00	.00	0	.
32768.00	.00	0	.

*Figure 39.—Total Engineering Time-Sharing Jobs—
Distribution of CM Units (Units—64k Sectors)*

MS ACCESS UPPER LIMIT	NO. JOBS	%	
5	9	0	.
10	5	0	.
20	767	11	.XXXXXXXXXXX
40	1562	22	.XXXXXXXXXXXXXXXXXXXXXX
80	1384	19	.XXXXXXXXXXXXXXXXXXX
160	1095	15	.XXXXXXXXXXXXXXX
320	930	13	.XXXXXXXXXXXXX
640	752	10	.XXXXXXXXXX
1280	425	6	.XXXXXX
2560	200	3	.XXX
5120	79	1	.X
10240	17	0	.
20480	5	0	.
40960	0	0	.
81920	0	0	.
163840	2	0	.

MS ACCESS UPPER LIMIT	TOTAL MS ACCESSES	%	
5	22	0	.
10	42	0	.
20	13347	1	.X
40	46581	2	.XX
80	78627	4	.XXXX
160	124747	6	.XXXXXX
320	213407	10	.XXXXXXXXXX
640	339699	16	.XXXXXXXXXXXXXXXX
1280	377074	17	.XXXXXXXXXXXXXXXXX
2560	354103	16	.XXXXXXXXXXXXXXXX
5120	270084	12	.XXXXXXXXXXXX
10240	112836	5	.XXXXX
20480	77303	4	.XXXX
40960	0	0	.
81920	0	0	.
163840	172778	8	.XXXXXXXX

Figure 40.—Total Engineering Time—Sharing Jobs—Distribution of MS Access (Units—Accesses)

MS SECTORS UPPER LIMIT	NO. JOBS	%	
25	1	0	.
50	5	0	.
100	3	0	.
200	519	7	.XXXXXXX
400	1304	18	.XXXXXXXXXXXXXXXXXX
800	1317	18	.XXXXXXXXXXXXXXXXXX
1600	1031	14	.XXXXXXXXXXXXXX
3200	969	13	.XXXXXXXXXXXXX
6400	892	12	.XXXXXXXXXXXX
12800	653	9	.XXXXXXXXX
25600	324	4	.XXXX
51200	152	2	.XX
102400	42	1	.X
204800	11	0	.
409600	9	0	.
819200	0	0	.
1638400	0	0	.
3276800	0	0	.
6553600	0	0	.
13107200	0	0	.
26214400	0	0	.

MS SECTORS UPPER LIMIT	TOTAL MS SECTORS	%	
25	0	0	.
50	190	0	.
100	211	0	.
200	90232	0	.
400	389945	1	.X
800	752304	2	.XX
1600	1181467	4	.XXXX
3200	2238926	7	.XXXXXXX
6400	4080625	12	.XXXXXXXXXXXX
12800	5950055	18	.XXXXXXXXXXXXXXXXXX
25600	5712136	17	.XXXXXXXXXXXXXXXXX
51200	5474926	17	.XXXXXXXXXXXXXXXXX
102400	2843273	9	.XXXXXXXXX
204800	1506800	5	.XXXXX
409600	2559953	8	.XXXXXXXX
819200	0	0	.
1638400	0	0	.
3276800	0	0	.
6553600	0	0	.
13107200	0	0	.
26214400	0	0	.

*Figure 41.—Total Engineering Time-Sharing Jobs—
Distribution of MS Sectors (Units—Sectors)*

CP SEC UPPER LIMIT	NO. JOBS	%	
1.00	1030	15	.XXXXXXXXXXXXXXX
2.00	427	6	.XXXXXX
4.00	518	7	.XXXXXXX
8.00	674	10	.XXXXXXXXXX
16.00	778	11	.XXXXXXXXXXX
32.00	949	14	.XXXXXXXXXXXXXX
64.00	819	12	.XXXXXXXXXXXX
128.00	782	11	.XXXXXXXXXXX
256.00	472	7	.XXXXXXX
512.00	330	5	.XXXXX
1024.00	144	2	.XX
2048.00	53	1	.X
4096.00	30	0	.
8192.00	12	0	.
16384.00	0	0	.

CP SEC UPPER LIMIT	TOTAL CP SEC	%	
1.00	312.25	0	.
2.00	624.31	0	.
4.00	1533.11	0	.
8.00	3895.66	1	.X
16.00	9038.14	1	.X
32.00	22189.47	3	.XXX
64.00	37884.58	6	.XXXXXX
128.00	69929.41	10	.XXXXXXXXXX
256.00	85990.21	13	.XXXXXXXXXXXXX
512.00	123331.10	18	.XXXXXXXXXXXXXXXXXX
1024.00	101408.46	15	.XXXXXXXXXXXXXXX
2048.00	74796.86	11	.XXXXXXXXXXX
4096.00	86227.49	13	.XXXXXXXXXXXXX
8192.00	63888.42	9	.XXXXXXXXX
16384.00	.00	0	.

Figure 42.—Total Engineering Batch Jobs—Distribution of CP Sec (Units—Sec)

RUT SEC UPPER LIMIT	NO. JOBS	%	
1.00	281	4	.XXXX
2.00	241	3	.XXX
4.00	433	6	.XXXXXX
8.00	537	8	.XXXXXXXX
16.00	645	9	.XXXXXXXXX
32.00	841	12	.XXXXXXXXXXXX
64.00	1032	15	.XXXXXXXXXXXXXXX
128.00	1065	15	.XXXXXXXXXXXXXXX
256.00	908	13	.XXXXXXXXXXXXX
512.00	534	8	.XXXXXXXX
1024.00	322	5	.XXXXX
2048.00	106	2	.XX
4096.00	47	1	.X
8192.00	23	0	.
16384.00	3	0	.

RUT SEC UPPER LIMIT	TOTAL RUT SEC	%	
1.00	200.03	0	.
2.00	345.08	0	.
4.00	1290.35	0	.
8.00	3082.50	0	.
16.00	7509.02	1	.X
32.00	19574.01	2	.XX
64.00	47530.31	4	.XXXX
128.00	99761.83	8	.XXXXXXXX
256.00	166658.35	14	.XXXXXXXXXXXXXX
512.00	189114.04	16	.XXXXXXXXXXXXXXXX
1024.00	221577.36	18	.XXXXXXXXXXXXXXXXXX
2048.00	149774.68	12	.XXXXXXXXXXXX
4096.00	137870.69	11	.XXXXXXXXXXX
8192.00	134288.61	11	.XXXXXXXXXXX
16384.00	33533.35	3	.XXX

*Figure 43.—Total Engineering Batch Jobs—
Distribution of RUT Sec (Units—Sec)*

CM UNITS UPPER LIMIT	NO. JOBS	%	
1.00	1135	16	.XXXXXXXXXXXXXXXX
2.00	428	6	.XXXXXX
4.00	474	7	.XXXXXXX
8.00	644	9	.XXXXXXXXX
16.00	730	10	.XXXXXXXXXX
32.00	872	12	.XXXXXXXXXXXX
64.00	867	12	.XXXXXXXXXXXX
128.00	776	11	.XXXXXXXXXXX
256.00	598	9	.XXXXXXXXX
512.00	263	4	.XXXX
1024.00	142	2	.XX
2048.00	50	1	.X
4096.00	26	0	.
8192.00	10	0	.
16384.00	3	0	.
32768.00	0	0	.

CM UNITS UPPER LIMIT	TOTAL CM UNITS	%	
1.00	366.25	0	.
2.00	620.23	0	.
4.00	1395.91	0	.
8.00	3773.16	1	.X
16.00	8521.49	1	.X
32.00	20084.14	3	.XXX
64.00	40469.43	6	.XXXXXX
128.00	70726.37	11	.XXXXXXXXXXX
256.00	106021.96	16	.XXXXXXXXXXXXXXXX
512.00	93382.75	14	.XXXXXXXXXXXXXX
1024.00	99163.40	15	.XXXXXXXXXXXXXXX
2048.00	69882.48	10	.XXXXXXXXXX
4096.00	70711.18	11	.XXXXXXXXXXX
8192.00	52736.96	8	.XXXXXXXX
16384.00	32249.67	5	.XXXXX
32768.00	.00	0	.

*Figure 44.—Total Engineering Batch Jobs—
Distribution of CM Units (Units—64k Sectors)*

MS ACCESS UPPER LIMIT	NO. JOBS	%	
5	0	0	.
10	2	0	.
20	128	2	.XX
40	362	5	.XXXXX
80	781	11	.XXXXXXXXXXX
160	883	13	.XXXXXXXXXXXXX
320	1024	15	.XXXXXXXXXXXXXXX
640	1095	16	.XXXXXXXXXXXXXXXX
1280	1052	15	.XXXXXXXXXXXXXXX
2560	799	11	.XXXXXXXXXXX
5120	506	7	.XXXXXXX
10240	244	3	.XXX
20480	101	1	.X
40960	25	0	.
81920	8	0	.
163840	5	0	.

MS ACCESS UPPER LIMIT	TOTAL MS ACCESSES	%	
5	0	0	.
10	20	0	.
20	2031	0	.
40	11185	0	.
80	46924	0	.
160	99769	1	.X
320	242443	2	.XX
640	506831	5	.XXXXX
1280	939244	9	.XXXXXXXXX
2560	1420516	14	.XXXXXXXXXXXXXX
5120	1778200	18	.XXXXXXXXXXXXXXXXXX
10240	1666667	17	.XXXXXXXXXXXXXXXXX
20480	1434563	14	.XXXXXXXXXXXXXX
40960	678300	7	.XXXXXXX
81920	404569	4	.XXXX
163840	684479	7	.XXXXXXX

*Figure 45.—Total Engineering Batch Jobs—
Distribution of MS Accesses (Units—Accesses)*

MS SECTORS UPPER LIMIT	NO. JOBS	%	
25	0	0	.
50	0	0	.
100	4	0	.
200	199	3	.XXX
400	260	4	.XXXX
800	557	8	.XXXXXXXX
1600	672	10	.XXXXXXXXXX
3200	834	12	.XXXXXXXXXXXX
6400	1150	16	.XXXXXXXXXXXXXXXX
12800	1026	15	.XXXXXXXXXXXXXXX
25600	968	14	.XXXXXXXXXXXXXX
51200	701	10	.XXXXXXXXXX
102400	361	5	.XXXXX
204800	169	2	.XX
409600	68	1	.X
819200	31	0	.
1638400	14	0	.
3276800	2	0	.
6553600	2	0	.
13107200	0	0	.
26214400	0	0	.

MS SECTORS UPPER LIMIT	TOTAL MS SECTORS	%	
25	0	0	.
50	0	0	.
100	350	0	.
200	31216	0	.
400	76891	0	.
800	347568	0	.
1600	795279	0	.
3200	1956866	1	.X
6400	5418663	3	.XXX
12800	9559007	5	.XXXXX
25600	17409692	10	.XXXXXXXXXX
51200	25035724	14	.XXXXXXXXXXXXXX
102400	25768096	15	.XXXXXXXXXXXXXXX
204800	24266473	14	.XXXXXXXXXXXXXX
409600	18859957	11	.XXXXXXXXXXX
819200	17016843	10	.XXXXXXXXXX
1638400	15202535	9	.XXXXXXXXX
3276800	4448740	3	.XXX
6553600	8738099	5	.XXXXX
13107200	0	0	.
26214400	0	0	.

Figure 46.—Total Engineering Batch Jobs—Distribution of MS Sectors (Units—Sectors)

KIT CH OUT UPPER LIMIT	NO. JOBS	%	
20	4	0	.
40	0	0	.
80	2	0	.
160	252	4	.XXXX
320	513	7	.XXXXXXX
640	640	9	.XXXXXXXXX
1280	872	12	.XXXXXXXXXXXX
2560	1057	15	.XXXXXXXXXXXXXXX
5120	1331	18	.XXXXXXXXXXXXXXXXXX
10240	1268	18	.XXXXXXXXXXXXXXXXXX
20480	788	11	.XXXXXXXXXXX
40960	369	5	.XXXXX
81920	101	1	.X

KIT CH OUT UPPER LIMIT	TOTAL KIT CH OUT	%	
20	0	0	.
40	0	0	.
80	154	0	.
160	35598	0	.
320	116588	0	.
640	303717	1	.X
1280	821570	2	.XX
2560	1963523	4	.XXXX
5120	4947659	11	.XXXXXXXXXXX
10240	9127893	21	.XXXXXXXXXXXXXXXXXXXXX
20480	11225705	25	.XXXXXXXXXXXXXXXXXXXXXXXXX
40960	10273138	23	.XXXXXXXXXXXXXXXXXXXXXXX
81920	5349944	12	.XXXXXXXXXXXX

*Figure 47.—Total Engineering Time—Sharing Jobs—
Distribution of KIT CH OUT (Units—Characters)*

TTY CONNCT UPPER LIMIT	NO. JOBS	%	
30.00	135	2	.XX
60.00	214	3	.XXX
120.00	464	6	.XXXXXX
240.00	650	9	.XXXXXXXXX
480.00	1034	14	.XXXXXXXXXXXXXX
960.00	1387	19	.XXXXXXXXXXXXXXXXXXX
1920.00	1515	21	.XXXXXXXXXXXXXXXXXXXXX
3840.00	1228	17	.XXXXXXXXXXXXXXXXX
7680.00	489	7	.XXXXXXX
15360.00	105	1	.X
30720.00	10	0	.
61440.00	1	0	.
122880.00	0	0	.

TTY CONNCT UPPER LIMIT	TOTAL TTY CONNCT	%	
30.00	2685.00	0	.
60.00	9827.00	0	.
120.00	41945.00	0	.
240.00	116130.00	1	.X
480.00	366130.00	3	.XXX
960.00	981364.00	9	.XXXXXXXXX
1920.00	2101843.00	20	.XXXXXXXXXXXXXXXXXXXX
3840.00	3258127.00	30	.XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
7680.00	2524228.00	24	.XXXXXXXXXXXXXXXXXXXXXXXX
15360.00	1044263.00	10	.XXXXXXXXXX
30720.00	198242.00	2	.XX
61440.00	46961.00	0	.
122880.00	.00	0	.

Figure 48.—Total Engineering Time-Sharing Jobs—Distribution of TTY CONNCT (Units—Sec)

CALC CRUS UPPER LIMIT	NO. JOBS	%	
1.00	4539	32	.XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
2.00	2267	16	.XXXXXXXXXXXXXXXX
4.00	2512	18	.XXXXXXXXXXXXXXXXXX
8.00	1920	13	.XXXXXXXXXXXXX
16.00	1500	11	.XXXXXXXXXXX
32.00	890	6	.XXXXXX
64.00	368	3	.XXX
128.00	159	1	.X
256.00	54	0	.
512.00	28	0	.
1024.00	11	0	.
2048.00	2	0	.
4096.00	0	0	.
8192.00	0	0	.
16384.00	0	0	.

CALC CRUS UPPER LIMIT	TOTAL CALC CRUS	%	
1.00	1847.38	2	.XX
2.00	3250.07	3	.XXX
4.00	7280.68	6	.XXXXXX
8.00	10949.15	9	.XXXXXXXXX
16.00	16726.43	14	.XXXXXXXXXXXXXX
32.00	19996.46	17	.XXXXXXXXXXXXXXXXX
64.00	16478.33	14	.XXXXXXXXXXXXXX
128.00	14290.03	12	.XXXXXXXXXXXX
256.00	9575.54	8	.XXXXXXXX
512.00	9395.63	8	.XXXXXXXX
1024.00	7102.19	6	.XXXXXX
2048.00	2568.78	2	.XX
4096.00	.00	0	.
8192.00	.00	0	.
16384.00	.00	0	.

*Figure 49.—Total Engineering Jobs—
Distribution of CALC CRUS (Units—Crus)*

CP/RUT UPPER LIMIT	NO. JOBS	%	
.1000	2965	21	.XXXXXXXXXXXXXXXXXXXXX
.2000	1675	12	.XXXXXXXXXXXX
.3000	1937	14	.XXXXXXXXXXXXXX
.4000	1757	12	.XXXXXXXXXXXX
.5000	1536	11	.XXXXXXXXXXX
.6000	1284	9	.XXXXXXXXX
.7000	1128	8	.XXXXXXXX
.8000	897	6	.XXXXXX
.9000	561	4	.XXXX
1.0000	463	3	.XXX

Figure 50.—Total Engineering Jobs—Distribution of CP/RUT

MSS/MSA UPPER LIMIT	NO. JOBS	%	
2.0	6	0	.
4.0	61	1	.X
8.0	483	7	.XXXXXXX
16.0	4546	63	.XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
32.0	1716	24	.XXXXXXXXXXXXXXXXXXXXXXXX
64.0	313	4	.XXXX
128.0	74	1	.X
256.0	27	0	.
512.0	5	0	.
1024.0	1	0	.
2048.0	0	0	.

*Figure 51.—Total Engineering Time-Sharing Jobs—
Distribution of MSS/MSA*

```
MSS/MSA
 UPPER      NO.
 LIMIT      JOBS      %
   2.0        21      0   .
   4.0        74      1   .X
   8.0      1005     14   .XXXXXXXXXXXXXX
  16.0      3148     45   .XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  32.0      2047     29   .XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  64.0       626      9   .XXXXXXXXX
 128.0        86      1   .X
 256.0        10      0   .
 512.0         1      0   .
1024.0         0      0   .
2048.0         0      0   .
```

Figure 52.—Total Engineering Batch Jobs—
Distribution of MSS/MSA

```
CRUS/TTYCT
UPPER        NO.
LIMIT        JOBS   %

 .001           4    0  .
 .001           0    0  .
 .002        5603   77  .XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 .004        1279   18  .XXXXXXXXXXXXXXXXXX
 .008         288    4  .XXXX
 .016          55    1  .X
 .032           3    0  .
 .064           0    0  .
 .128           0    0  .
 .256           0    0  .
 .512           0    0  .
```

*Figure 53.—Total Engineering Time-Sharing Jobs—
Distribution of CRUS/TTYCT*

AV EFF FL UPPER LIMIT	NO. JOBS	%	
020000	4392	31	.XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
040000	2754	19	.XXXXXXXXXXXXXXXXXXX
060000	2358	17	.XXXXXXXXXXXXXXXXX
100000	2092	15	.XXXXXXXXXXXXXXX
120000	1382	10	.XXXXXXXXXX
140000	859	6	.XXXXXX
160000	195	1	.X
200000	107	1	.X
220000	54	0	.
240000	16	0	.
260000	19	0	.
300000	8	0	.
320000	12	0	.
340000	2	0	.

