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IPAD USER REQUIREMENTS IMPLEMENTATION (FIRST-LEVEL IPAD)

D6-IPAD-70016-D-1

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ABSTRACT

This document presents the requirements implementation strategy for First-Level development of the computing system denoted Integrated Programs for Aerospace-Vehicle Design (IPAD). These requirements are selected from the requirements for full IPAD (document D6-IPAD-70040-D).

The capabilities of First-Level IPAD are sufficient to demonstrate management of engineering data on two computers (CDC CYBER 170/720 and DEC VAX 11/780 computers) using the IPAD system in a distributed network environment.

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ACRONYMS AND ABBREVIATIONS

AD-2000	The general purpose design drafting system provided with First-Level IPAD.
IPAD	Integrated Programs for Aerospace-Vehicle Design
IPIP	IPAD information processor
ITAB	Industry Technical Advisory Board

SUMMARY

This document establishes a definitive set of requirements to be satisfied by the First-Level IPAD implementation. These requirements are selected from the requirements for full IPAD (document D6-IPAD-70040-D).

The First-Level IPAD demonstrates advanced computing technology for management of engineering data on two computers connected by a high speed communication network with First-Level IPAD operating in a distributed environment.

The First-Level IPAD system is capable of being extended to satisfy additional requirements. Volumes 2 and 3 of this document contain requirements for two additional levels of IPAD development. This additional information has no direct bearing on First-Level IPAD, however, it might prove valuable in the future as a guide to extend the IPAD system and with this intent, it is recorded as part of this document. Volume 2 represents an assessment by engineering of the minimum IPAD system which can be used to demonstrate the IPAD capability to integrate the engineering design process. Likewise, Volume 3 represents an assessment by engineering of the minimum IPAD system which can be used to demonstrate the IPAD system in a production engineering environment.

1.0 INTRODUCTION

First-Level IPAD is a software system based on a subset of full IPAD requirements. This document contains a definitive description of the requirements met by the First-Level IPAD implementation. These requirements are selected from the requirements for full IPAD (document D6-IPAD-70040-D). Some requirements are only partially met. Subsequent volumes of this document contain definitive descriptions of the requirements for additional levels of implementation. These volumes describe additional features which may be used as a basis for extending the First-Level IPAD should funds become available.

1.1 BACKGROUND

The IPAD user requirements were collected and generated by a team of engineers and computer scientists from NASA, Boeing Commercial Airplane Company (BCAC) and Boeing Computer Services Company (BCS) representing a cross-section of users. A concensus was reached which resulted in the documentation of 151 user requirements (March 1977). These requirements were separated into three categories: 52 data base requirements, 63 data processing requirements and 36 interface requirements. In order that proper attention be placed to the selection of First-Level IPAD, the Industry Technical Advisory Board (ITAB) was requested in April 1977 to "rank" the requirements and identify those considered to be mandatory. By September 1977, 12 ITAB members had responded, half of which indicated some requirements were of a mandatory nature. Further team studies brought about the deletion, consolidation and addition of requirements resulting in a new total of 129 requirements arranged in seven groups and formally documented in D6-IPAD-70040-D, IPAD Requirements (December 1977).

The ranking of the resulting 129 requirements was accomplisned by reducing the original ITAB ranking (151 requirements in the three categories) to decimals and then consolidating them into one list. Requirements resulting from consolidation carried the highest constituent rank. New requirements were ranked by the IPAD engineering staff.

1.2 SELECTION OF FIRST-LEVEL REQUIREMENTS

First-Level IPAD user requirements are selected by the IPAD engineering and computing staffs. In general the requirements selection and degree of implementation are influenced by the requirements ranking, ITAB recommendations at the Preliminary Design Review, and the obligation to build the most effective enginering tool within the funds and time span available.

1.3 FIRST-LEVEL IPAD CAPABILITIES

This section contains a brief description of the capabilities of First-Level IPAD.

The principal objective of First-Level IPAD is to produce a functional prototype software system to aid in handling engineering data associated with the design process.

The prototype consists of a high speed data communication subsystem, a distributed data management subsystem, a graphics library and a geometry display subsystem. These subsystems communicate with one another using IPAD service routines and the high speed communication subsystem when communications cross machine boundaries. These subsystems have independent, limited user interface capabilities. The prototype is sufficiently developed to demonstrate the following:

User Interface

- limited user interface provided for the geometry display utility and the integrated application program
- the interface will include menus and limited prompting for the geometry display utility and integrated application program

Information Management

- a facility based on the three schema approach is provided to support definition of an engineering data base including geometric entities and to impose logical structure (hierarchial, network) upon the data in the data base
- provisions to interface application programs with the data base management system to store and retrieve data using multiple views (external schemas) of the data base
- provisions for an application program to access data on a computer which is remote to the application program; this distribution of data is invisible to the user or application program
- the ability to create and manipulate geometric entities via subroutine calls
- provisions for transforming canonical geometric entities between IPAD and ANSI Y14.26.1 standard forms

Auxiliary/External System Interface

- a message protocol is implemented which supports communication of character data between two computing systems
- a CDC CYBER 170/720 and a DEC VAX 11/780 are connected with a local network supporting high speed communications between the two computers

Graphics and Geometry

- an IPAD geometry standard is implemented and includes approximately 60% of the entities recommended by the proposed ANSI standard Y14.26.1
- basic interactive graphic support routines for passive graphic terminals on CYBER only
- limited design drafting function on DEC only with a postprocessor also on the DEC only to the IPAD geometry standard
- geometry display utility on the CYBER only

The following documentation is supplied with the functional prototype and will include:

User manual to provide reference on First-Level IPAD functional capabilities

System manual to provide reference material on the First-Level IPAD system

Programmer manual describing how to develop application programs for installation into IPAD and how to install existing application programs into the IPAD prototype

2.0 FIRST-LEVEL IPAD USER REQUIREMENTS

This section contains the requirements implemented by First-Level IPAD. A supplemental description is included to limit the scope of the requirement where only a partial First-Level implementation is planned. The limited scope is identified as 30% or 60% of the full requirement and is an approximate estimate. See figure 2.0-1.