Figure 54.—Total Engineering Jobs—Distribution of AV EFF FL (Units—OCTAL)

```
CP/TTYCT
UPPER      NO.
LIMIT      JOBS     %

  .001     3030    42   .XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  .002      810    11   .XXXXXXXXXXX
  .004      975    13   .XXXXXXXXXXXXX
  .008      932    13   .XXXXXXXXXXXXX
  .016      712    10   .XXXXXXXXXX
  .032      470     6   .XXXXXX
  .064      213     3   .XXX
  .128       73     1   .X
  .256       17     0   .
  .512        0     0   .
 1.024        0     0   .
```

Figure 55.—Total Engineering Time-Sharing Jobs—Distribution of CP/TTYCT

MSA/TTYCT UPPER LIMIT	NO. JOBS	%	
.005	13	0	.
.010	71	1	.X
.020	254	4	.XXXX
.040	620	9	.XXXXXXXXX
.080	1280	18	.XXXXXXXXXXXXXXXXXX
.160	1833	25	.XXXXXXXXXXXXXXXXXXXXXXXXX
.320	1647	23	.XXXXXXXXXXXXXXXXXXXXXXX
.640	1011	14	.XXXXXXXXXXXXXX
1.280	400	6	.XXXXXX
2.560	87	1	.X
5.120	13	0	.

Figure 56.—Total Engineering Time-Sharing Jobs—Distribution of MSA/TTYCT

MSS/TTYCT UPPER LIMIT	NO. JOBS	%	
.200	196	3	.XXX
.400	496	7	.XXXXXXX
.800	943	13	.XXXXXXXXXXXXX
1.600	1499	21	.XXXXXXXXXXXXXXXXXXXXX
3.200	1801	25	.XXXXXXXXXXXXXXXXXXXXXXXXX
6.400	1334	18	.XXXXXXXXXXXXXXXXXX
12.800	700	10	.XXXXXXXXXX
25.600	212	3	.XXX
51.200	44	1	.X
102.400	6	0	.
204.800	1	0	.

Figure 57.—Total Engineering Time-Sharing Jobs—Distribution of MSS/TTYCT

```
                  NO.
ORIGIN TYPE       JOBS     %

  LOCAL           5201    36   .XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  REMOTE          1808    13   .XXXXXXXXXXXXX
  KIT             7232    51   .XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  SYSTEM             9     0   .
  UNKNOWN            0     0   .
```

*Figure 58.—Total Engineering Jobs—
Distribution of Origin Type*

Table 1.—Computing Resources Utilization—Typical Technology Staff

WORK GROUP / PROCESSING TYPE	STRUCTURES STAFF						ALL OTHER STAFFS					
	TIME SHARING JOBS		BATCH JOBS		ALL JOBS		TIME SHARING JOBS		BATCH JOBS		ALL JOBS	
PARAMETER	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.
CP SEC	7.91	20.73	93.63	267.65	–	–	15.28	55.57	108.85	403.17	–	–
RUT SEC	17.65	46.11	201.05	479.46	–	–	26.30	76.61	166.76	577.37	–	–
CM UNITS	6.13	24.19	109.47	317.61	–	–	9.36	32.96	92.66	416.36	–	–
MS ACCESS	234	631	2,135	5,859	–	–	283	658	1,036	4,451	–	–
MS SECTORS	4,042	14,987	35,200	127,917	–	–	4,422	14,082	18,560	98,776	–	–
KIT CH OUT	4,384	5,778	–	–	–	–	6,994	10,289	–	–	–	–
TTY CONCT	1,226	1,440	–	–	–	–	1,555	2,172	–	–	–	–
CALC CRUS	–	–	–	–	10.69	32.37	–	–	–	–	7.85	34.35
CP/RUT	–	–	–	–	.3527	.2421	–	–	–	–	.3814	.2759
MSS/MSA	15.3	9.4	18.4	16.5	–	–	15.7	18.2	15.9	10.6	–	–
CRUS/TTYCT	.002	.001	–	–	–	–	.002	.001	–	–	–	–
AV EFF FL	–	–	–	–	51,025	37,256	–	–	–	–	42,737	33,332
CP/TTYCT	.006	.011	–	–	–	–	.007	.016	–	–	–	–
MSA/TTYCT	.244	.343	–	–	–	–	.227	.279	–	–	–	–
MSS/TTYCT	3.692	6.533	–	–	–	–	3.193	4.328	–	–	–	–
ORIGIN TYP	1,658	–	2,348*	–	4,006	–	4,260	–	3,736**	–	7,996	–

*777 RJE & 1571 LOCAL

**689 R JE & 3,047 LOCAL

Table 2.—Computing Resources Utilization—Typical Detail Design

WORK GROUP PROCESSING TYPE / PARAMETER	DETAIL DESIGN STRUCTURES						ALL OTHER DETAIL DESIGN					
	TIME SHARING JOBS		BATCH JOBS		ALL JOBS		TIME SHARING JOBS		BATCH JOBS		ALL JOBS	
	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.
CP SEC	11.09	22.02	36.15	80.23	–	–	37.00	85.93	45.23	83.13	–	–
RUT SEC	24.63	43.13	74.82	133.04	–	–	132.04	421.56	65.02	105.61	–	–
CM UNITS	10.63	21.19	38.30	61.99	–	–	71.72	251.56	38.70	66.74	–	–
MS ACCESS	316	803	650	1,118	–	–	4,630	18,015	684	2,209	–	–
MS SECTORS	5,556	11,488	12,152	21,768	–	–	10,960	25,779	5,387	8,411	–	–
KIT CH OUT	5,479	6,971	–	–	–	–	7,223	12,769	–	–	–	–
TTY CONCT	1,508	1,744	–	–	–	–	2,218	2,999	–	–	–	–
CALC CRUS	–	–	–	–	4.15	6.42	–	–	–	–	8.88	26.42
CP/RUT	–	–	–	–	.3265	.2404	–	–	–	–	.3717	.2926
MSS/MSA	20.6	21.9	25.0	25.9	–	–	24.1	24.6	19.2	12.3	–	–
CRUS/TTYCT	.002	.001	–	–	–	–	.003	.003	–	–	–	–
AV EFF FL	–	–	–	–	50,642	35,221	–	–	–	–	62,061	46,312
CP/TTYCT	.006	.012	–	–	–	–	.011	.020	–	–	–	–
MSA/TTYCT	.221	.282	–	–	–	–	.347	.710	–	–	–	–
MSS/TTYCT	3.593	3.996	–	–	–	–	4.376	4.392	–	–	–	–
ORIGIN TYP	832	–	541*	–	1,373	–	46	–	60**	–	104	–

*247 RJE & 294 LOCAL

*14 RJE & 46 LOCAL

Table 3.—Computing Resource Utilization—Typical Preliminary Design and All Other Engineering

WORK GROUP / PROCESSING TYPE / PARAMETER	PRELIMINARY DESIGN						ALL OTHER ENGINEERING					
	TIME SHARING JOBS		BATCH JOBS		ALL JOBS		TIME SHARING JOBS		BATCH JOBS		ALL JOBS	
	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.
CP SEC	14.91	59.56	94.83	216.73	–	–	7.23	16.23	102.97	252.34	–	–
RUT SEC	27.01	86.95	241.75	567.88	–	–	18.03	31.36	152.85	260.10	–	–
CM UNITS	10.47	35.94	150.91	674.80	–	–	8.81	18.21	77.94	116.03	–	–
MS ACCESS	308	932	2,250	5,042	–	–	141	275	1,016	1,214	–	–
MS SECTORS	4,625	9,754	58,472	175,913	–	–	5,553	12,390	19,963	19.271	–	–
KIT CH OUT	5,639	6,811	–	–	–	–	5,603	7,002	–	–	–	–
TTY CONCT	1,516	1,519	–	–	–	–	1,660	1,940	–	–	–	–
CALC CRUS	–	–	–	–	10.51	44.98	–	–	–	–	6.34	11.18
CP/RUT	–	–	–	–	.3383	.2499	–	–	–	–	.3305	.2556
MSS/MSA	16.3	7.6	19.9	18.6	–	–	34.6	54.3	25.2	17.5	–	–
CRUS/TTYCT	.002	.002	–	–	–	–	.002	.001	–	–	–	–
AV EFF FL	–	–	–	–	44,575	34,372	–	–	–	–	53,244	35,765
CP/TTYCT	.008	.020	–	–	–	–	.004	.010	–	–	–	–
MSA/TTYCT	.246	.288	–	–	–	–	.159	.174	–	–	–	–
MSS/TTYCT	3.714	4.386	–	–	–	–	3.220	3.599	–	–	–	–
ORIGIN TYP	321	–	244*	–	565	–	117	–	80**	–	197	–

*54 RJE & 190 LOCAL

**27 RJE & 53 LOCAL

Table 4.—Computing Resource Utilization—Typical Engineering

WORK GROUP / PROCESSING TYPE / PARAMETER	TOTAL ALL ENGINEERING					
	TIME SHARING JOBS		BATCH JOBS		ALL JOBS	
	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.	MEAN	STD. DEVIA.
CP SEC	13.09	46.84	97.04	337.60	–	–
RUT SEC	24.67	75.33	172.71	519.11	–	–
CM UNITS	9.18	36.05	95.48	378.16	–	–
MS ACCESS	301	1,597	1,413	4,840	–	–
MS SECTORS	4,532	13,953	24,926	109,133	–	–
KIT CH OUT	6,136	8,973	–	–	–	–
TTY CONCT	1,478	1,960	–	–	–	–
CALC CRUS	–	–	–	–	8.38	32.44
CP/RUT	–	–	–	–	.3656	.2631
MSS/MSA	16.6	18.2	17.7	15.1	–	–
CRUS/TTYCT	.002	.001	–	–	–	–
AV EFF FL	–	–	–	–	45,411	35,061
CP/TTYCT	.007	.015	–	–	–	–
MSA/TTYCT	.230	.299	–	–	–	–
MSS/TTYCT	3.384	4.888	–	–	–	–
ORIGIN TYP	7,232	–	7,009*	–	14,241	–

*1,808 RJE & 5,201 LOCAL

5.0 GENERAL DATA MANAGEMENT

This section describes the general principles of how IPAD should support data management and the definition and control of data generated during the execution of complex computer processes.

5.1 DATA STORAGE

An IPAD information bank is required and shall consist of all data which can be stored and retrieved by individuals or computer programs utilzing the IPAD system. It is envisioned that the organization of the information bank will be the responsibility of an information bank administrator(s). Information administration is considered to include authority over data integrity and security and the responsibility for the overall efficiency of the information bank. NASA CR 2985 contains additional requirements for system administration and information bank administration. The following or an equivalent hierarchial data storage modeling capability shall be provided to support data partitioning within the IPAD information bank (these items will be described in reverse order):

- Information bank
  - Data area
    - Data set

5.1.1 DATA SETS

A data set is defined to be a named unit of data and shall be the primary means for data communication within IPAD and between IPAD and remote systems. All occurrences of data in the information bank shall exist as values in data sets. A data set may contain a single data value or an arbitrary collection of values. The content of the data set may or may not be defined to IPAD. Section 6.0 contains specific requirements for definition of the contents of data sets.

A data set shall consist of two general items: a header identifing the source of the data and the occurrence of data values it contains. (Note: The word occurrence is used throughout this document to indicate that data values exist in a data set.)

5.1.2 Data Areas

A data area is defined to be a named collection of data sets and/or data areas and shall be the primary means to partition the information bank into a logical organization such as the example information bank organization described in section 5.1.3.2. The need to partition or split data by responsibility and other criteria is noted by many authors. References 3, 8, 9 and 10 are examples.

A data area shall consist of two general items; a dictionary or index describing what the area may contain and the actual occurrences of data sets it contains.

Each active user in IPAD will have a special subtask data area, which will function as a private working data space. All data generated by actions of a user is automatically placed in the user's working area. Separate action must be specified to make a given data set a member of more than one data area. (See sections 5.2.1 and 5.3.2.1.)

5.1.3 INFORMATION BANK

The information bank is defined to be the domain or collection of all data areas defined to IPAD. The following illustrates how an IPAD information bank may be organized.

5.1.3.1 Nested Data Areas

The use of nested data areas will allow the information bank administrator(s) to view the total information bank as having regions and subregions made up of many nested data areas containing many data sets.

Figure 59 illustrates a method which can be used to create a logical organization for an IPAD information bank. The following describes the elements of this organization technique.

Information Bank--An IPAD information bank consists of the collection of all data areas which are defined to the IPAD system.

Region--A region consists of a collection of all data areas related to one major functional organization using IPAD.

Subregion---A subregion consists of a collection of all data areas related to one discipline within a major functional organization.

Work Type--A work type consists of a data area which contains a collection of related data sets.

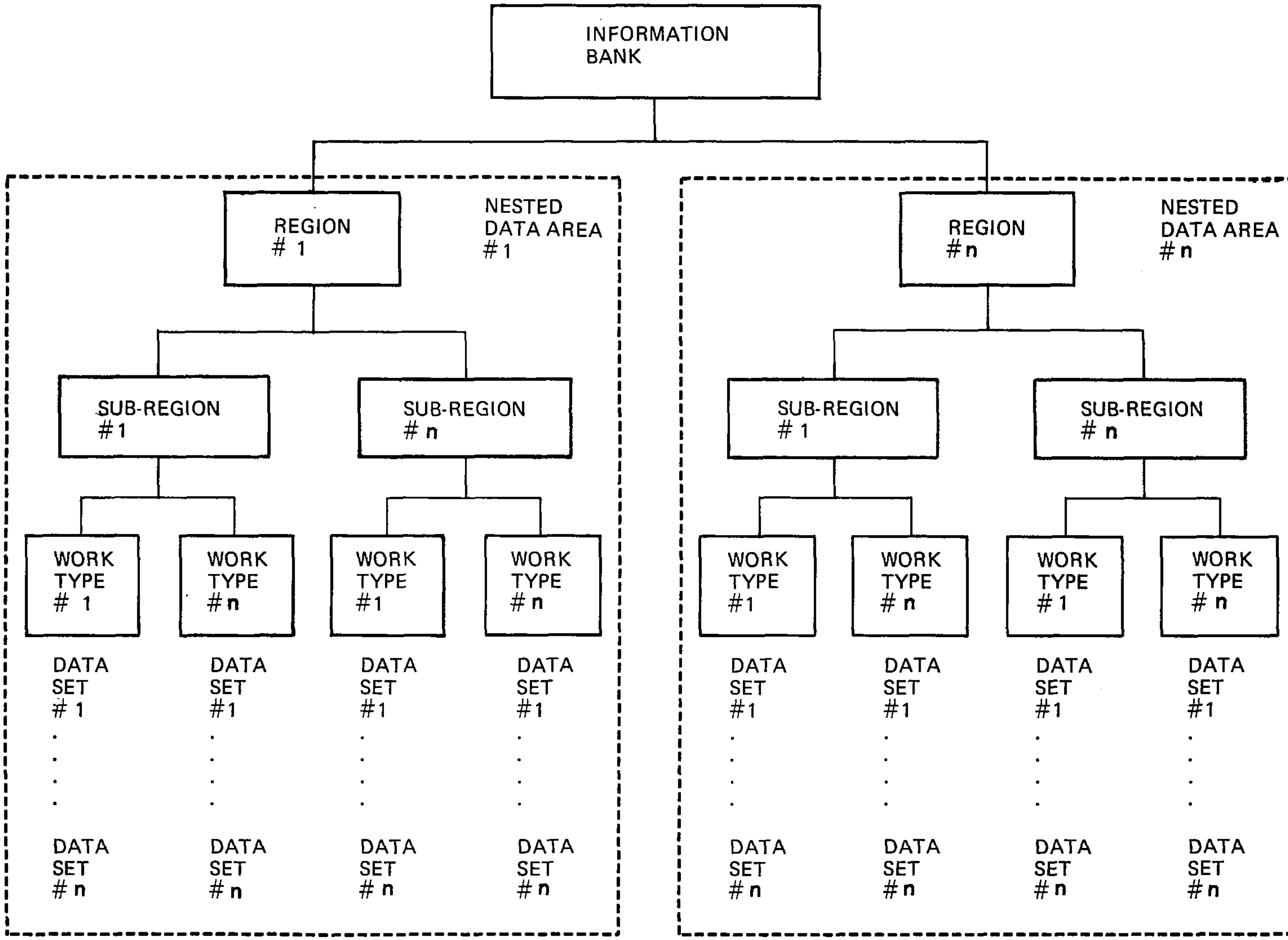


Figure 59.—Method to Organize Information Bank

Data Set—A data set consists of a collection of data values that are input or output for a problem solved within IPAD or received from a system remote to IPAD. (See section 5.4.)

5.1.3.2 Example Information Bank Organization

Large engineering organizations are usually divided into groups of specific technical or functional disciplines. These groups are organized into design development projects and staffs which develop technology and perform analysis. All of these groups have large quantities of information and data stored in direct access devices, tape, film, filing cabinets, etc. Much duplication occurs and results in some data not being current, however, it may still be in use. To correct this situation it is desirable to develop a single-source information bank accessible to all having a use for the data but with data modification capability limited to those having responsibility for the data.

The purpose and primary advantage of a single-source information bank is to provide the capability to control and manage data as a company resource and to provide improved product configuration control by eliminating redundant data from the technical definition of the configuration under development.

A logical organization is required to partition the information bank so that it can be controlled. Logical relationships promote the grouping of data into sets for convenience of handling. Control of access to specific data both for information or modification will promote grouping of data sets into data areas. Reporting requirements and program input/output will also promote grouping of data sets into data areas.

A hierarchy of relationships based on the logic of section 5.1.3.1 can be established as a model to organize an integrated information bank into data areas. Figure 60 shows the highest organization of an example information bank and establishes relationships to the major division of information development within a product-oriented program. Each of these data areas logically can be considered a region of the information bank.

The areas (regions) labeled product configuration design and product configuration analysis are highly dynamic in the early stages of a product development effort, and a unique occurrence of data sets in these areas will apply to each unique configuration under investigation. By contrast, all other areas contain data sets which are generally stable over long periods of time and should only require small changes for correction or update.

Figure 61 shows nested data areas for configuration design. Each of these data areas can logically be considered a subregion of the information bank that is related to a discipline or set of disciplines. These subregions can be further divided to contain the data sets related to a work type or component part of the product.

As previously stated, the configuration design area of the information bank is highly dynamic, especially in conceptual design and in the early stages of preliminary design. This area should accommodate five to ten configurations on-line and have provisons for back-up storage for up to 200 previously defined configurations. The capability should be provided to bring selected configurations from back-up storage to online status within a maximum of 24 hours and at a low computing cost. The amount of data for each of these configurations will vary depending on the level of design and analysis completed. (See section 6.0 of CR 2985 for a description of the levels of the design process.)

As in figure 61 for configuration design, and as a further illustration of the type of organization required, figures 62 through 65 expand the configuration analysis, configuration evaluation, procedural information, and management information regions into their nested data areas.

5.1.4 DATA STORAGE CONTROL

Control over the data is required in order to maintain its integrity. Every user wants to be assured that modification of data can only be made by its owner or by a designated person. The consequences of lack of control become more serious as data becomes accessible to more people.

Another aspect of data control is associated with the quality of the data itself. In addition to change control, there needs to be provision for "signing off" data under certain circumstances. Today this is generally handled by memos, i.e., no computerized action. Some analogous mechanism will have to be present for the computer stored data, as approval categories such as "preliminary," "checked," and "approved," are required. The IPAD system will provide for several categories of approval, however, it shall be possible for each company using IPAD to change the approval identification names and the number of approval categories.