2.1 USER INTERFACE

Ten of the 43 user interface requirements are selected for First-Level IPAD. The planned implementation includes 1 at 100%, 1 at 60% and 8 at 30%. See figures 2.1-1, 2.1-2, and 2.1-3.

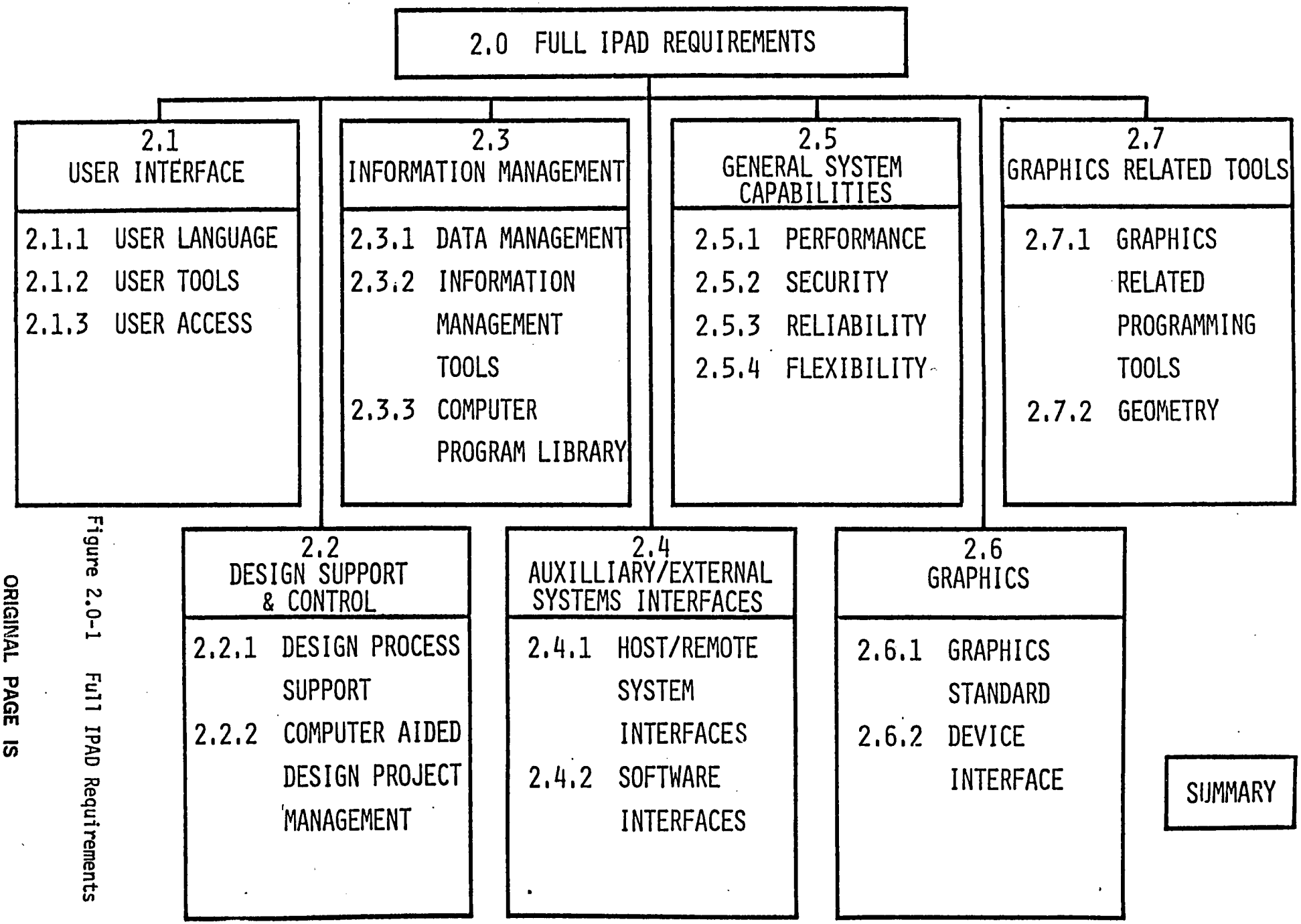


Figure 2.0-1 Full IPAD Requirements

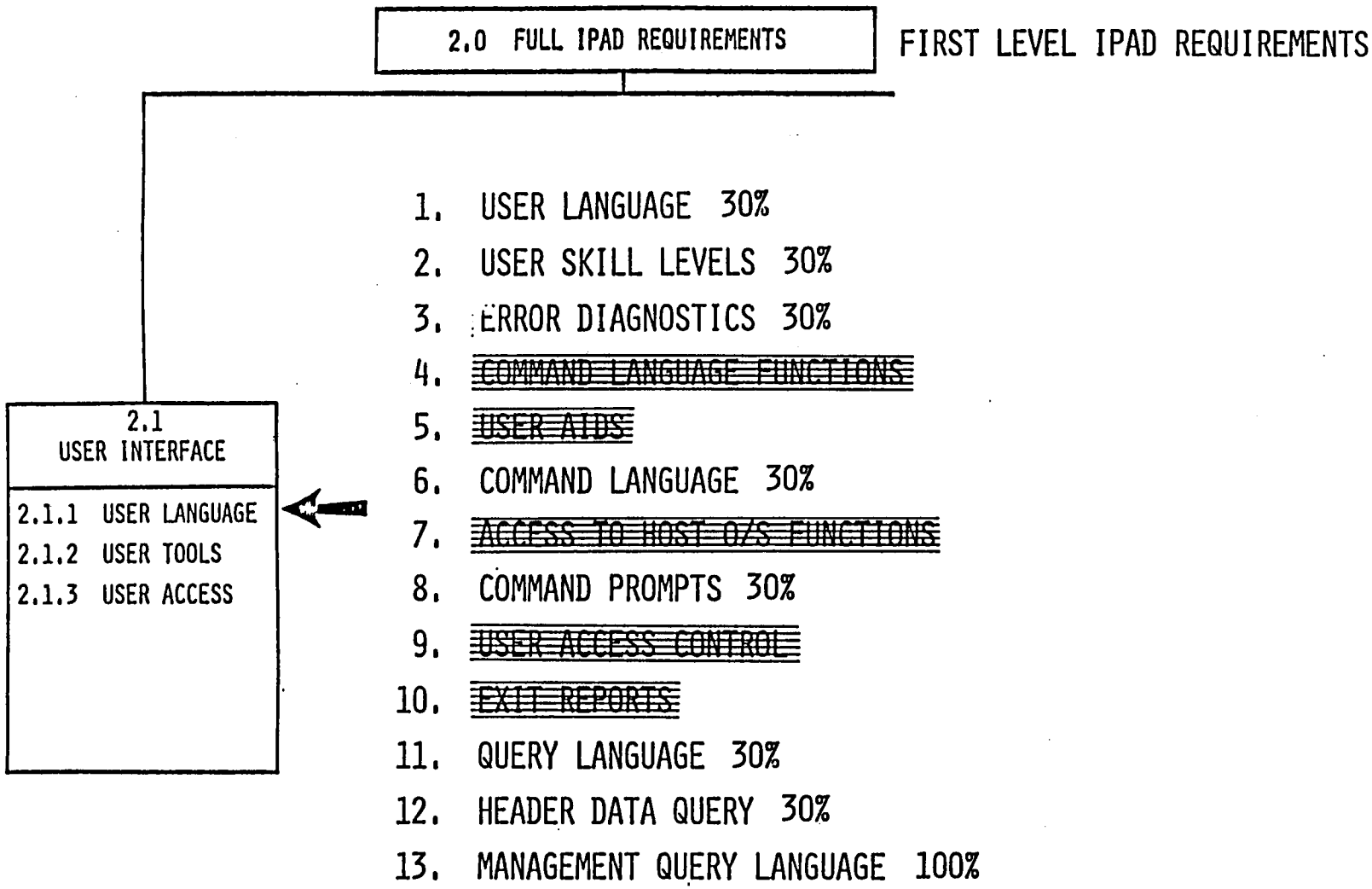