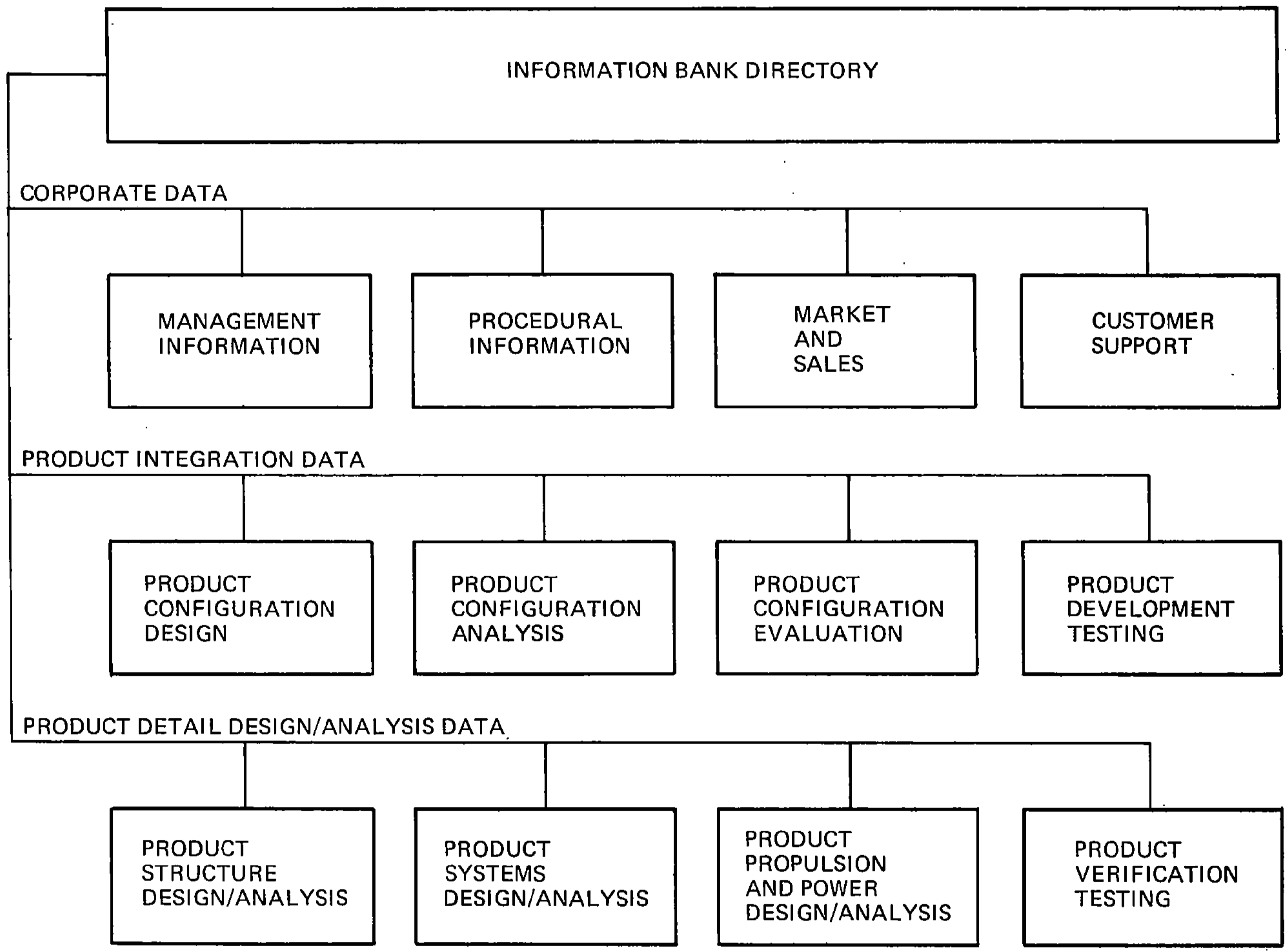


Figure 60.—Example Information Bank—Directory

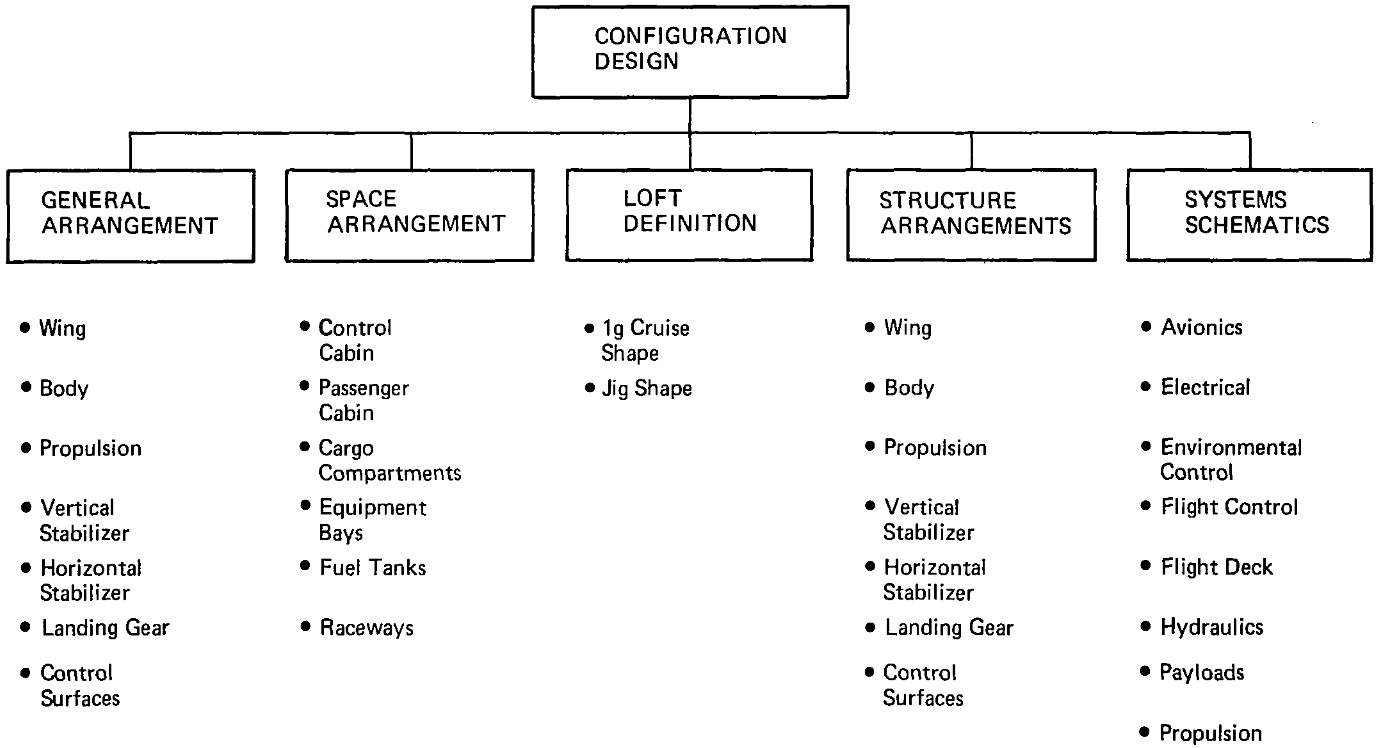


Figure 61.—Example Information Bank—Configuration Design Region

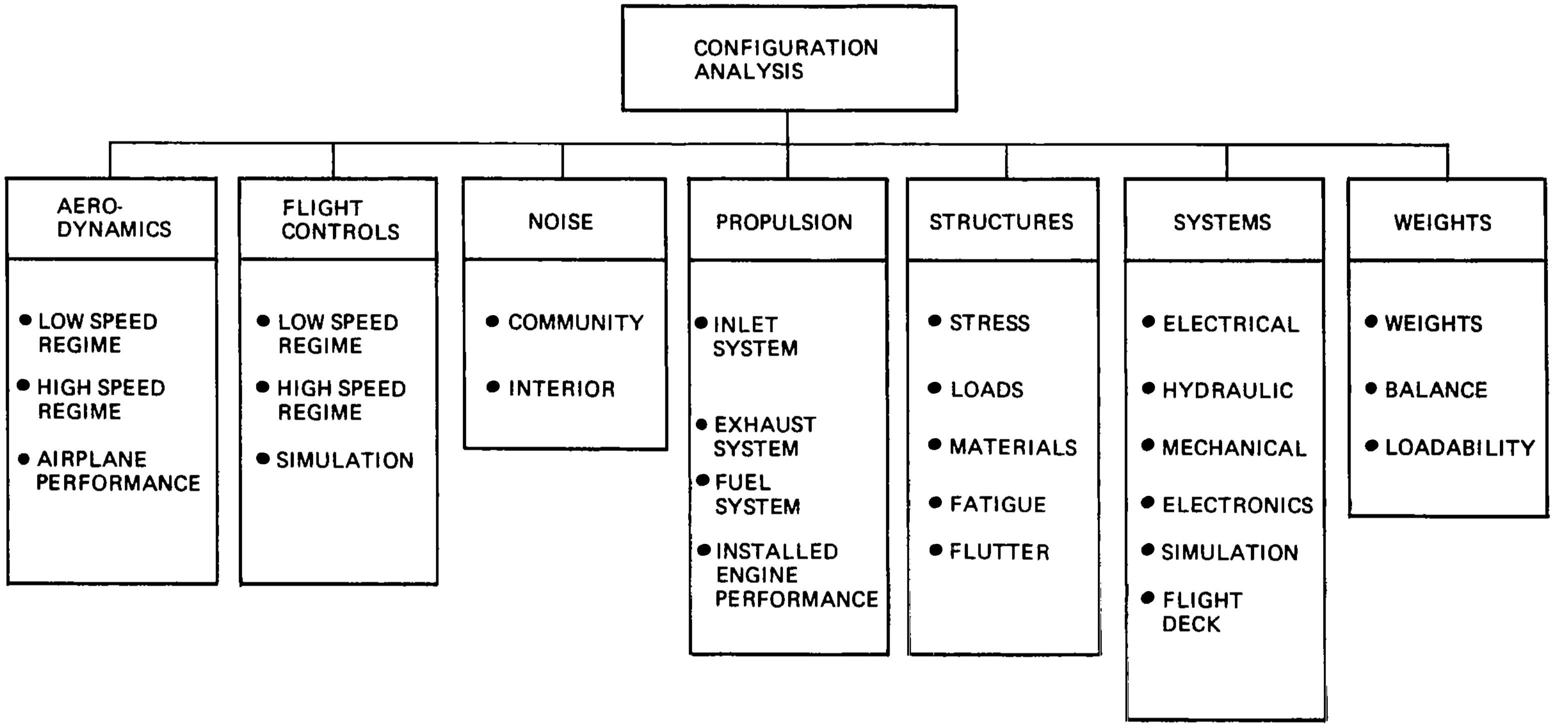


Figure 62.—Example Information Bank—Configuration Analysis Region

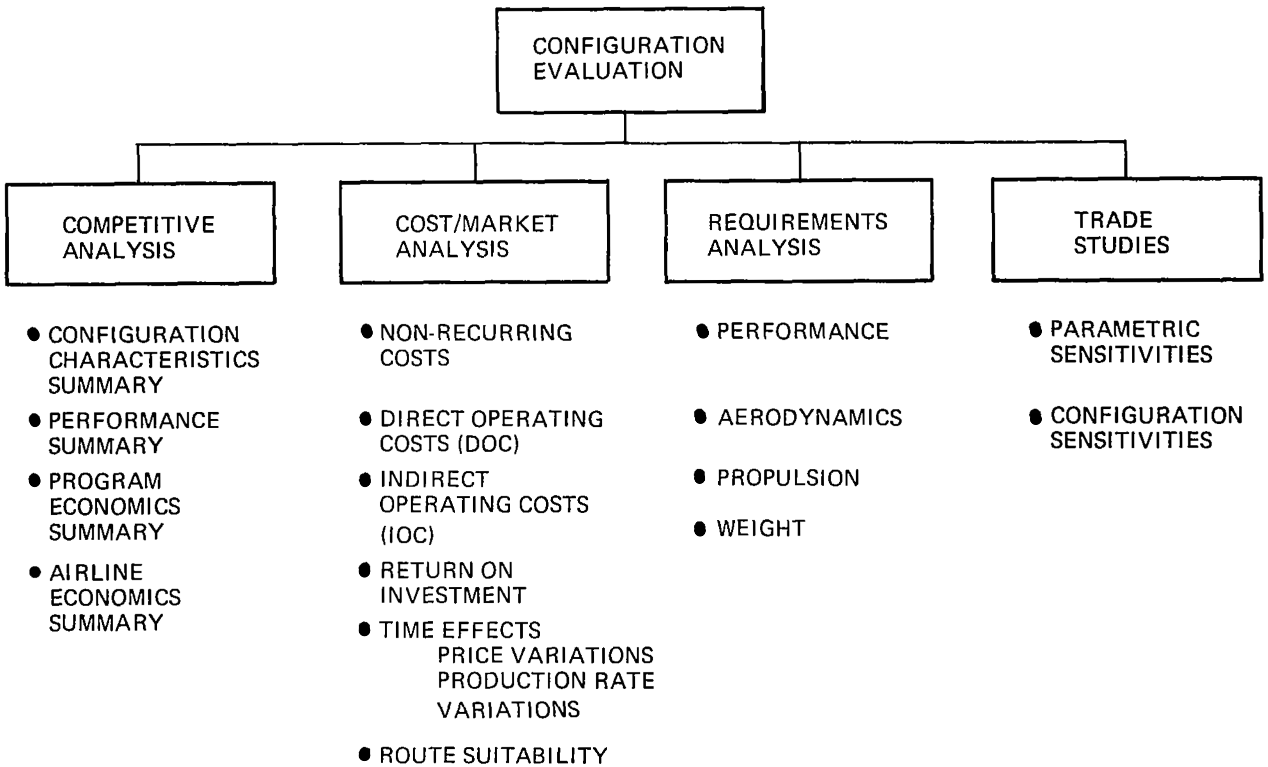


Figure 63.—Example Information Bank—Configuration Evaluation Region

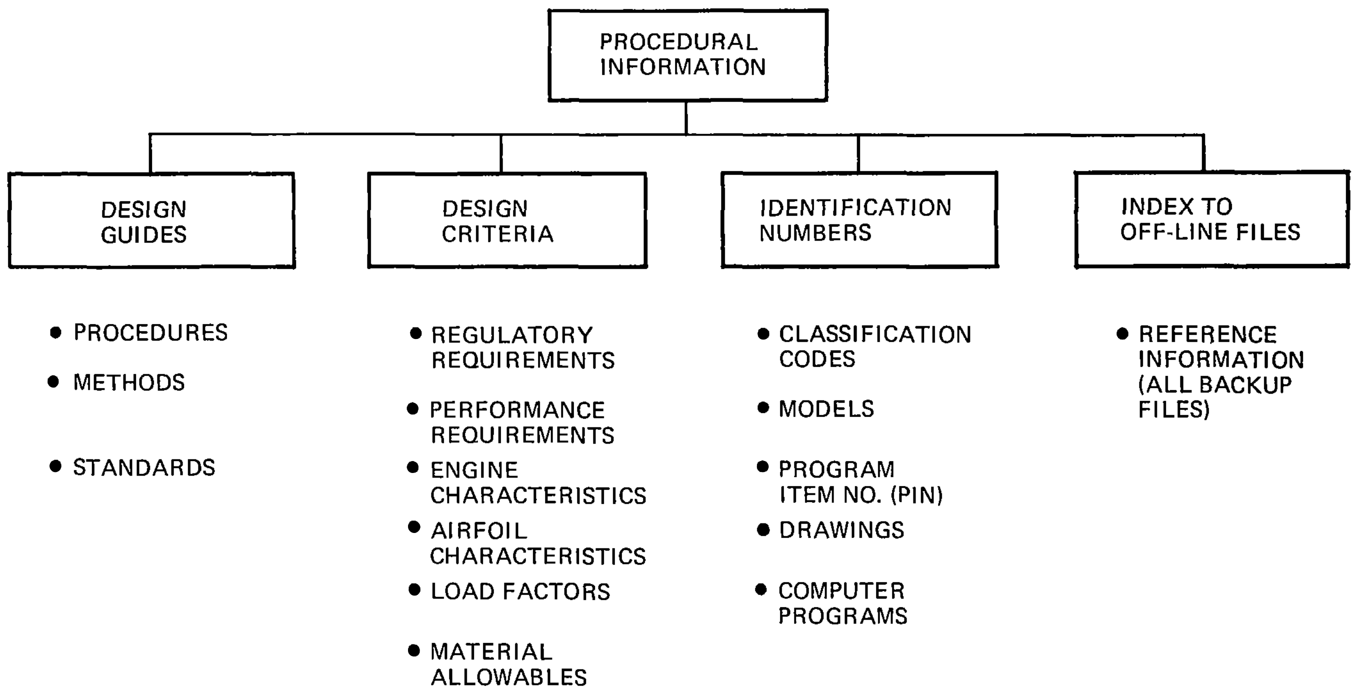


Figure 64.—Example Information Bank—Procedural Information Region

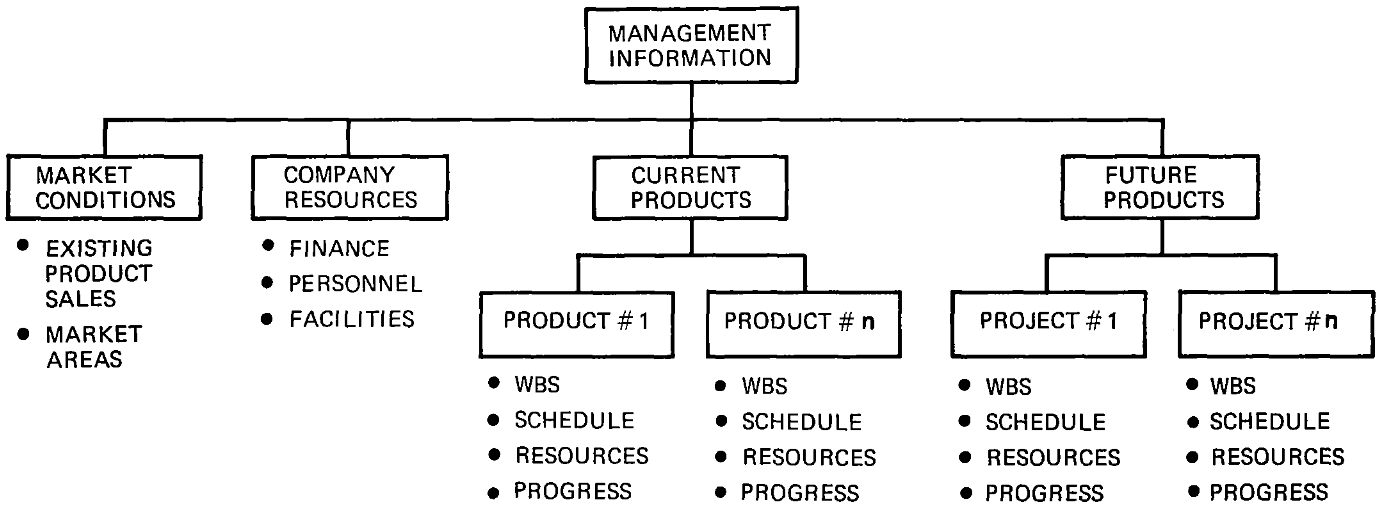


Figure 65.—Example Information Bank—Management Information Region

5.1.4.1 Responsibility for Data Control

In general, responsibility for data sets lies with those responsible for the associated data area. This means that all data sets in a given data area are the responsibility of the person or persons in charge of the data area. The responsibility is for:

Change control:

Who can insert new data

Who can make changes to existing data

Tracking changes which are made

Quality

Data labels are accurate

Data values are verified and "signed off"

5.1.4.2 Establishment of Data Change Controls

For change control, the system must guarantee that data set content changes cause a change in data set identification. Two classes of identification changes may take place:

(1) Insertion of a new name

(2) Qualification of an existing name by a version number

Class (1) is always at the user's discretion. Class (2) is a possible user choice, but the system must have a systematic means of assigning version numbers. When data is altered, the user must select one of these options for recording in the header the fact that the new data set is different from the old.

5.1.4.3 Data Identification

An additional area of data control is the identification of data sets when they are generated. There are three basic ways data can be inserted into the information bank:

From an external source under user direction

From a system function (executed under control of the user)

From a job in the IPAD computer program library (executed under control of the user)

In the first case the user will wish to identify data by some reference to the origin of the data (airplane model number, configuration number, case number, etc.). This label is totally arbitrary from the system's standpoint, although such labels are expected to be instances of defined data elements (see section 6.0).

In the second and third cases, desirability for complete and accurate record keeping of the origin of computer-generated data dictates computer control of a portion of the label associated with computer-generated data. The intent is that every data set in the information bank carries with it sufficient identification to guarantee precise knowledge of its origin. In general, this means that identification of all input data and computer programs contributing to the generation of a data set must be kept. If, for the entire IPAD system, this is optional, there must be a mechanism to make it mandatory for specified data sets (see section 5.3.7).

5.2 DATA RETRIEVAL

Controlled retrieval of data from the information bank shall be supported for access by users and by computer programs.

5.2.1 ACCESS TO DATA SETS

Data sets stored in the data area of a functional organization will obviously be accessed by users and computer programs belonging directly to that functional organization. However, it shall also be possible for users and computer programs from other functional organizations to access the same data sets subject to assigned limitations (see section 5.2.3).

Ownership of data sets can be visualized in a hierarchial way; however, access to data may be visualized as a network that permits lateral relationships between data sets. For example, in figure 61, the data area "wing" under subregion general arrangement would contain four data sets: planform, thicknessform, twistform, and camberform. Also, the data area "wing" under subregion structural arrangement would contain data sets to describe the wing centerline structure, e.g., spars, ribs, etc. It should be noted in these examples that the data for structural arrangements would not stand alone, i.e., the wing structural arrangement data sets plus the wing planform data set would be required to fully describe the structural arrangement and how it relates to the wing. This implies that a combination tree/network may be required, the tree to identify ownership and the network to permit the required access relationship. IPAD should permit the user to display the arrangement data sets and the planform data sets by specifying the structural arrangement data sets only.

5.2.2 DATA SET QUERY

The requirements stated in this section apply to query at the data set level. See section 6.5 for query requirements on the content of data sets. Query of data sets will be based on data contained in a header. The header data will consist of data generated by the IPAD system and data supplied by the user. The data generated by the IPAD system is identified in section 5.3.7 and consists of records identifying the source of the data set. The header data supplied by the user identifies what the data set represents, i.e., airplane model number, wing planform version number, etc. This user-supplied data would normally be included as part of the data set when the content of the data set is defined to IPAD in accordance with section 5.1.4.3 and section 6.0.

5.2.2.1 User Query

It should be possible for the users to access data sets by entering the information bank as a whole or by entering a specified data area. The latter should be considered the normal user access technique. If several data sets are identified by the user query, it will be the user's responsibility to make the final decision as to the data sets selected for further use. IPAD should support user queries such as the following:

List headers for all existing sets for a specific data set name.

List content of a data set by specifying data set name and specific header data.

Compare contents of two or more data sets by specifying data set name and specific header data.

Create new data set(s) from existing data set(s) by specifying data set name(s), specific header data and parameters for data transformation or data reformatting. (See CR 2985, sec. 5.3.19.)

5.2.2.2 Computer Program Query

It should be possible to link computer programs to data sets in specific data areas by defining the linkage and by specifying header data for input data sets and resultant output data sets at the time of program execution. The IPAD system shall have provisions to ensure that ambiguities cannot occur when data sets are accessed by computer programs, i.e., it is the IPAD system's responsibility to deliver the proper data set(s) to the requesting program.

5.2.3 DATA ACCESS CONTROL

Access to data set headers and data values shall be subject to controls over user access and computer program access.

5.2.3.1 User Access

User query of header data shall be subject to security classification of the data set. This means that with the proper security clearance and proven need to know, a user may read any data set header.

User access of data values of classified data sets shall be subject to the same restrictions applied to header data. In addition, access to unclassified data values by a person other than the owner for the purpose of reading (and perhaps making a copy) shall be subject to control. The purpose of this additional control is to limit to certain designated persons access to data which is preliminary in nature, difficult to interpret, etc.

5.2.3.2 Computer Program Access

Computer program access to a data set, including its header, shall be subject to the same control as a user access based on the person executing the computer program. In addition, computer program query may be subject to schedule limitations. (See section 5.3.4.)

5.3 DATA GENERATION

The capability to plan and define a computer process such as the reference design process described in CR 2981 and the required data interfaces such as the data model described in section 4.0 shall be supported by IPAD.

5.3.1 PROCESS MODEL

It is required that a general activity modeling capability for work integration be provided within IPAD that will support a structured definition of a work process consisting of the following principal elements (these elements will be described in reverse order):

PROCESS

LEVEL

ACTIVITY

JOB

5.3.1.1 Job

A job (see sec. 7.0) is defined to be any computer program, group of interfaced computer programs, or system function when any of these is executed on a computer as a single unit of work. A job may be submitted for batch processing or interactive processing where interaction between the job and the user is required during execution.

5.3.1.2 Activity

An activity is defined to be one job or a set of related jobs. An activity consisting of more than one job is usually grouped by managers of the design process for the purpose of efficiency, control and convenience.

5.3.1.3 Level

A level is defined to be one activity or a set of related activities. A level consisting of more than one activity is usually grouped by management for the purpose of establishing a predicted confidence level which may be used for risk evaluation. Levels are most significant as management tools in the early stages of a process, i.e., conceptual design and preliminary design.

5.4.1.4 Process

A process is defined to be one level or a set of levels. A process consisting of more than one level is usually related to the phases required to develop a complete technical definition of a product, i.e., conceptual, preliminary, and detail design. A process requires that formal data interfaces for all related jobs be established and defined to IPAD.

5.3.2 DATA MODEL

The IPAD system must provide the capability to identify data flow paths within any arbitrary process defined to IPAD. A general data modeling capability of the type described in section 4.0 is required. The resultant data flow will normally be under direct control of IPAD. Also, jobs within a defined process (see sec. 5.3.1.1), which are executed on a satellite computer (a remote system) must be recognized and supported by the IPAD system.

All data will be transferred in data sets as follows:

a) Transfer from a job to the information bank

b) Transfer from the information bank to a job

c) Transfer from one job to another

d) Any combination of a, b, and c

e) Sent from the information bank to a satellite computer (remote system) in the IPAD communication network (see sec. 3.4)

f) Received in the information bank from a satellite computer (remote system)

Modes e) and f) require that the data be in a national standard format or IPAD standard format that can be interpreted by the receiving system. (See section 5.4.3.)

Figure 66 represents typical planning for data flow within a defined process. The concept of data set types will promote packaging data into convenient sets for such things as review of interim results at a terminal, data used by a known downstream activity, etc.

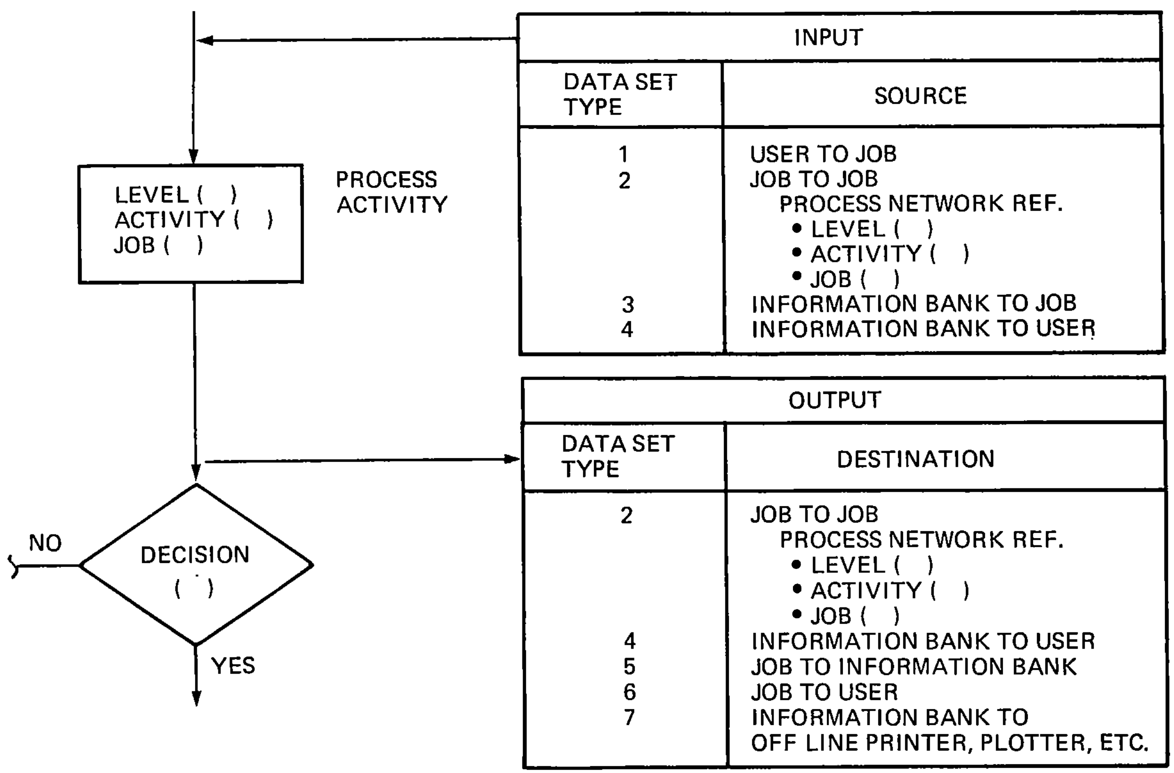


Figure 66.—Data Flow Planning—Process Networks

5.3.3 CONTROL MODEL

The IPAD system must support the capability to control the progress of design projects. It is required that a general modeling capability for project planning be provided within IPAD that will recognize the following principle elements (these elements will be described in reverse order):

PROJECT

TASK

SUBTASK

5.3.3.1 Subtask

A subtask is defined to be the sequence of work accomplished by one individual which is a meaningful step in a project plan. A subtask may be recognized by IPAD as a scheduled event. A subtask may include one or more jobs.

5.3.3.2 Task

A task is defined to be the sequence of subtasks accomplished by a group (discipline) which is a milestone in the project plan. A task may be recognized by IPAD as a scheduled event and may include one or more subtasks.

5.3.3.3 Project

A project is defined to be the sequence of tasks that are associated for the purpose of reporting. A project is usually accomplished by all disciplines required to produce the technical definition of a product. A project may include one or more tasks, however, within IPAD the size of a project will not be limited and may be only one subtask. Two types of projects may be defined. The first type will have formal schedule control and is the normal mode of operation. The second type will be informal and will not have schedule control. This mode is used for work not defined in a formal process such as computer program development, research, etc.

5.3.4 SCHEDULE

It is required that schedule planning for a project be supported by IPAD. It is envisioned that tasks will be scheduled by design project management and that subtasks will be scheduled by group supervision. Job execution will be scheduled by the person doing the work and will not have formal identification in the project schedule. The capability will be provided to limit job execution based on the subtask schedule; however, in some cases it may be desirable to allow a subtask to begin prior to the subtask scheduled date.

5.3.4.1 Critical Paths

IPAD must support identification of critical paths for a project based on both task and subtask dependencies.

5.3.4.2 Schedule Reports

IPAD must support identification of schedule problems. Lookahead capability must be provided. This should identify such items as tasks due for completion in the next six months and subtasks due for completion in the next month. Provisions must be incorporated to notify responsible persons of potential schedule delays. This should be accomplished by monitoring data set occurrences in the information bank for projects under formal schedule control. The notification should list subtasks for which approved input data sets are not available one week before the scheduled start date of a dependent subtask.

5.3.5 COMPUTING RESOURCES

It is required that computer resource planning and control be supported by IPAD.

5.3.5.1 Computing Resource Planning

A computing resources budget will be established for each subtask of a project. The subtask will be related to the appropriate program item numer (PIN) established by the work breakdown structure (WBS). (See sec. 4.0 of CR 2983.)

5.3.5.2 Computing Resource Report and Control

A computing resource report is required which compares resources used to budgeted resources. This report should identify subtasks, and accounting should be collected for each program item number (PIN). The IPAD system should only monitor resources and give alarms when unplanned resources are used. The user will be responsible for the resources consumed by each job and will establish appropriate time and/or resources limits. In cases where limits are exceeded, the system should suspend the subtask and hold for review by the user. Under control of the user, it should be possible to restart any subtask at the exact point in the computation where the subtask was suspended.

5.3.5.3 Computing System Performance, Monitoring and Control

It shall be possible to monitor performance of the computing system during the prime interactive computing hours, i.e., 9:30 a.m. to 4:30 p.m. This monitoring shall be based on parameters that identify the current use of resources. Response time based on tests of a standard interactive job and a set of test inquiries should be measured on a suitable frequency to establish a control level of response performance. (See resource model, section 4.4.) If the response control level is less than a minimum standard for the tests, it shall be possible to make adjustment to improve response time. (See section 4.3 of CR 2985 for specific response time requirements.)

5.3.6 IPAD WORKING ENVIRONMENT

The IPAD system must provide the capability to execute an arbitrary number of processes and corresponding data models defined in accordance with section 5.3.1 and 5.3.2 and control the execution of each process by an arbitrary number of projects defined in accordance with section 5.3.3.

The primary IPAD working environment shall be interactive; however, IPAD shall also support batch processing. It is intended that the IPAD system recognize each user, the user's computing jobs, and the user's data sets during the entire time of an active project under formal schedule control. There shall be no limit to the number of active projects, and the IPAD system design will provide for an adequate number of host computers and storage devices operated in a distributed computing network. (See sec. 5.4.) Figure 67 illustrates the working environment for one project executed under IPAD control.

Since the primary mode of operation is interactive, it is anticipated that users will be required to work for long periods of time at the terminal. IPAD shall have the following or equivalent provisions:

> The users should be able to suspend execution of a subtask for periods ranging from minutes to days. It should be possible to restart the subtask at the exact point in the computation where the subtask was suspended.

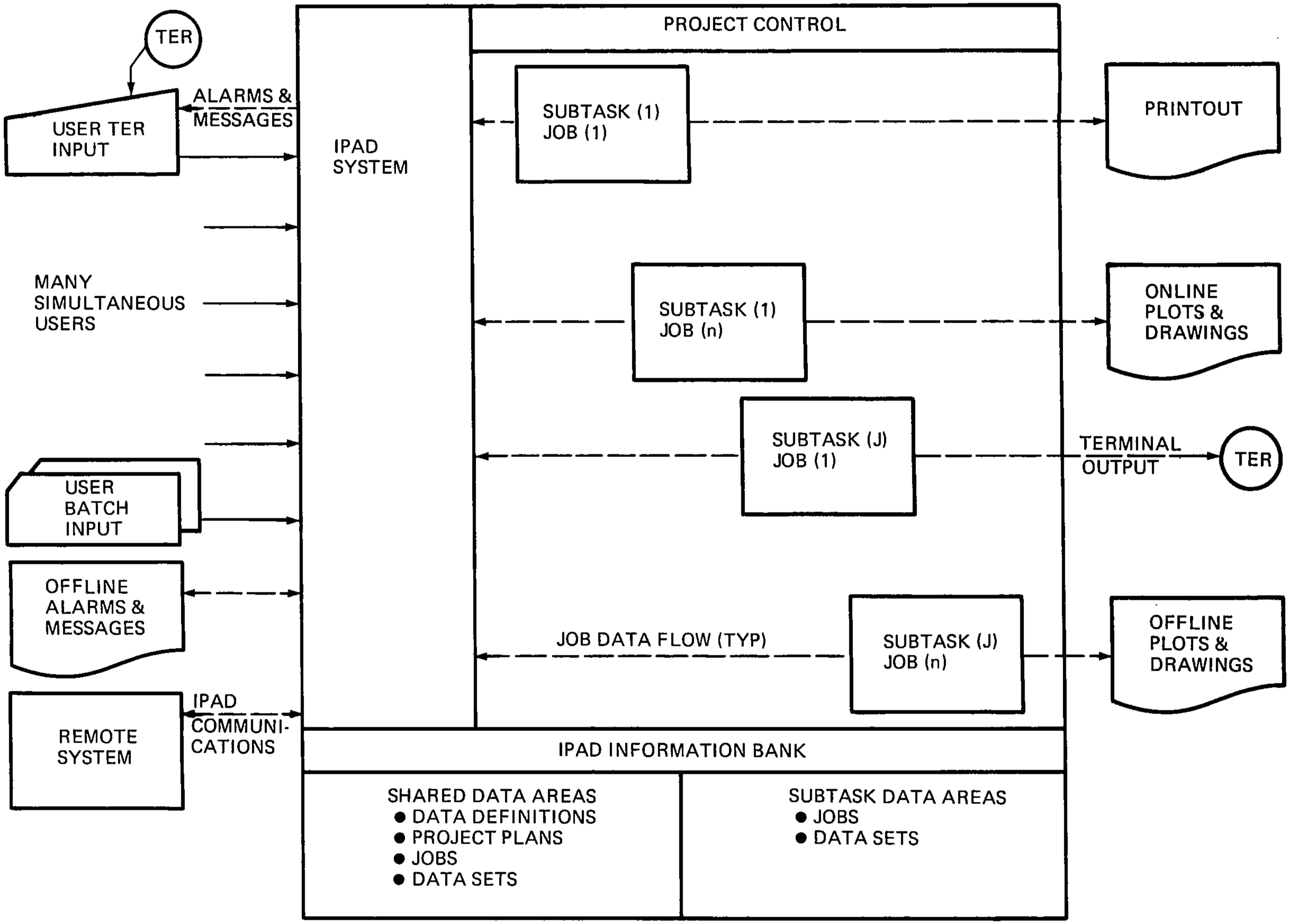


Figure 67.—IPAD Working Environment

The user should be able to switch from interactive to batch processing when long computations are under way. In this case the system should suspend the subtask after the job or a series of jobs have executed. It shall also be possible to restart the subtask at the exact point in the computation where the subtask was suspended.

Provisions to monitor subtask status are required to aid the user during interactive and batch processing and after suspension of a subtask for any reason.

The use of optimization techniques imposes special requirements. The user will specify the computational flow, i.e, the execution sequence of the modules that will provide the optimizer with the required information. Once the program execution has begun, the optimization driver will control the solution and the user will want to have intermediate results reported. These may cause the user to interrupt the solution, modify some of the initial information, and restart the optimization process. The user should be able to specify whether IPAD "should" or "should not" maintain copies of interim results. Optimization techniques are discussed in detail in section 5.0 of reference 6, Volume II.

An analysis of the decision control specified in section 6.0 of CR 2981 and the typical questions in appendix A identified the need for three basic decision modes: 1) computer (C), 2) combination computer and user (C/U), and 3) user (U). Decision modes 1) and 2) can be characterized as programmable and decision mode 3) as nonprogrammable. The programmable decision can usually be fully automated but may optionally be operated in an interactive computer-supported mode. The nonprogrammable decisions are judgemental and may be interactive computer-supported or absolute-control-specified by the user. Figure 68 depicts some characteristics of typical decision modes.

5.3.7 RECORDS OF DATA OCCURRENCES

It is required that records identifying data occurrences be provided within IPAD. It is intended that the IPAD system provide automatic bookkeeping capable of fully auditing all occurrences of data within the information bank which have been generated by jobs executed under formal project control. These records will permit tracing the process that generated any output data set. These records should include the following as a minimum.

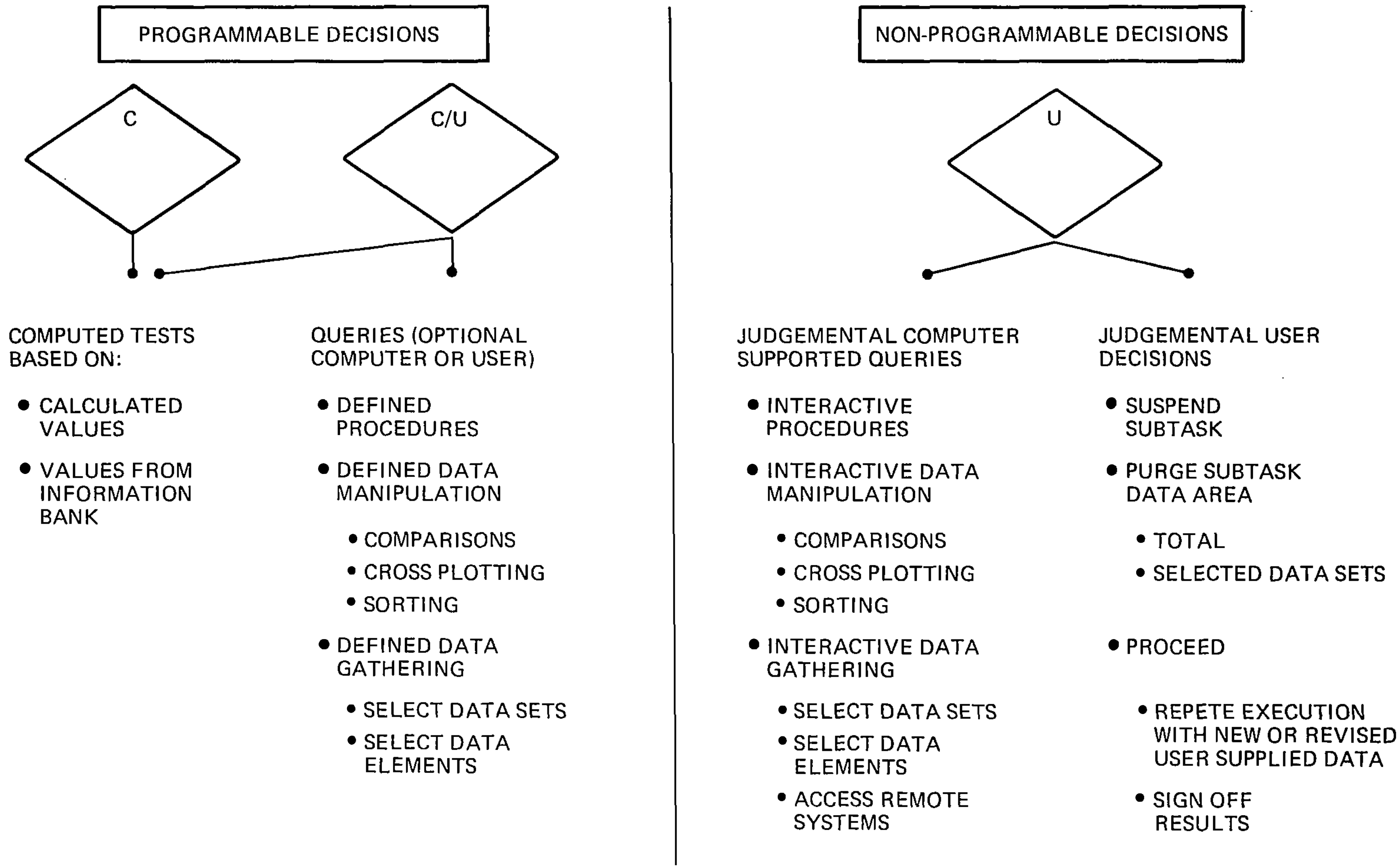


Figure 68.—Characteristics—Typical Decision Modes

5.3.7.1 Data Set Origination Log

All data occurrences shall be identified at the time they are generated. These records should include the following information:

Date and time of origination

User ID (owner)

Data set ID:

Data Set Name
Project
Task
Subtask
Process
Level
Activity
Job
PIN
Classification code

System-assigned unique qualifier

5.3.7.2 Data Set Access Log

All read accesses of data set occurrences generated under formal project control shall be recorded. These records should include 1) date and time of access and 2) user ID.

5.3.7.3 Data Set Modification Log

a) Each write access shall produce a new occurrence of the data set and shall be recorded as a version when generated under formal project control. The records should include:

Date and time of modification

User ID

Modification ID:

Project
Task
Subtask
Process
Level
Activity

Job
PIN
Classification code

System-assigned unique version of the data set qualifier

b) All extend accesses shall produce an appended version of the data set and shall be recorded as a version when generated under formal project control. The records should include:

Date and time of extension

User ID

Modification ID:

Project
Task
Subtask
Process
Level
Activity
Job
PIN
Classification code

System-assigned unique version of the data set qualifier

5.3.7.4 <u>Notification of Data Set Changes</u>

The system must be able to notify affected users of data set modifications. These notifications shall be issued as both on-line messages and off-line batch reports mailed to the user. Data set change notifications shall be issued to all users identified on the access and modification logs. (See CR 2985, sec. 4.7.)

5.3.7.5 <u>Data Set Purge Control</u>

Special permission shall be required to purge any data set that has a dependent data set while these data sets are under formal project control. When such a purge is required, there should be several levels of removing data with possible recovery before final purging. In addition, a retention classification such as permanent, program life, project life, time (years, months, or days) shall be provided. Project life should be the default rating and the system shall have provisions to selectively purge data set occurrences determined by retention classification to be no longer required.

5.4 DATA COMMUNICATIONS

The feasibility study IPAD system architecture (ref. 1, volume IV) was conceived as a host system with teleprocessing facilities to support interactive user communications with the IPAD system, information bank, and libraries. The trend in the engineering design environment is to move away from a centralized host which supports all activities to distributed remote facilities. These remote facilities may consist of processors with computational and data storage capabilities connected to each other by communication links. Some or all of the processors may be: 1) specialized, 2) under the administrative control of a particular using organization, and 3) physically located with the using organization.

5.4.1 SCOPE OF IPAD DATA COMMUNICATIONS

IPAD shall permit access to central design data from remote sites and systems. The remote systems may or may not have remote IPAD system capabilities. Direct communications between remote systems shall also be supported. Data produced at remote IPAD sites shall have integrity equivalent to data produced on the host IPAD. Data produced on non-IPAD remote systems shall be received into any IPAD system. Such data shall have appropriate safeguards and controls while in the custody of IPAD.

5.4.2 REMOTE SYSTEMS

Remote systems communicating with the host system shall be permitted to operate in any of the following modes:

Timesharing

Remote job entry

Message/file transfer

Remote systems shall include intelligent systems tailored for specific design functions which may or may not have remote IPAD capability. The IPAD man-machine interface on a remote IPAD system must not differ from that for the IPAD host interface unless required for special functions.

5.4.3 STANDARDS

Standards should be used for all IPAD communications. The following are basic guidelines.

5.4.3.1 Existing Standards

Existing standards should be selected, where feasible, for IPAD to facilitate communication between computing systems and between aerospace companies. The standards identified by the National Bureau of Standards for the Air Force ICAM development (see reference 6), should be reviewed with the goal to make communications compatible between IPAD and ICAM.

5.4.3.2 IPAD Standard Geometry Format

If geometric data are to flow freely within and among the companies of the aerospace industry, a standard format for geometry data is needed. This format should express the basic ways of creating and storing a geometry description of aerospace vehicles and their component parts. The standard format would provide a reference point for the design of future geometry processors, thus reducing duplication of geometry programs and minimizing data translation.

The IPAD standard should not limit the user's geometry capabilities. The standard is simply the data that IPAD can recognize as geometry. The user may have other geometry, formatted for the convenience of special-purpose geometry programs, that will be handled simply as data by IPAD or will be translated into the IPAD standard geometry format.

The American National Standards Institute Y14.26 subcommittee (ref. 5) has proposed a standard for the digital representation of physical object shapes, based on associative geometry. In an associative system, an element (e.g., a surface) is defined by reference to other elements (e.g., curves). Only the lowest-order elements—points—are defined numerically. The Y14.26 element types include points, curves, surfaces, and volumes.

Such a standard is considered adequate for the communication of geometry, which is to say that physical shapes can, in general, be translated into associative formats. Y14.26, however, is not intended as a written language to support geometry generation. Also, its associative structure is less efficient to evaluate than geometry based on explicit coefficients. Therefore, the IPAD geometry format should extend the Y14.26 proposal by including additional ways to generate elements and by allowing a (nonassociative) coefficient format where it serves the user. (All elements that can be expressed according to the Y14.26 proposal should be expressible in the IPAD format.)

The IPAD extensions to the Y14.26 proposal should adhere to the following groundrules:

Be restricted to bounded geometry in parametric form

Allow new element types and geometry techniques to be accommodated as they are developed

Operate in 2-D or 3-D according to the needs of the user

Include a hierarchical structure for relating data such as assemblies, subassemblies, components, subcomponents, levels, groups, cells, strings, arrays, etc.

The specific IPAD format should be developed in consultation with all members of the IPAD community. The following offers a starting point for this development.

Geometry elements should be stored in the information bank in either associative or coefficient subformat (associative for easy modification during development of geometry, coefficient to optimize evaluation of finalized elements). Translation from associative to coefficient and back to associative subformat should not degrade the accuracy of the geometry definition.

Under either subformat, each named element should store a header containing the name, element type, coordinate system name, optional title array, and the number of composite elements. (As an example of a composite element, a major airplane surface such as a wing might be composed of flap, leading edge, root, wing box, and tip surfaces.)

Under the IPAD associative subformat, which should be an extension of the Y14.26 proposal, each element should also store, in appropriate representation, the function and parameter list of the written format that created the element.

Under the IPAD coefficient subformat, the data after the header are the following:

For points,

x y z

For polygonal functions,

$t \quad _1 \quad _2 \quad n \quad x_1 \quad y_1 \ldots,$

where "t" is an integer code indicating that a polygonal curve follows, $_1 \leq x \leq _2$, "n" is the number of coordinate values expressing the curve, and "x_1 y_1 ..." are the coordinates of the 2-D or 3-D points describing the curve.

For polynomial functions,

$t \quad _1 \quad _2 \quad k \quad c \quad c \qquad c \quad \ldots c$

where f(x) = c x + c x + ... + c

Also polynomial functions of several variables will be defined in a similar manner, e.g.,

where f (x,y) = c x y

For conic functions

t 1 2 a b c d e f,

where f(x) = ax + b + c dx² + ex + f .

5.5 DATA MAINTENANCE

Data maintenance is concerned with the day-to-day upkeep of the IPAD information bank as it is stored on various types of storage devices. These devices fall into three broad categories: on-line/direct access, on-line/archival, and off-line/archival. Maintenance of off-line storage is not an IPAD system concern, but is dealt with by procedures and manual methods. Since on-line storage devices are subject to mechanical and electronic failures, the following or equivalent maintenance features must be provided.

5.5.1 RESPONSIBILITY FOR DATA MAINTENANCE

Responsibility for data maintenance of the entire IPAD information bank lies with the information bank administrator(s). This includes data in all data areas and all aspects of online data maintenance.

5.5.2 DATA MAINTENANCE FUNCTIONS

The following functions should be a part of the IPAD system and available to the administrator(s):

Dump to offline storage of:

One or more specified data sets

One or more data areas

All data sets which have been altered since a specified time and date

Entire information bank

Restore from offline storage of any previous dump with:

Elimination of current on-line version

Restoration of only those not currently on-line

Restoration of specifically designated data sets and/or data areas

Catalog of entire contents, one or more areas, or one or more data sets

Diagnostic program to check catalogues and data sets for abnormalities

6.0 INFORMATION MANAGEMENT

This section describes the general principles of how data should be organized in detail to support the information processing requirements for the engineering design process. It is required that IPAD support an orderly growth of data definitions within an IPAD information bank. In addition, IPAD shall support an orderly growth of occurrences of data corresponding to the definitions.