Figure 2.1-1 User Language Requirement

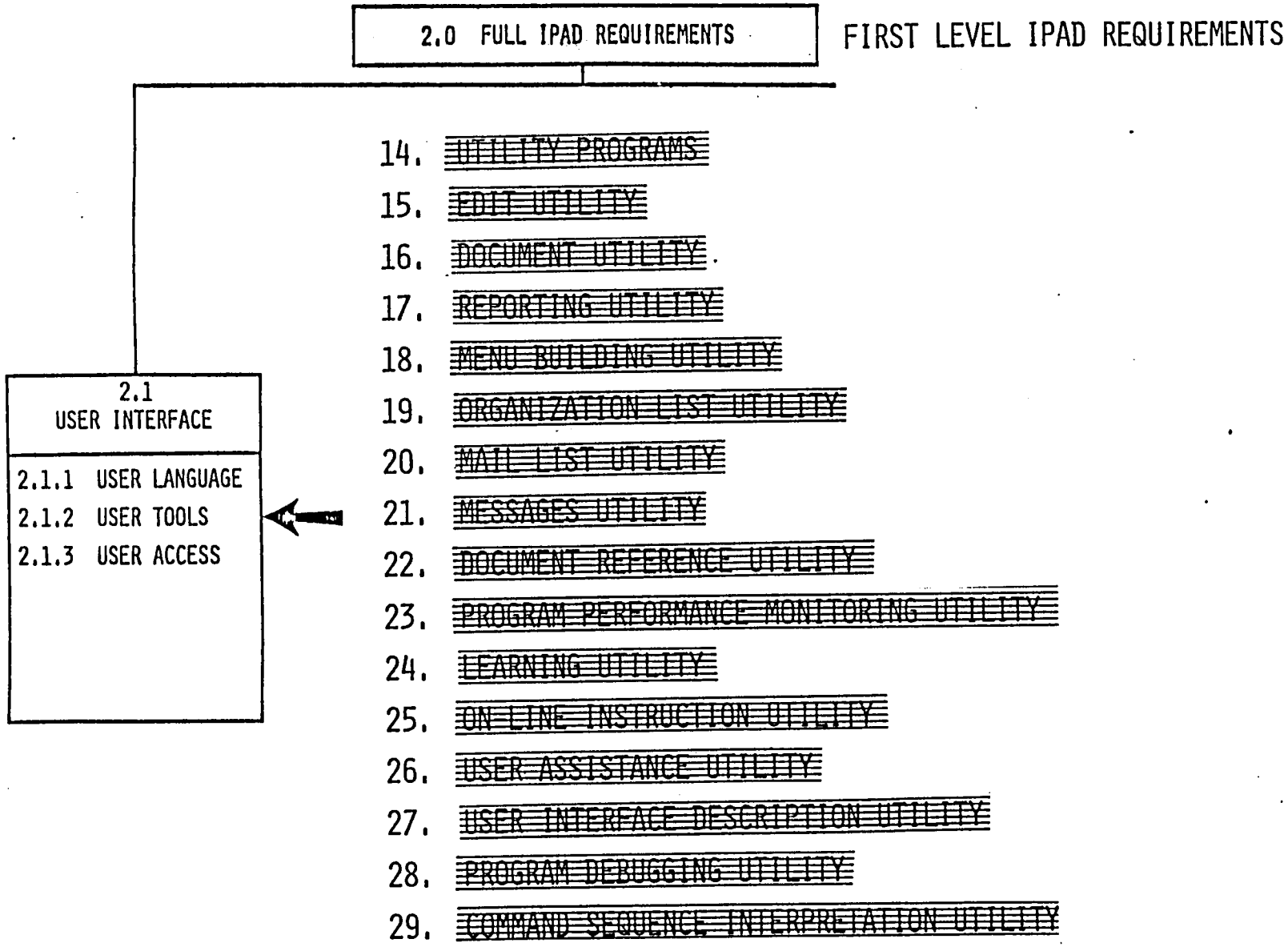


Figure 2.1-2 User Tools Requirements

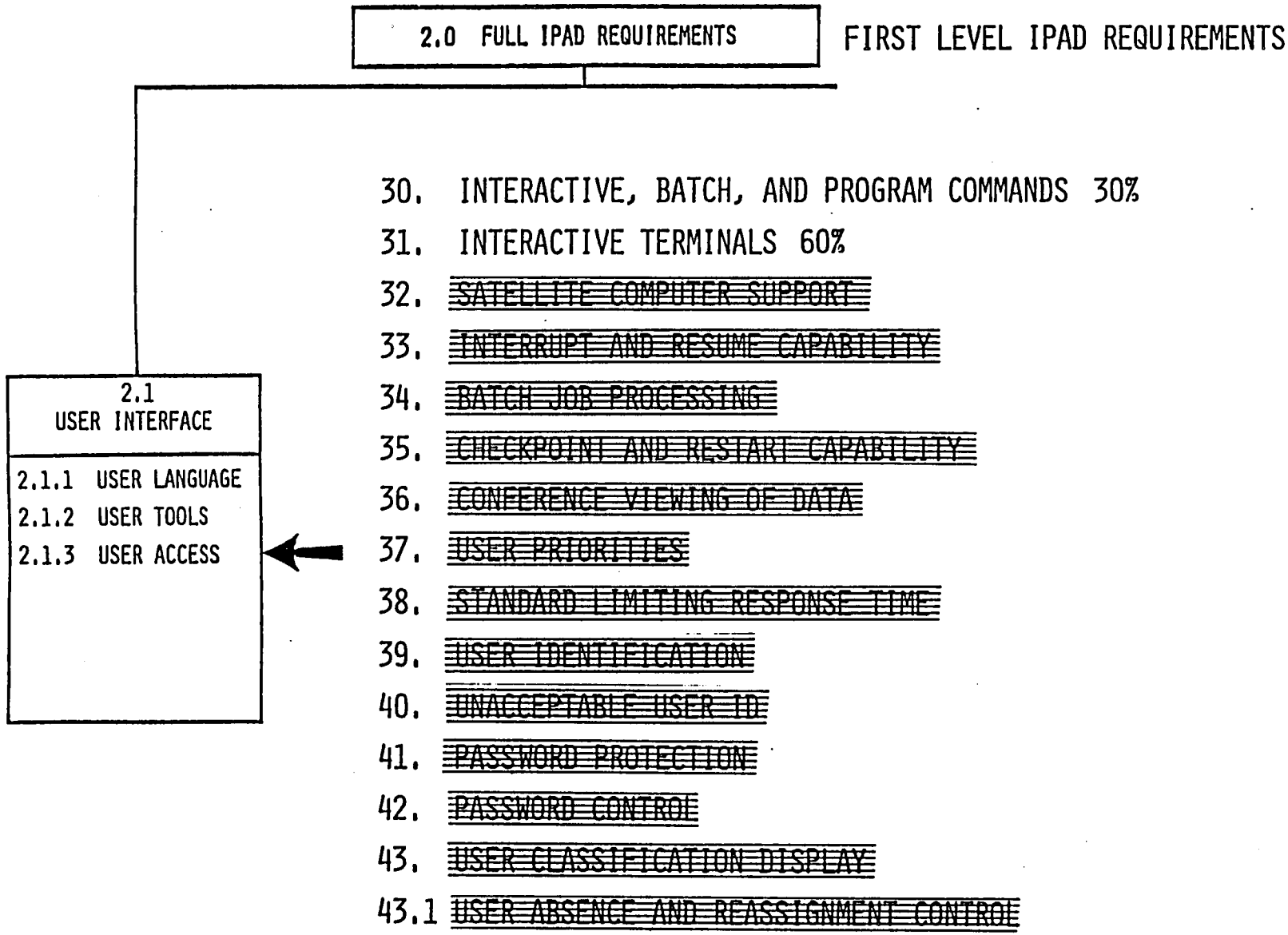


Figure 2.1-3 User Access Requirements

REQUIREMENT 1 USER LANGUAGE

SOURCE 1.4/2.1.1

DESCRIPTION

The IPAD user languages (e.g., command, query, edit, etc.) is user oriented and consistent in vocabulary, and syntax. Defaults are employed when practical and are directed towards the experienced user.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD user languages is user oriented and consistent in vocabulary, and syntax. Defaults are employed when practical and are directed towards the experienced user.