6.1 LOGICAL INFORMATION MODEL

The IPAD information bank shall have provisions to relate information in a specifically defined sense to the IPAD system. The following or an equivalent hierarchial information modeling capability shall be provided to support information definition within the IPAD information bank. (These will be described in reverse order.) The need to define data and relationships within data is expressed in many publications. References 4, 11, 12, 13, 14, 15, and 16 are some examples.

Data Format

Data Relationship

Data Element

6.1.1 DATA ELEMENT

A data element is the smallest definable item in the information bank. A data element definition consists of the meaning (engineering, mathematical, etc.) of the entity and some description of its nature, if appropriate. Some examples are:

Mach No. = The ratio of translational velocity in a fluid to the accoustic velocity in the same fluid

Load Vector = A one-dimensional array of numbers representing the loads applied to a structure at a specified set of points

Airplane Model No. = An identifier for a specific airplane model

Actual occurrences of data associated with a data element exist only as members of data sets (sec. 5.1.1). Data elements may be single valued (in the sense of scalars) or multiple-valued (in the sense of vectors and matrices).

6.1.2 DATA RELATIONSHIP

A data relationship is a logical grouping of data elements and data relationships. The purpose of a data relationship is to logically associate a set of data elements (the inclusion of a data relationship in another data relationship is the way of expressing nested relationships). Some examples of data relationships are:

Wing Planform	=	aspect ratio, taper ratio, sweep angle, area basic trapezoid, span, wing model number, configuration model number.
Loads Matrix	=	repeated load vectors with an associated load set number.

Data relationships are the medium in which users express how they associate and use data. A data relationship will be used to describe all the logical relationships which exist in the information bank. Some relationships may be a permanent part of the information bank and others may be transient, such as queries or reports. In this manner, the logical description of data input to a program will be one or more relationships and so will a Boolean query request.

If multiple data relationship occurrences appear in the information bank, the values of a subset of the data elements will, in general, permit unique identification among all occurrences of that data relationship. This subset may range from one element to all elements in the relationship. It should be possible to reference any or all items in a relationship in the manner of a query.

A data element may be a member of any number of data relationships. A data relationship may be a member of any number of data relationships, but cannot be a member of itself.

6.1.3 DATA FORMAT

A data format defines the structure of one or more data relationships and/or data elements which are grouped together because:

They form an input set to some program

They form an output set of some program

They are easier to handle as a single item

They are required for a report

Processing requirements make it advisable

Any other reason relating to user or computer needs

A data format should have physical storage structure associated with it, sample data format definition information includes:

The logical contents:

Data elements names

Data relationship names

The structure:

Sequential (order of items, no. of files, etc.)

Nonsequential (access method identifier)

The format:

Each data element

Each data relationship

Units of measure (same as data element unless conversion is required, see sec. 6.2.2)

File type(s)

Data management program(s) identifier

6.2 DATA ELEMENT DEFINITION

The definitions of data are expressed as data element definitions. The total set of data element definitions existing in the IPAD information bank at any one time fully denotes all the data that can be accessed as information by the system. These definitions contain information about its meaning, physical significance, or mathematical nature.

6.2.1 RESPONSIBILITY FOR DATA ELEMENT DEFINITION

The responsibility for data element definition is separate from the responsibility for generating or maintaining actual data element values. All definitions residing in a common data element dictionary must be unique and unambiguous. In principle there is a dictionary for data elements associated with each data area in the information bank. Since any given data element may be a member of many data areas, a dictionary common for areas may be necessary.

6.2.2 ESTABLISHMENT OF DATA ELEMENT DEFINITION

Data element definitions are established in the dictionary consistent with its data area membership.

Establishment of data element definitions can be controlled by permission codes (see CR 2985, sec. 4.8.1) and by access to the appropriate dictionary. The act of establishing a given data element definition involves the submission of all the required definition information and any desired portion of the optional information, as described below.

Required information includes:

- Data element name--must be unique within the designated dictionary
- Data elements synonym(s)--must be unique within the designated dictionary
- Textual definition
- Keyword list for data element definition
- Type of data primitive, e.g., scalar, vector, table, etc., (see 6.2.4)
- Units (meters, seconds, etc.)

Optional information:

- Display format
- Default value
- Mathematical definition
- Restrictions on usage

6.2.3 USES OF DATA ELEMENT DEFINITION

The primary use for the data element definitions is to establish a systematic basis for communication. In this case the communication needs involve three parties: engineering users, technical computer programs, and the information bank. Since two of these are computerized, it will place some restrictions on how the definitions will be handled.

A primary conflict between human usage of definitions and computer usage is the human's ability to "understand" the context in which certain terms are used without having to be explicitly told each time. This permits (or perhaps causes) people to use a language that contains ambiguities and lacks mathematical preciseness. The computer will always respond out of the context it is in, i.e., out of the dictionary it is looking at; therefore, the elements of each dictionary must be unique.

Among the three parties mentioned above, there are three basic communication paths:

Human to/from information bank

Human to/from jobs

Jobs to/from information bank

If a request for information results in an ambiguous response, the recipient must have some means of resolving the ambiguity or communication fails. For example, a person could ask to see the definition of "wing area" and receive five items all defined as "wing area." He could then examine the definitions and decide that one (or none) of them is what he wants. Since this decision process is not, in general, describable as a mathematical algorithm, this kind of communciation would fail if the requestor were a technical program. This leads us to the conclusion that ambiguity is sometimes permissible and even desirable when humans are in the loop, but not when both parties are computerized.

There are two basic uses of data definitions:

> A data element name is known and must be identified uniquely among all other data elements.
>
> Some knowledge about the definition of a data element is known and it is desired to establish the name of the associated data element.

The first of these is required by computer programs; the second is typical of a searching activity by people unfamiliar with the total contents of the dictionary. The first may also be done by people (say, by a person who wants to be sure of a definition of a known element), but the second may not done by technical programs apart from human interaction. Thus the data element definitions must serve these functions.

6.2.4 TYPES OF DATA ELEMENT DEFINITION EXPECTED

The IPAD information bank must accommodate all data element types that can be produced by any language processor in common use. Type refers to the nature or characteristics of the elements. Below are a few examples of such types, hereafter referred to as data primitives.

1)	Label or title	Arbitrary set of characters used by engineer to identify data
2)	Text	Arbitrary set of characters used to describe any data
3)	Single-valued quantity (scalar)	Single number representing a calculated or assigned value of a mathematically defined item
4)	Vector or matrix	An array of numbers representing a set of values which have a precise mathematical relationship
5)	List or table	An array of numbers representing a set of values resulting from observation or data collection of some type

While these examples do not exhaust the possibilities, they illustrate one of the distinct differences to be found in the information bank. The major difference between 4) and 5) is the presence of a mathematical basis for the relationship within the array, and the possibility of complex calculations to derive the array. The items in 5) tend to be observed or tabulated data, and operations like updating tend to be simple replacement with another tabulated number.

6.3 DATA RELATIONSHIP DEFINITION

Data relationships are described through data relationship definitions. A data relationship is a named collection of data elements and/or data relationships. Each data element or data relationship contained in a data relationship is referred to as a member of that relationship. The only restriction is that a relationship may not be designated as a member of itself. As with data elements, data relationships contain no information about the physical form in which the data is stored, but only logical associations between elements and relationships. However, some kinds of relationships imply a physical form which would be a "natural" way to arrange the data values.

6.3.1 RESPONSIBILITY FOR DATA RELATIONSHIPS

Since data relationships are established through data relationship definitions, data relationship dictionaries will be established in a manner similar to the data element dictionaries, i.e., associated with the appropriate data areas.

Responsibilities for the various data relationship dictionaries are exactly parallel with the data element dictionaries.

6.3.2 ESTABLISHMENT OF DATA RELATIONSHIPS

Data relationships are established through the definition of a data relationship in a data area dictionary. The definition of a particular data relationship can be controlled by:

Permission codes for data relationship definition

Access to the appropriate dictionary for the purpose of extending it

The act of establishing a data relationship definition requires the following information to be specified:

a) A symbolic representation of the data relationship such as:

$$\text{data relationship} = R \quad = r \quad (r\ ) \qquad \text{where } K \neq j$$

or

$$R \quad = r \quad (R\ ) \qquad \text{where } K \neq i$$

where r = data record = an enumeration of data elements and/or data records

i = 1, m; m being the number of data relationships
j = 1, L; L being the total number of data records
K = any number in the set 1, m or 1, L
N = number of occurrences for each occurrence of r

b) Specification of which data element in the relationship is primary and which are secondary

Note that a relationship name is only a label for a collection of data elements and relationships and thus is a kind of pointer to other names. There is no purpose in having a relationship defined to have just one member.

6.3.3 USES OF DATA RELATIONSHIPS

The primary use of data relationships is to help organize the data for access by the users. Some data is always directly accessed by the users and some data is accessed only through other data. In a personnel information bank, a person's organization is generally accessed after his name or company identification has been used to locate the additional information. In a similar way, the performance figures for an airplane can be accessed through model number, i.e., by configuration identification. In both of these cases, the access path may be reversed (e.g., what airplane model numbers have range between 2000 and 3000 miles and payloads between 175 and 200 passengers).

6.3.4 TYPES OF DATA RELATIONSHIPS EXPECTED

Within the IPAD information bank there exists a small number of types of relationships, but because of the nested definition of a data relationship, there may be an arbitarily large selection of relationships available. The following are examples of two common types of relationships and some of their characteristics.

Nested lists (ordered or unordered):

- Number of elements per list
- Number of levels of nesting
- Type of elements as a function of each nested level
- Searching logic required
- Number of keys

Nested (intersecting) rings (ordered or unordered):

- Number of elements in a ring
- Number of intersections
- Types of elements in the ring
- Searching logic required
- Number of keys

6.4 DATA FORMAT DEFINITIONS

Data formats are required to describe the storage and retrieval structure of each specific occurrence of data. The data elements and relationships have to do with the meaning of data and how it is used in a logical sense. The data formats have to do with the practicalities of handling data for use by people and computer programs. Prior to the generalization of data management, definitions and format were both dictated by the computer programs. Relationships were seldom formally defined and existed implicitly in the program and in the user's mind. Now that the three concepts are being treated separately, there is a need to formalize data format apart from the defining computer program.

6.4.1 RESPONSIBILITY FOR DATA FORMATS

Data formats are required for defined and undefined data sets.

6.4.1.1 Data Formats for Defined Data Sets

A data format for a defined data set involves one or more data elements and/or data relationships. Consequently, the responsibility for data format definition lies with the corresponding element and relationship dictionaries.

Because data formats have associated occurrences of data sets, there is the additional responsibility for the occurrences apart from the definition. Since all occurrences of data begin in a single subtask data area, the storage data area dictionary must be known to obtain the definition.

6.4.1.2 Data Formats for Undefined Data Sets

A data format for an undefined data set is considered a degenerate case for which the content data is not defined to IPAD. Data sets of this type will be related to the host operating system and in essence IPAD will only provide file management. (See section 5.0.)

6.4.2 ESTABLISHMENT OF DATA FORMATS

Data formats are established through a definition entered into a data format dictionary. Its data area membership is dependent upon the data area membership of its component elements and relationships. Establishment of new data format definitions can be controlled by:

a) Permission codes for data format definition

b) Access to the appropriate dictionary for the purpose of extending it

The act of entering a data format requires information such as the following to be supplied:

a) Fixed Structure--Data format name

b) Variable Structure--Formal description of the storage and retrieval structure of the data in terms of the elements and/or relationships and the logical order within the data set (if order is of importance)

c) Algorithmic descriptions of how elements can be stored and retrieved from the data set (may be more than one for each element)

d) A table of permissible data elements and units of measure

6.4.3 USES OF DATA FORMATS

Data format definitions are used to interpret the contents of a defined data set, i.e., to know the storage structure of the data set. The fixed portion of the definition defines the logical content while the variable portion defines the actual form of the data. A data set carries with it specifications of which options of the variable portion are in effect. Programs requesting data from a particular data set will specify its required options and expect any required transformations to be done if there is a mismatch.

6.5 INFORMATION QUERY

The requirements stated in this section apply to query at the data element level. This implies that the data elements and data relationships have been defined and their structure is specified in a data format for a defined data set. The requirements for data set header information specified in section 5.2.2 also apply to defined data sets.

6.5.1 USER ACCESS TO DATA ELEMENTS

It should be possible for the users to access data elements values within defined data sets by entering the information bank as a whole or by entering a specified data area. The latter should be considered the normal user access technique. If several data elements are identified by the user query, it will be the user's responsibility to make the final decision as to which values are selected for further use. IPAD should support user queries such as the following:

List all values for a specified data element name

Example: List DEn

List all aggregates of data values for a data relationship name

Example: List DRn

List an aggregate of data values based on a data relationship but qualified by values of data elements or values calculated from data elements.

Example: List DRn where DEn EQ specified value or range of values

List DRn where DEn^2 - DEn EQ specified value or range of values

6.5.2 COMPUTER PROGRAM ACCESS TO DATA ELEMENTS

It should be possible to link computer programs to data elements and aggregates of elements based on data relationship in a specific data area by defining the linkage and by specifying header data for input data sets and resultant output data sets at the time of program execution. (See section 5.2.2.) The IPAD system shall have provisions to ensure that ambiguities cannot occur when values for data elements are accessed by computer programs, i.e., it is the IPAD system's responsibility to deliver the proper values for data elements to the requesting program.

7.0 COMPUTER PROGRAM MANAGEMENT

This section describes the general principles of how computer programs are to be organized to support the information-processing requirements. These requirements apply generally to both user programs and IPAD system programs, although there may be exceptions.

7.1 COMPUTER PROGRAM LIBRARY ORGANIZATION

An IPAD computer program library consists of user-supplied programs that use or create data identified in the IPAD information bank dictionaries. An IPAD computer program library has the following or equivalent structure. (These will be described in reverse order.)

Job

Operational module

Coding module

7.1.1 CODING MODULE

A coding module is the smallest collection of computer code that can be defined to IPAD. It may be as small as a single FORTRAN subroutine or as large as an overlay program. It has two key characteristics:

a) It is handled as a unit by IPAD (but not necessarily executable as a unit).

b) The source code portion may be submitted to a single language processor.

The first characteristic motivates one to define coding modules for maximum modularity unless the code is totally special purpose. The second is oriented to neatness. A coding module must have source code and may optionally have object code.

7.1.2 OPERATIONAL MODULE

An operational module is one or more coding modules that form an executable unit. The key characteristic of an operational module is that it is an executable collection of computer code (a coding module is not necessarily executable). A parallel property to the source code of coding modules is that the object code for an operational module is submittable to an operating system loading processor.

A large computer program composed of highly interdependent modules may well be inserted as a single coding module, which in turn is defined as a single operational module. A long-range goal is that operational modules will be made up of a number of coding modules, some of which are present in other operational modules as well.

7.1.3 JOBS

A job is an executable sequence of operational modules and/or other jobs that produces meaningful results for a user. A job is the only form of computer code that the user actually executes. In general, a job consists of a number of operational modules connected with logical decisions (programmed or left to human interaction at execution time) which determine the sequence of execution. The nested characteristic of jobs permits building new jobs on the basis of already defined jobs. In the simplest case, a single coding module defined as a single operational module can be defined and executed as a job. Similar to the coding module/operational module relationship, the long-range goal for jobs is that they be composed of many operational modules, some of which are used in many jobs.

7.1.4 DATA AREA MEMBERSHIP OF COMPUTER PROGRAMS

Membership of a job in a given data area is mandatory when that job references a data format belonging to the data area. The execution of a job will always take place in a subtask data area and all data generated will initially reside in that area. If the job modifies an existing data set, area membership of that data set must have already been established.

7.2 CONTROL OF COMPUTER PROGRAMS

Control of computer programs is as important as control of the data they generate. If a given data set is generated by a program, total control over that data is not possible without having control over the program that generated it. Therefore, the generated (output) data must also contain the input data and the identity of the program that produced it in order to be complete. IPAD must not permit deletion of a computer program (version) having a dependent data set in the information bank.

7.2.1 RESPONSIBILITY FOR COMPUTER PROGRAMS

The execution of an operational module as a part of a job always produces occurrences of data and affects the IPAD information bank. Since coding modules are normally not executed, the operational module becomes the focus for control of computer programs.

Responsibility for operational modules is normally linked to their output data formats. The person or persons responsible for definition of the data formats referenced in a given operational module as output should also be responsible for the operational modules and their coding modules.

Responsibility for a job definition involving one or more operational modules may lie with anyone authorized to construct jobs. Of course, the data area containing that job must be one of those listed in the data format definition of the output data for the job.

7.2.2 COMPUTER PROGRAM CERTIFICATION

In order to document the integrity of a given job execution, its component operational modules must be certifiable in some fashion. By "certifiable," it is meant that a judgment may be made about the trustworthiness of the computer code to perform its intended task. As an example, an operational module may have one of the following certifications:

In checkout

Research use only

Staff use

Airplane program/model use

FAA certification use (legally certified)

Since only a job is executed by a user, the certification of a job is the same as the "highest" certification operational module contained in the job.

7.2.3 VERSION CONTROL

Since many changes may be made to a computer program, there must be a mechanism for automatically recording program versions. This applies to coding modules, operational modules, and jobs.

7.3 COMPUTER PROGRAM INSTALLATION INTO IPAD

IPAD is required to support several modes of program/data/information interfaces with the information bank. The primary purpose is to make provisions which allow simple installation of existing programs into IPAD. All programs installed in IPAD should have the full benefits of the general data management feature described in section 5.0, and it should be possible to utilize any or all of the information management features described in section 6.0. Four possible modes of installation are illustrated by figure 69 and are identified as:

Mode 1 This concept implies that the contents of all input and output data sets are defined to IPAD and that all data management by IPAD is implicit.

Mode 2 This concept implies that the contents of some input and output data sets are defined to IPAD and that both implicit and explicit I/O is performed by IPAD.

Mode 3 Like mode 2, this concept implies that the contents of some input and output data sets are defined to IPAD but are translated for explicit I/O by IPAD.

Mode 4 This concept implies that the contents of input and output data sets are not defined to IPAD and that all data management by IPAD is explicit.

The use of the terms "implicit" and "explicit" I/O should be interpreted as follows:

Implicit input/output action to and from a data set is totally under the direct control of IPAD. Note: Query is possible at the level of data elements.

Explicit input/output action to and from a data set is under control of the user program. IPAD is responsible only for the data set as a unit. Query is possible at the level of data set and in general, IPAD is not capable of interpreting the content of any data set handled in this way.

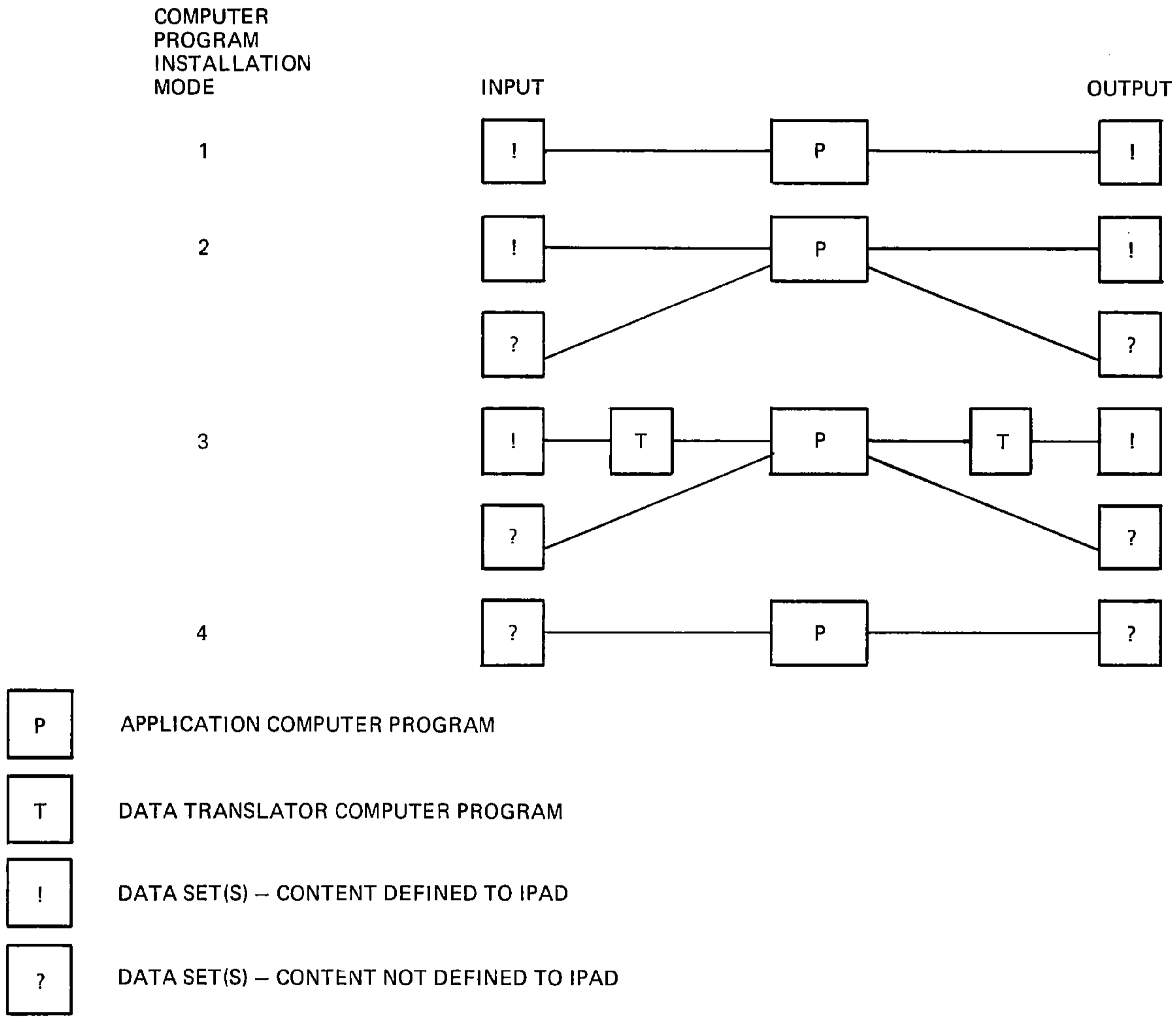


Figure 69.—Computer Program Installation Into IPAD

8.0 CONCLUSIONS

Current commercially available data management systems enable the information systems designer to adequately define simple business-type data such as text, date, money, and numbers. Many of these data management systems provide multiple interfaces to the information system in the form of self contained query-type languages plus a data manipulation language that can be used with host languages such as FORTRAN or COBOL. It is concluded that the unique requirements for an engineering information bank are expressible as additions to these capabilities and that IPAD should provide features for general scientific data management at the set (or file) level, information management at the element level and management of user supplied computer program in the form of a library of modules that are readily available to a community of users. The element types in scientific data management must include all those in business systems plus complex vector and matrix types, which may be very large yet still be considered a single data element.

It is further concluded that the IPAD system management features should take the form of general tools that will allow any company to implement its version of the design process, computer program library, and information bank. Finally, it is concluded that each of the management features should be subdivided so that the degree of implementation chosen by a company can be tailored to the needs of that company. For example, it should be possible to "switch off" such features as the records showing source of data sets or the project control features for schedule control. In addition, it should be possible to operate in a file management mode where data sets are treated as files and the content (elements) of the files are not defined to IPAD.

APPENDIX A

TYPICAL QUESTIONS

This appendix contains a list of typical questions that users must answer relative to the control decisions identified in the reference design process described in section 6.0 of CR 2981. The decisions are identified by the same number and include project 1 the subsonic transport (sec. 6.2), gather information (sec. 6.5) and structural detail design (sec. 6.6.1).

Decision II-4. Design Mission OK?

1. Will mission yield a competitive share of market?

2. Have growth and off-design performance requirements been identified (e.g., growth range and payload, wind, temperature, airfield conditions, etc.)?

Decision II-8. Suitable Sales Potential?

Will sales potential and return on investment justify development costs?

Decision III-4. Type B Weights Available?

Has block III-17 (calculate weight, balance, loadability, Type B) been executed for the configuration being sized and, if so, is weight data valid?

Decision III-8. Loadability/OEW Criteria Met?

1. Is the calculated and allowable OEW within acceptable tolerance?

2. Are the center-of-gravity excursions based on operational criteria within available aerodynamically calculated forward and aft center-of-gravity limits?

3. Does the OEW center of gravity result in acceptable airplane balance?

Decision III-10. Design Criteria Met?

Do deficiencies in meeting criteria exist (as determined by comparing calculated performance with criteria)?

Decision III-16. Flexibility Change Significant?

Are calculated flexibility of structure and initial assumed flexibility of structure within acceptable tolerance?

Decision III-19. Loadability/OEW Criteria Met?

Question types are the same as decision III-8.

Decision III-20. Do Flutter Analysis?

Has block III-22, Flutter Analysis, been executed for the configuration being sized or for an equivalent configuration and, if so, is flutter data valid?

Decision III-25. Configuration Acceptable?

Will primary structure sizing result in significant changes in the estimate of performance, noise, cost, and market suitability?

Decision III-26. Modify Configuration or Mission?

If configuration is not acceptable (Decision III-25), can the configuration be modified or is a modified mission required?

Decision IV-3. Geometry Change?

1. Are the objectives for isobar patterns and span loading met?

2. Are camber, twist, or thickness modifications required?

Decision IV-6. Geometry Change?

1. Is stability deficient?

2. Is control effectiveness below requirements?

3. Are significant changes required in size of control surfaces?

Decision IV-7. Stability and Control Acceptable?

1. Are stability and control criteria met within acceptable tolerance?

2. Are minor modifications of control surfaces size or rate of surface actuation required?

3. Should stability and control analysis be repeated?

Decision IV-8. Start Wind Tunnel Model?

1. Does the aerodynamic analysis (ref. block IV-2) and Stability and Control Analysis (ref. block IV-4) show good results?

2. Should design of a cruise shape wind tunnel model be initiated?

Decision IV-11. Entered at M?

Have flight control system synthesis and analysis--elastic body modes (block IV-53)--been executed for this or a similar configuration and are the data valid?

Decision IV-13. Flight Control System Criteria Met?

1. Are flight control system criteria met within acceptable tolerance?

2. Is a technical review required to determine action?

Decision IV-16. Installed Thrust on Specific Fuel Consumption Change Significant?

1. Are the calculated installed thrust and specific fuel consumption within acceptable tolerance with the values assumed in levels II and III?

2. Are changes in the configuration required?

Decision IV-19. Entered at M?

1. Have all required level IV analyses been completed and are results satisfactory?

2. Are manufacturing reviews required?

3. Are summaries of level IV activities completed?

Decision IV-22. Flexibility Change Significant?

1. Is calculated flexibility of structure and the flexibility of structure assumed from level III within acceptable tolerance?

2. Should static loads (block IV-20) and structure sizing (block IV-21) analysis be repeated?

Decision IV-24. Structural Concepts Satisfactory?

1. Can structural concepts be changed to improve efficiency?

2. Can structural concepts and arrangements be further optimized?

3. Is redefinition of structural concepts required?

Decision IV-26. Panel Mass or Inertia Change Significant?

1. Are effects of panel mass, center-of-gravity, and inertia changes within acceptable tolerance?

2. Should the loads and structural analyses be repeated?

Decision IV-27. Loadability/OEW Criteria Met?

1. Is OEW within acceptable tolerance?

2. Is center-of-gravity excursion within available aerodynamic c.g. limits?

3. Is airplane balance satisfactory?

Decision IV-32. Flutter Criteria Met?

1. Does flutter deficiency exist?

2. Is any change in geometry, mass, or stiffness required?

3. Should an active flutter suppression sytem be investigated?

Decision IV-3. Geometry Change?

1. Are modifications of the primary lifting surfaces and/or control surfaces required?

2. Are new control surfaces required to achieve flutter clearance?

Decision IV-34. Use Flutter Suppression System?

1. What are benefits, risks, cost, complexity, and weight of flutter suppression system?

2. Should flutter suppression system be incorporated?

Decision IV-36. Change Stiffness?

1. What is weight increase for required increase in structural stiffnss?

2. Should structural stiffness be incorporated to achieve flutter clearance?

Decision IV-39. Loadability/OEW Criteria Met?

Question types are the same as decision IV-27.

Decision IV-40. Entered H from J?

Have dynamic load and ride quality analysis (block IV-42) been executed for this or similar configuration and are the data valid?

Decision IV-44. Negative Margins of Safety?

Are dynamic loads critical for any structural element?

Decision IV-47. Flexibility Change Significant?

1. Are new calculated flexibility and the previous flexibility within acceptable tolerance?

2. Should static loads (block IV-45) and structure sizing (block IV-46) analyses be repeated?

Decision IV-49. Panel Mass or Inertia Change Significant?

1. Are effects of panel mass, center-of-gravity, and inertia changes within acceptable tolerances?

2. Should the loads and structural analyses be repeated?

Decision IV-50. Loadabilty/OEW Criteria Met?

Question types are the same as decision IV-27.

Decision IV-51. Do Flutter Analysis?

Has flutter analysis (block IV-31) been executed for this or a similar configuration and is the data valid?

Decision IV-54. Do Dynamic Loads Analysis?

1. Have significant changes in weight, flexibility, or flight control been identified and, if so, should dynamic loads analysis (block IV-42) be repeated?

2. Is final update of systems required?

Decision IV-57. Will Engine be Available for Product?

Is engine availability schedule compatible with airframe development schedule?

Decision IV-59. Configuration Acceptable?

Have reviews indicated deficiencies in the configuration?

Decision IV-61. Start Wind Tunnel Model?

1. Does the completed level IV analysis show good results?

2. Should design of a cruise shape wind tunnel model be initiated?

3. Is technical review required to determine next action?

Decision IV-62. Wind Tunnel Model Started?

Was cruise shape wind tunnel model initiated by decision IV-8?

Decision IV-63. Modify Configuration or Mission?

If the configuration is not acceptable (decision IV-59) can the configuration be modified or is a modified mission required?

Decision V-1. Wind Tunnel Model Changes Required?

Does the cruise shape wind tunnel model design initiated in level IV require any modification?

Decision V-7. Configuration Acceptable?

1. Is cruise performance as predicted or within acceptable tolerance?

2. Are longitudinal stability and control acceptable?

3. Are lateral and directional stability and control acceptable?

Decision V-14. Recycle?

Do test results indicate additional testing or revision in design?

Decision V-15. Configuration Acceptable?

1. Can the configuration meet the initial design criteria?

2. Are adequate growth capabilities identified to fully establish growth criteria affecting the selection of such critical factors as wing areas, high lift configuration, propulsion arrangements, and fuselage extensions or deletions to increase or decrease payload, etc.?

Decision V-18. Sales Go-Ahead?

Has a management commitment been made to authorize sales of the product?

Decision V-19. Firm Orders?

Are there sufficient customer orders to initiate product go-ahead?

Decision V-21. Product Go-Ahead?

Do projected future sales and estimated return on investment justify development costs?

Decision VIA-5. External Loads Available?

1. Have the basic airplane loads been distributed to the structure?

2. Have the local maximum shears and moments been determined for this structure for all load conditions, maneuver loads, gust loads, ground-air-ground loads, internal pressure loads torsion loads?

Decision VIA-9. Structural Element Concept Developed?

1. Has a design concept been developed for this structure that appears feasible and needs only sizing for completion?

2. Is a typical cross-section (channel, zee, etc.) available?

3. Is the frame concept a formed or built-up section?

Decision VIA-14. Structural Element Concept Compatible?

Is the structural element concept compatible with the interfacing structure in strength, stiffness attachment, appearance, and is it within envelope boundaries (inner/outer contours and width)?

Decision VIA-15. New Structural Element Concept Required?

Can the structural element concept be varied enough to be compatible with interfacing structure and carry its loads and fit the envelope, or must a new structural element concept be developd?

Decision VIA-16. Revise Structural Element Concept?

Will a different structural element concept carry the loads, fit the envelope, and still be compatible with the existing adjacent structure for strength, stiffness and attachment?

Decision VIA-18. Revise Adjacent Structural Concept?

1. Can a revised adjacent structural concept carry its loads and be compatible in strength, stiffness, and attachment to its adjacent members?

2. Are the cost, weight, appearance, and envelope of a revised adjacent structure acceptable?

Decision VIA-20. System Interface Developed?

1. Are there systems interfaces?

2. Are system interfaces developed for location, function, and support?

3. Is structural reinforcement required to accommodate system interface?

Decision IVA-25. System Interface O.K.?

Are the system interface and structural concept satisfactory for location, system function, systems support, structural efficiency for access, and servicing?

Decision VA-26. Revise Systems?

Should the system (location, attachment, support, or function) be revised for improved system/structure interface?

Decision VIA-28. Internal Loads Available?

Are all internal (static/dynamic) loads available that impact the structure due to systems interface, system function, equipment attachment and function, linings, etc.?

Decision VIA-33. Internal Loads Satisfactory?

1. Are the internal loads reasonable in magnitude and direction?

2. Are the internal loads complete and current and have all the interface attachments been accounted for?

Decision VI-36. Structural Concept Satisfactory?

Does the structure adequately support the internal static, dynamic loads with no deterioration of external load-carrying capability or fatigue life?

Decision VIA-37. Joint Location Developed?

Are the joint locations developed for the structural element concept?

Decision VIA-42. Joint Locations Satisfactory?

1. Do the joint locations occur at low stress locations?

2. Are the joints located away from interface areas to avoid interference?

3. Do the joints divide the basic structure into reasonable sizes for material availability and part handling?

4. Are the joints located to enhance inspection?

Decision VIA-44. Joint Concept Developed?

Has a joint concept been developed for the structural element being joined?

Decision VIA-49. Joint Concept O.K.?

1. Does the joint concept adequately splice the structural elements to effect a smooth stress flow without stress concentration?

2. Is the joint concept practical to manufacturé and install?

3. Does the joint concept adequately address problems of fatigue, corrosion, and replacement?

Decision VIA-50. Revise Joint Concept?

Can the joint concept be modified to reinforce any shortcomings such as stress concentrations, manufacturing or installation difficulties, fatigue and corrosion potentials, or replcement inadequacies?

Decision VIA-52. New Joint Concept Required?

Will a new joint concept be adequate as to stress flow manufacturing ease, fatigue, and corrosion prevention?

Decision VIA-56. Sizing for Strength O.K.?

Is the joint concept adequate for splicing the shears and moments in the structural member?

Decision VIA-57. Revise Joint Sizing?

Should the joint be resized to adequately accommodate the shears and moments to be spliced and join the structural elements without change in stiffness without initiating a fatigue condition or a corrosion potential?

Decision VIA-59. Sizing for Stiffness O.K.?

Does the joint concept adequately splice the structural element with a continuity of stiffness so as not to create a "soft" or "hard" spot in the structural assembly?

Decision VIA-60. Sizing for Durability O.K.?

Does the joint concept adequately address fatigue life, corrosion resistance, and inspection and replacement facilities?

Decision VIA-64. Sizing for Strength O.K.?

Is the sizing of the structural elements between the joints adequate for the shear and moment loads imposed?

Decision VIA-65. Revised Structural Element Sizing?

Should the structural element between joints be resized to accommodate the shears and moment, required stiffness, and/or the fatigue resistance required?

Decision VIA-67. Sizing for Stiffness O.K.?

Is the sizing of the structural element between joints sufficiently stiff to support major loads and interface attachment within deflection limits?

Decision VIA-68. Sizing for Durability O.K.?

Is the sizing of the structural element between joints adequate for the fatigue life and durability goals as established?

Decision VIB-3. Design Appropriate?