The user interface for the geometry display and integrated application program will be menu driven with limited user prompts.

REQUIREMENT 2 USER SKILL LEVELS

SOURCE SOW/5.2.2, 1.4/2.1.1

DESCRIPTION

IPAD shall address the problem of variation in expertise in the use of computers and IPAD itself.

The system shall direct by virtue of the user inputs, the level of response required and make dynamic adjustments based on the detected skill of the user. It is intended that IPAD minimize frustrations at all user skill levels by optimizing guidance in the use of IPAD commands and supplying explanations of diagnostics, prompts, defaults as indicated by the user input.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

For First-Level IPAD, some user aids are included in the user interface to the IPAD geometry display utility and the integrated application programs.

REQUIREMENT 3 ERROR DIAGNOSTICS

SOURCE SOW/5.2.2, 1.4/3.3.1, 1.4/2.4.3

DESCRIPTION

All user input to IPAD or its utilities (excluding user supplied utilities and application programs) shall be checked for errors. IPAD error diagnostics shall

a. Be complete, clear, concise, courteous, and spelled correctly.

b. Explain the error and how to rectify the problem.

c. Be specifically identified as to source.

d. Be fully explained in both the user's manual and through HELP mode.

e. Include warnings for semantically suspicious commands.

f. Include a brief mode which at the user's option will eliminate all but the most essential portions of diagnostic messages.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

All user input to First-Level IPAD (limited to IPAD geometry display utility and the integrated application programs are checked for errors. Diagnostics:

a. are complete, clear, concise, courteous, and spelled correctly

b. are explained in the user's manual

REQUIREMENT 6 COMMAND LANGUAGE

SOURCE SOW/5.2.2

DESCRIPTION

The command language shall be easy for the engineering user to understand and use. The commands shall appear to the user to be independent of the host computer, except in those cases where it may be necessary or desirable to allow an IPAD user to have direct access to host commands.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

The user interface provided in First-Level IPAD (which are IPAD geometry display utility and the integrated application program) are easy for the engineering user to understand and use.

REQUIREMENT 8 COMMAND PROMPTS

SOURCE SOW/5.2.2, 1.4/3.3.1

DESCRIPTION

IPAD shall interpret or translate commands into appropriate operating system functions, possibly initiating other IPAD software.

IPAD shall provide command decoding, provide error diagnostics for syntactically ill-formed commands, provide warning messages for semantically suspicious commands, accept abbreviated commands, supply default parameters, and provide lists of alternate parameters and their descriptions on request from the user.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD provides command decoding and error diagnostics for syntactically ill-formed commands.

REQUIREMENT 11 QUERY LANGUAGE

SOURCE SOW/5.2.1.3, 1.3/4.5.1

DESCRIPTION

Access to data element values shall be through an interactive query language. The query language shall support logical requests which include arithmetic operations and refer to any data element. The result of a query may be a single value or a list of values of one or more elements. Results of one query may be referenced in another query. Queries may be restricted to user designated data areas on data sets. The query language shall also be usable from within an operational module running either in batch or interactive mode.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

Users will be able to query data through an interactive query language facility of IPIP. Queries are restricted to a single relation at a time. Each command may include a qualification clause to restrict the data to be queried.

REQUIREMENT 12 HEADER DATA QUERY

SOURCE 1.3/3.2.2.1, 1.4/2.5.2

DESCRIPTION

IPAD shall provide the capability to query data set header on any information contained in the data set header. (See requirements 60.)

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

Users may simulate query of header data by doing the following: 1) set up a data base and associated schemas to represent header data and then 2) query this data base with the IPIP query facility.

REQUIREMENT 13 MANAGEMENT QUERY LANGUAGE

SOURCE BCAC-NASA

DESCRIPTION

A management query language, which may be part of the IPAD query language, shall permit interrogation of official project data.

FIRST-LEVEL IMPLEMENTATION (PERCENT 100

REQUIREMENT 30 INTERACTIVE, BATCH, AND PROGRAM COMMANDS

SOURCE SOW/5.2.2

DESCRIPTION

The user shall have the ability to communicate with IPAD through interactive terminal commands, batch control cards, or commands or calls from user programs in execution under IPAD control. The format of the commands shall be compatible in these three modes wherever possible.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

For each utility provided in First-Level IPAD, the user has the ability to communicate through interactive terminal commands or batch control cards.

REQUIREMENT 31 INTERACTIVE TERMINALS

SOURCE SOW/5.1.1, 1.3/3.3.6, 1.4/3.5.3

DESCRIPTION

IPAD shall accommodate interactive terminals as primary user interface. Communication rates shall be limited only by hardware factors unless stated as a part of the system design. The design shall not preclude advances in terminal technology.

FIRST-LEVEL IMPLEMENTATION (PERCENT 60)

First-Level IPAD facilitates both alphanumeric and graphical interactive terminals (see req. 122) as the primary user interface. Refreshed graphics is not available.

2.2 DESIGN SUPPORT AND CONTROLS

One of the 14 design support and control requirements is selected for First-Level IPAD and a 30% implementation is planned. See figures 2.2-1 and 2.2-2.

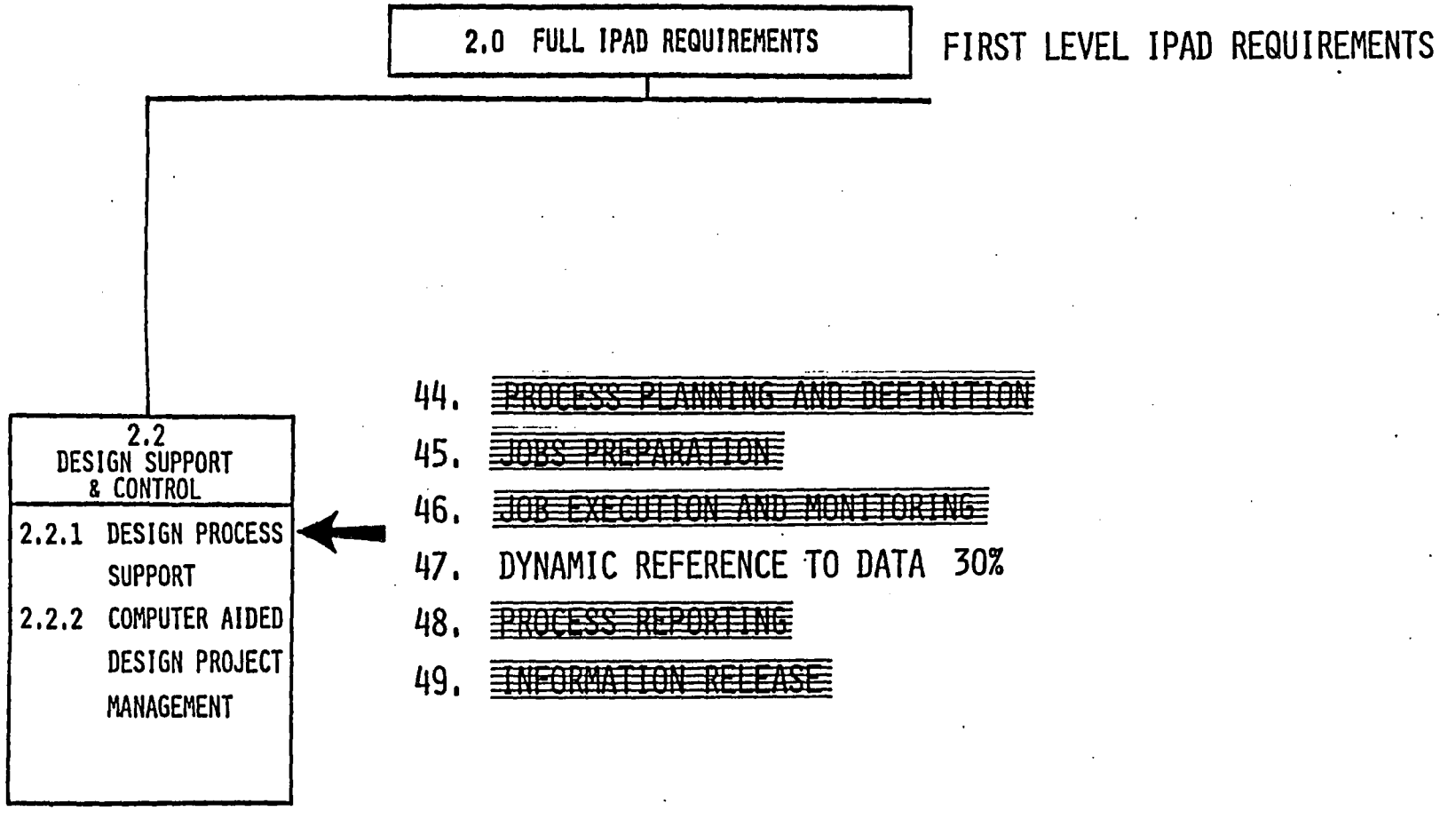


Figure 2.2-1 Design Process Support Requirements

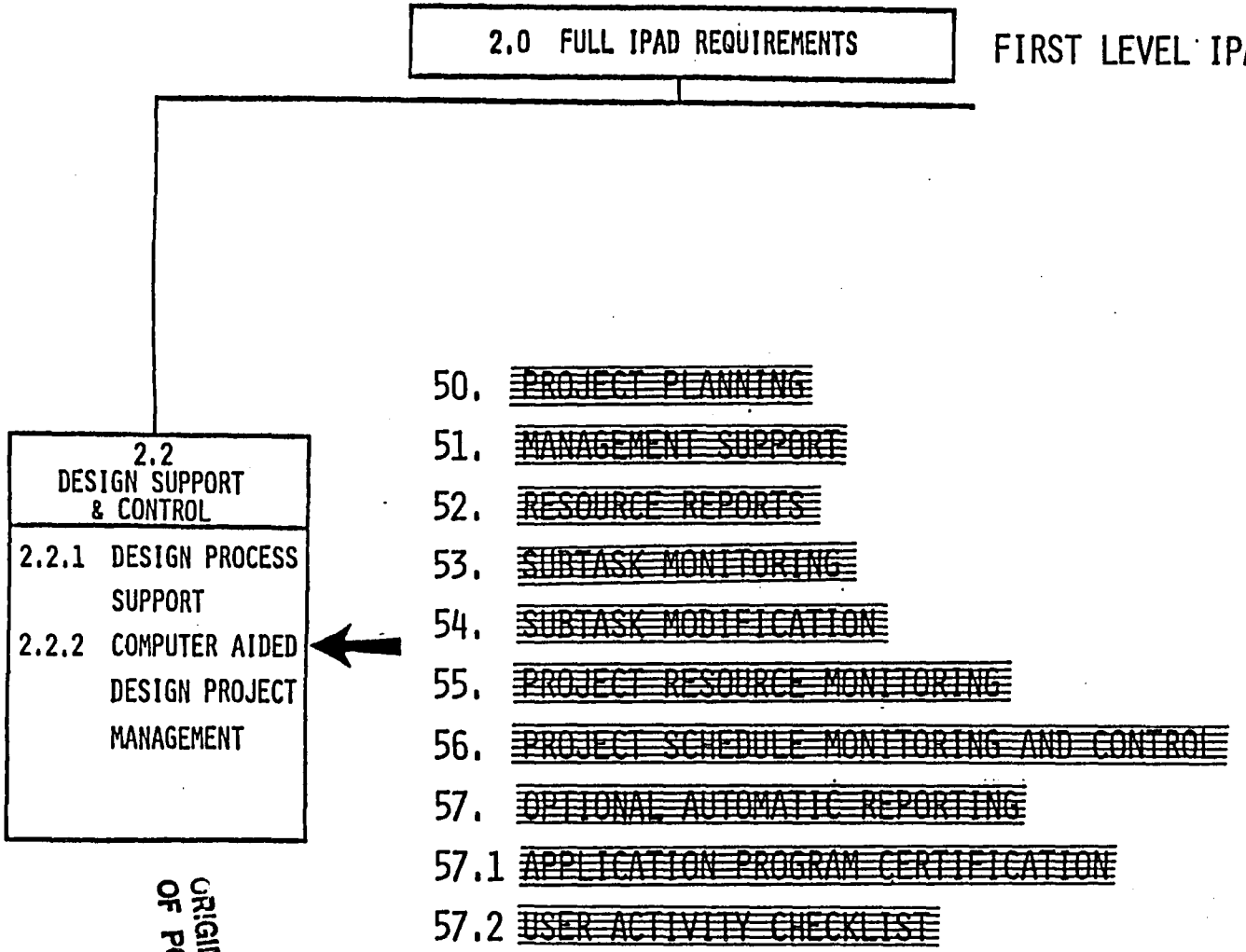


Figure 2.2-2 Computer-Aided Design Project Management Requirements

REQUIREMENT 47 DYNAMIC REFERENCE TO DATA

SOURCE 1.3/4.5.2

DESCRIPTION

IPAD shall permit computer programs to reference data sets in specific data areas with the user identifying the input and output data sets to the job or group of jobs at execution time. These data sets may be identified by information supplied either by the user or the program.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD permits computer programs to reference data with the user identifying the inputs and the outputs at execution time. Data referenced by the computer program may be processed as a collection of related data (data set).

2.3 INFORMATION MANAGEMENT

Twelve of the 43 requirements for information management are selected for First-Level IPAD. The planned implementation includes 1 at 60% and 11 at 30%. See figures 2.3-1, 2.3-2, 2.3-3, and 2.3-4.