1. Is the design adequate for the loads (internal/external) that must be carried?

2. Do the joints splice the parts adequately within acceptable stiffness limits?

3. Are the joint elements easy to make and install?

4. Does the design fulfill durability goals?

5. Are corrosion potentials reduced or handled adequately?

6. Are interfaces (system/structure) accommodated?

7. Is the part geometry within required envelope?

8. Are materials selected according to design directions?

9. Is the design compatible with the overall similar structural family?

Decision VIB-9. Engineering Advance Material Release (EAMR's) Required?

1. Are there any long-lead items of material that should be ordered at this time to ensure their availability when production requires them? Long-lead items are forgings, forged blocks, casting, large extrusions, etc.

Decision VIB-12. EAMR's Satisfactory?

1. Are all materials ordered that need to be?

2. Is the data on the EAMR correct (material, quantity, etc.)?

Decision VIB-13. Concept or Procedures Problem?

1. Is the EAMR form filled out properly?

2. Is the content of the EAMR correct or according to design direction as to what items and material are proper to order (i.e., casting, forging, forged block, extrusion, etc.)?

Decision VIB-14. EAMR O.K.?

1. Do the EAMR's call for the correct material, grain direction, heat treatment, alloy, etc.?

2. Is the EAMR procedurally correct?

Decision VIB-17. Gage Information Required?

Does the production department need the location of major pin joint, hinges, production breaks for tool planning and tool design, etc.?

Decision VIB-19. Class II Mockup Required?

1. Is a mockup required for any of the design area to assist design, (e.g., space, function of parts, sizing, etc.)?

2. Are space, arrangement, and function as desired?

3. Are interfaces adequately accommodated and supported without determination of the structure or interface?

Decision VIB-25. Structural Element Design Concept O.K.?

1. Does the design carry all loads (shears, moments) within design limits?

2. Are stiffness and durability within design limits?

3. Are materials and coatings according to latest approved directions?

4. Are production requirements (fit, finish, methods) adequate for the design use?

5. Are the designs weight-effective?

6. Does the weight fall within the projected weights?

7. Can the design be built with existing facilities?

8. Is there an easier concept to build?

9. Will a change or consolidation of parts lead to a cheaper, easier configuration to construct?

10. Are the materials available to build the design?

11. Does the part geometry fill or stay within desired limits?

Decision VIB-27. Update Work Breakdown Structure?

1. Does the WBS adequately describe the design?

2. Are there additions or deletions to the list items to be manufactured?

Decision VIC-4. Engineering Drawing Satisfactory?

1. Does the drawing describe the parts completely?

2. Are all of the features of the part (material, heat treatment, finish, identification, tolerance, coatings, quantity) defined?

3. Are all fasteners identified?

4. Does the item fit and accommodate interfacing structure and systems?

5. Does the design appear reasonable: similar to adjacent designs, esthetically reasonable, etc.?

6. Are the components and materials the same as those on the EAMR?

7. Is the design correct geometrically?

Decision VIC-5. Procedures or Other Problems?

1. Is the drawing correct according to established procedures?

   a) Is list of materials complete and correct?

   b) Is tabular block (usage information) complete and correct?

   c) Are notes adequate to complete the description of the desired part?

2. Is the design inadequate for the task it must do:

   a) For strength?

b) For weight?

c) For durability?

d) For life?

e) For producibility?

f) For cost?

Decision VIC-13. Drawing Satisfactory?

1. Does the design carry all loads (shears, moment) within design limits?

2. Are stiffness and durability within design limits?

3. Are materials, heat treatment, coatings, and fasteners according to directives?

4. Are production requirements (fit, finish, methods) adequate for design use?

5. Are designs weight-effective?

6. Does the weight fall within projected weight limits?

7. Can the design be built with existing facilities?

8. Is there an easier concept to build?

9. Will a change or consolidation of parts lead to a cheaper, easier configuration to build?

10. Are the materials available to build the design?

11. Does the part geometry fill or stay within desired limits?

12. Does the design appear reasonable; similar to adjacent designs, esthetically reasonable, etc.?

Decision VIC-15. Drawing Satisfactory?

1. Is materials technology staff satisifed with the drawing?

2. Is weights technology staff satisfied with the drawing?

3. Is the stress staff satisfied with the drawing?

4. Are the production, planning, material procurement, and tooling organizations satisfied with the drawing?

5. Is engineering management satisfied with the drawing?

Decision VII-2. Production Problem Requiring Redesign?

1. Have potential problems been identified during the manufacturing review?

2. Which problems could best be solved by changes in the engineering definition?

Decision VII-5. Production Problem Requiring Redesign?

1. Have problems been identified during the design of tooling?

2. Which problems could best be solved by changes in the engineering design definition?

Decision VII-8. Parts and Tool Satisfactory?

Have parts and/or tools been rejected?

Decision VII-9. Problem Requiring Redesign?

1. Should parts and/or tools be scrapped or reworked?

2. Is redesign of the part and/or tool the best solution?

Decision VII-10. Rework or Scrap?

Can rejected parts be reworked?

Decision VII-13. Production Problem Requiring Redesign?

1. Is redesign of the part the best solution?

2. Can liaison engineering correct problem?

Decision VII-14. Product Complete?

1. Has the quality control as-built audit identified any discrepancy from the as-designed definition?

2. Do exceptions require rework to complete the product?

Design VII-16. "As-Built" Same as "As-Designed"?

Are deficiency reports required?

Decision VIII-5. Problem Requiring Redesign?

1. Have problems been identified during the product verification?

2. Is redesign of parts the best solution?

Decision G-5. Information Available?

Is all of the information required available, understandable, and in a form that is applicable to the task? Can it be separated from other data and retrieved?

Decision G-10. Information Correct?

Is the information credible; does it withstand testing; is it correct and accurate enough for use in this design?

Decision G-12. Information Complete?

Is all of the information sufficiently complete to develop the design?

Decision G-14. Repeat?

Should another information item, similar to that just gathered, be selected or generated in the same manner as the last item? Is more of a similarly developed data required?

Decision G-15. Select or Generate?

Is the information to be selected from existing data or is it to be generated?

Decision G-17. Method Available?

Is there a method/procedure available to do the tasks needed to generate the required data?

Decision G-22. Information Correct?

Is the information generated correct or, at least, sufficiently accurate to use in the design? Does it have a sound basis for credibility?

Decision G-24. Method OK?

Is the method an acceptable process or algorithm? Is the method applicable to the input and output data? Is the output accuracy and volume sufficient for the needs of the design or is a more elaborate method needed?

Decision G-25. Revise Information?

Can the information be revised to be correct and complete enough for the task requirement? Is the information developed too inaccurate and/or too vague to be revised?

Decision G-27. Delete Information?

Is the information useless for any future use? Has the information any real value for some other or future task?

APPENDIX B

GLOSSARY

ACCESS CODE

Access codes will control access to data sets and jobs.

ACTIVITY

An activity consists of actions which are associated for any reason. An activity is usually accomplished by a group of individuals working together for the purpose of close coordination. These individuals are normally from one discipline, e.g., aerodynamics, structures, etc. The actions within an activity are normally the execution of one or more jobs.

CLASSIFICATION CODE

A classification code is used to identify items classified within a uniform classification and coding system. The system is based on organizing data in a consistent and disciplined manner. Each code is meaningful and discrete, and is a universal index for all information bearing the same code. It is useful as a tool for storing, retrieving, sorting, analyzing, collating, and identifying data. These codes may be used as sorting criteria for the data stored in the information bank.

CODING MODULE

A specific collection of symbolic code that contributes to the definition of one or more operational modules. Coding modules are the smallest division of user source code that can be defined.

DATA AREA

An arbitrary collection of data sets which are grouped together for purposes of control, management, ease of use, etc.

DATA ELEMENT

The smallest definable unit of data, i.e., an entity or item. It is not restricted in terms of size or complexity but only in that, in an engineering sense (as opposed to computing), the item is referencable as a single entity.

DATA FORMAT

Defines the information bank access method for storage and retrieval of a corresponding occurrence of a data set. Also defines the indexed structure of the data values contained in a defined data set.

DATA PRIMITIVES

The basic building blocks for data in the information bank.

DATA RECORD

A data record is an enumeration of data elements.

DATA RELATIONSHIP

A data relationship is a logical grouping of one or more data records.

DATA SET

Denotes that a specific occurrence of data corresponding to a given data format has been generated. A data set may or may not be defined to IPAD.

DATA SET HEADER

Data contained in a data set header is used to identify the owner and source of the data set and to control access to the values contained in the data set. The header for geometry data sets may contain additional information such as element type, coordinate system, etc.

DICTIONARY

Dictionaries contain definitions of data elements, data relationships, data formats, coding modules, operational modules, and jobs. Each data area may have at most one of each of these dictionaries. An information bank may have one set of common dictionaries for definitions that are common to all data areas.

DISPLAY FORMAT

A display format is a special class of data formats used for displaying data sets by defined graphical methods, whether online or offline.

EXPLICIT INPUT/OUTPUT

Input/output action to or from a data set under the control of a user program. IPAD is responsible only for the data set as a unit and, in general, is not capable of interpreting the contents of any data set handled in this way.

The data format for an undefined data set will not specify the structure of the data set.

HOST SYSTEM

The computer processing system (hardware and software) containing the host IPAD

HOST IPAD

The IPAD system software supporting user activity on the IPAD information bank and exercising sole control on the IPAD information bank

HOST USER

A user who is currently using the host system directly, i.e., not using the host IPAD

HOST IPAD USER

A user who is currently using the host IPAD

IMPLICIT INPUT/OUTPUT

Input/output action to and from a data set which is under the direct control of IPAD. The data format for a defined data set will specify the structure of the data set.

INFORMATION BANK

The domain or collection of all data areas defined to IPAD

INFORMATION BANK ADMINISTRATOR(S)

Information administration is a special form of managerial control including authority over both data integrity and security and responsible for overall efficiency. The information bank administrator is responsible for the overall organization of the information bank, its dictionaries, program libraries, and security provisions.

IPAD COMMUNICATION NETWORK

The IPAD communication network is defined to include all hardware and software furnished and maintained by the IPAD contractor or by independent vendors and used to provide communications between the IPAD host computers and any IPAD satellite computer. This includes any translators required to reformat data or computer programs for transmission between computers.

IPAD COMPUTER PROGRAM LIBRARY

The collection of all user-supplied computer programs installed into IPAD

IPAD HOST COMPUTER

The IPAD host computer includes all hardware and software furnished and maintained by the computer vendors.

IPAD SATELLITE COMPUTER

The IPAD satellite computer includes all hardware and software furnished and maintained by the computer vendors and used to support CAD/CAM work stations or any other application remote to the IPAD host computer.

IPAD SYSTEM

The IPAD system includes all software designed and developed under the IPAD contract and all existing software purchased and installed as part of the IPAD system, which shall be maintained by the IPAD contractor or subcontractor during the program's life.

JOB

A specific sequence of interfaced operational modules and/or other jobs that produce meaningful results for a user.

KEY WORD LIST

The key word list, an important item for each dictionary entry, allows users to search existing dictionary entries to fulfill their needs. This capability helps to limit the number of redundant entries in the dictionary containing the same information or having the same mathematical definition.

LEVEL

A level consists of activities associated for control by management. Levels relate to the degree or depth of the design process. Each level is normally accomplished by several disciplines working together to establish a predicted confidence level for risk evaluation by management.

OPERATIONAL MODULE

An executable collection of coding modules contributing to one or more jobs

OPERATING SYSTEM

The operating system for the host or satellite computer within which IPAD or remote (subset) IPAD executes

PERMISSION CODE

Permission codes will be equivalent to a management system within the IPAD command language. The typical user will operate with functional capability limits established by permission codes.

PROCESS

A series of continuous actions planned and defined within a hierarchical system of levels divided into activities accomplished by executing one or more jobs. Each level has forward and feedback data flow paths defined within activities and between related activities. Data transfer between levels may be forward or feedback.

PROGRAM ITEM NUMBER (PIN)

A number relating an item of work to the work breakdown structure and used as a primary index to work items and for cost collection

PROJECT

The sequence of tasks and subtasks to be performed during an associated design and/or analysis effort

PROJECT PLAN

The definition of all project tasks and subtasks and the associated control in terms of a network showing schedule dependencies

PROJECT REPORT

The collection of reports expected to be generated during the progress of a project

REMOTE SYSTEM

Any computer processing system (hardware and software) that is remote to the host system. A remote system may or may not contain a remote IPAD, i.e., a subset of IPAD.

REMOTE IPAD

A portion or subset of the IPAD system software residing on a remote system and supporting remote user activity and coordination with the host IPAD and other remote IPAD's

REMOTE USER

A user who is currently using the remote system directly, i.e., not using a remote part of IPAD

REMOTE IPAD USER

A user who is currently using a remote part of IPAD

REMOTE IPAD DATA

Data stored remotely from the host system in a manner compatible with host IPAD control and conventions

SECURITY CODE

Security codes are those coded conventions established to meet company or governmental rules pertaining to controlling access to data. These are a key subset of the total set of access codes.

SUBTASK

A sequence of jobs using IPAD and representing a meaningful step in a project

SUBTASK DATA AREA

A data area associated with an IPAD user during the execution of one subtask. Each subtask will have an associated subtask data area. The subtask data area is a private user working data area, and all data is generated in a subtask data area.

SUBTASK STEP

A single step occurring in a subtask, normally defined by a host operating system control card or the execution of a single IPAD utility program

TASK

A sequence of subtasks accomplished by a group (discipline) and representing a milestone in the project plan

USER IDENTIFICATION

A unique identifier associated with each user of IPAD. This ID must be associated with a person and not with an activity or an organization.

VERSION NUMBER

A special identification used to denote a specific version of a data set or a program

WORK BREAKDOWN STRUCTURE (WBS)

A structured index to all elements of work and all end items produced by a product program

APPENDIX C
SI–U.S. CONVERSION TABLE

METRIC TABLES

LENGTH

Myriameter	10,000 meters	6.2137 miles.	Meter	1 meter	39.37 inches.
Kilometer	1,000 meters	0.62137 mile.	Decimeter	0.1 meter	3.937 inches.
Hectometer	100 meters	328 feet 1 inch.	Centimeter	0.01 meter	0.3937 inch.
Dekameter	10 meters	393.7 inches.	Millimeter	0.001 meter	0.0394 inch.

AREA

Hectare	10,000 square meters	2.471 acres.
Are	100 square meters	119.6 square yards.
Centiare	1 square meter	1,550 square inches.

WEIGHT

Name	Number of grams	Volume corresponding to weight	Avoirdupois weight
Metric ton, millier or tonneau	1,000,000	1 cubic meter	2.204.6 pounds.
Quintal	100,000	1 hectoliter	220.46 pounds.
Myriagram	10,000	1 dekaliter	22.046 pounds.
Kilogram or kilo	1,000	1 liter	2.2046 pounds.
Hectogram	100	1 deciliter	3.5274 ounces.
Dekagram	10	10 cubic centimeters	0.3527 ounces.
Gram	1	1 cubic centimeter	15.432 grains.
Decigram	.1	0.1 cubic centimeter	1.5432 grains.
Centigram	.01	10 cubic millimeters	0.1543 grain.
Milligram	.001	1 cubic millimeter	0.0154 grain.

CAPACITY

Name	Number of liters	Metric cubic measure	United States measure	British measure
Kiloliter or stere	1,000	1 cubic meter	1.308 cubic yards	1.308 cubic yards.
Hectoliter	100	0.1 cubic meter	2.838 bushels; 26.417 gallons.	2.75 bushels; 22.00 gallons.
Dekaliter	10	10 cubic decimeters	1.135 pecks; 2.6417 gallons.	8.80 quarts; 2.200 gallons.
Liter	1	1 cubic decimeter	0.908 dry quart; 1.0567 liquid quarts.	0.880 quart.
Deciliter	.1	0.1 cubic decimeter.	6.1023 cubic inches; 0.845 gill.	0.704 gill.
Centiliter	.01	10 cubic centimeters.	0.6102 cubic inch; 0.338 fluid ounce.	0.352 fluid ounce.
Milliliter	.001	1 cubic centimeter	0.061 cubic inch; 0.271 fluid dram.	0.284 fluid dram.

COMMON MEASURES AND THEIR METRIC EQUIVALENTS

Common measure	Equivalent	Common measure	Equivalent
Inch	2.54 centimeters.	Dry quart, United States	1.101 liters.
Foot	0.3048 meter.	Quart, imperial	1.136 liters.
Yard	0.9144 meter.	Gallon, United States	3.785 liters.
Rod	5.029 meters.	Gallon, imperial	4.546 liters.
Mile	1.6093 kilometers.	Peck, United States	8.810 liters.
Square inch	6.452 square centimeters.	Peck, imperial	9.092 liters.
Square foot	0.0929 square meter.	Bushel, United States	35.24 liters.
Square yard	0.836 square meter.	Bushel, imperial	36.37 liters.
Square rod	25.29 square meters.	Ounce, avoirdupois	28.35 grams.
Acre	0.4047 hectare.	Pound, avoirdupois	0.4536 kilogram.
Square mile	259 hectares.	Ton, long	1.0160 metric tons.
Cubic inch	16.39 cubic centimeters.	Ton, short	0.9072 metric ton.
Cubic foot	0.0283 cubic meter.	Grain	0.0648 gram.
Cubic yard	0.7646 cubic meter.	Ounce, troy	31.103 grams.
Cord	3.625 steres.	Pound, troy	0.3732 kilogram.
Liquid quart, United States	0.9463 liter.		

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16. Abstract

This document presents the engineering-specified requirements for integrated information processing by means of the Integrated Programs for Aerospace-Vehicle Design (IPAD) system.

A data model is described and is based on the design process of a typical aerospace vehicle. General data management requirements are specified for data storage, retrieval, generation, communication, and maintenance. Information management requirements are specified for a two-component data model. In the general portion, data sets are managed as entities, and in the specific portion, data elements and the relationships between elements are managed by the system, allowing user access to individual elements for the purpose of query.

Computer program management requirements are specified for support of a computer program library, control of computer programs, and installation of computer programs into IPAD.

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