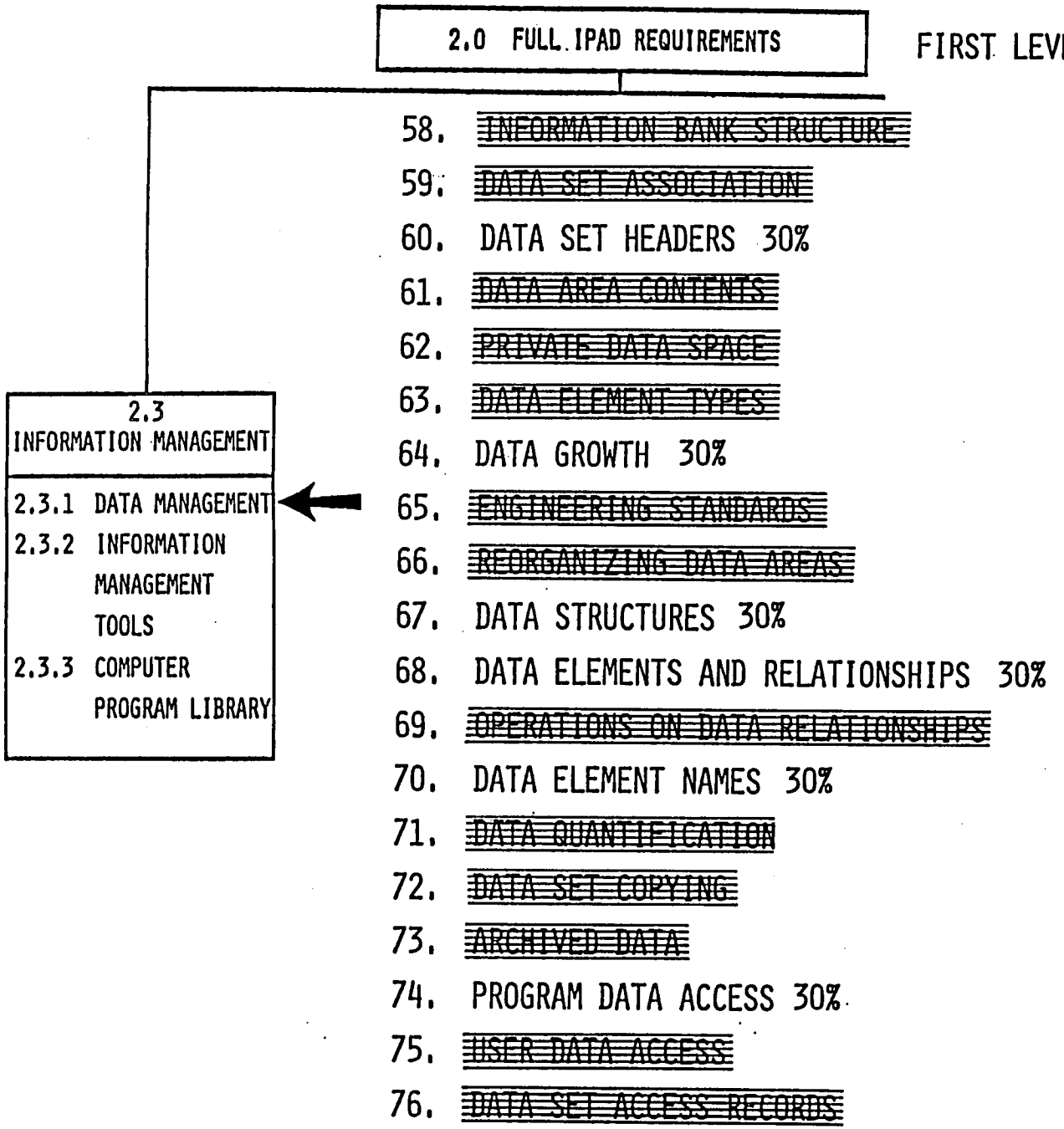


Figure 2.3-1 Data Management Requirements

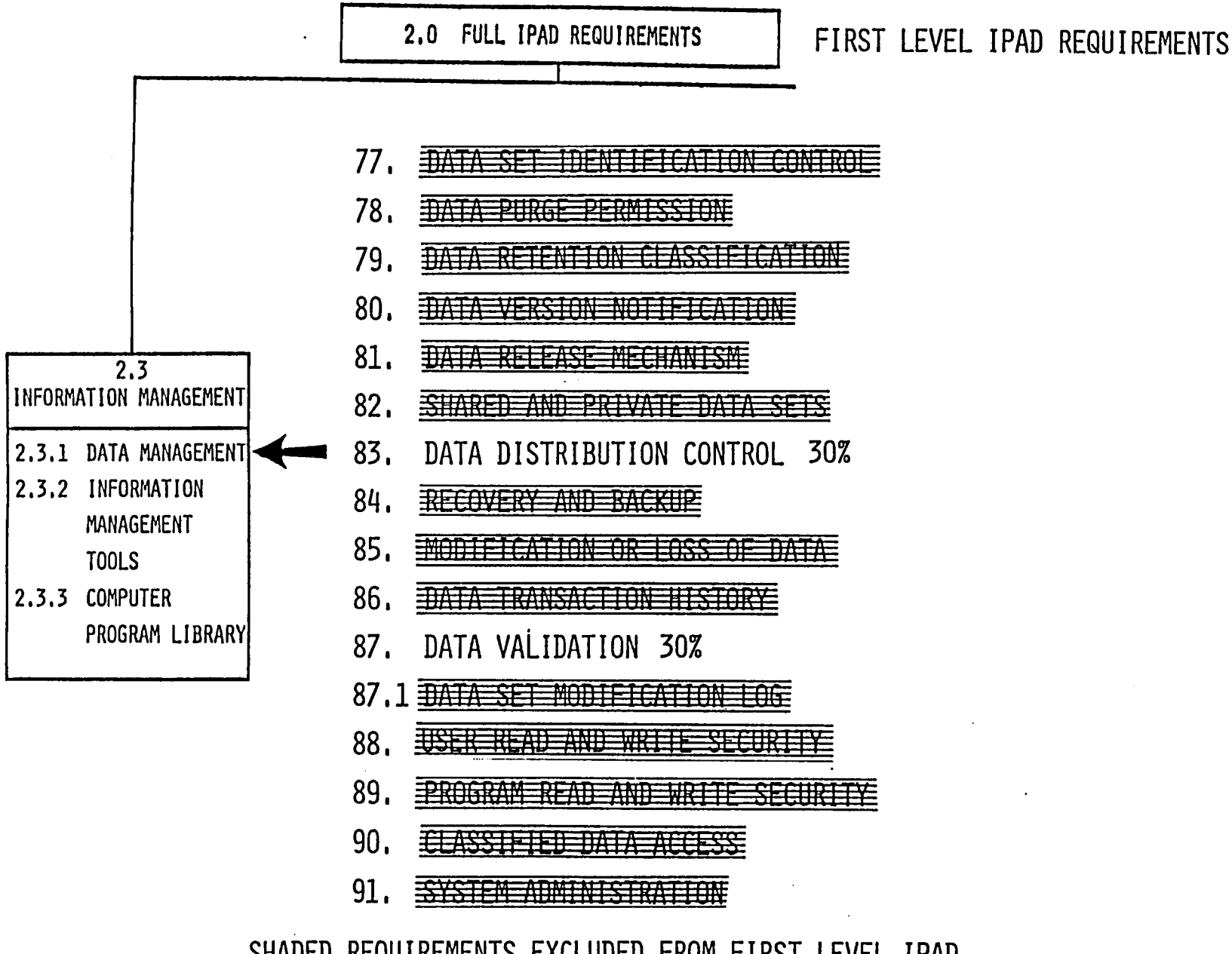


Figure 2.3-2 Data Management Requirements (cont'd)

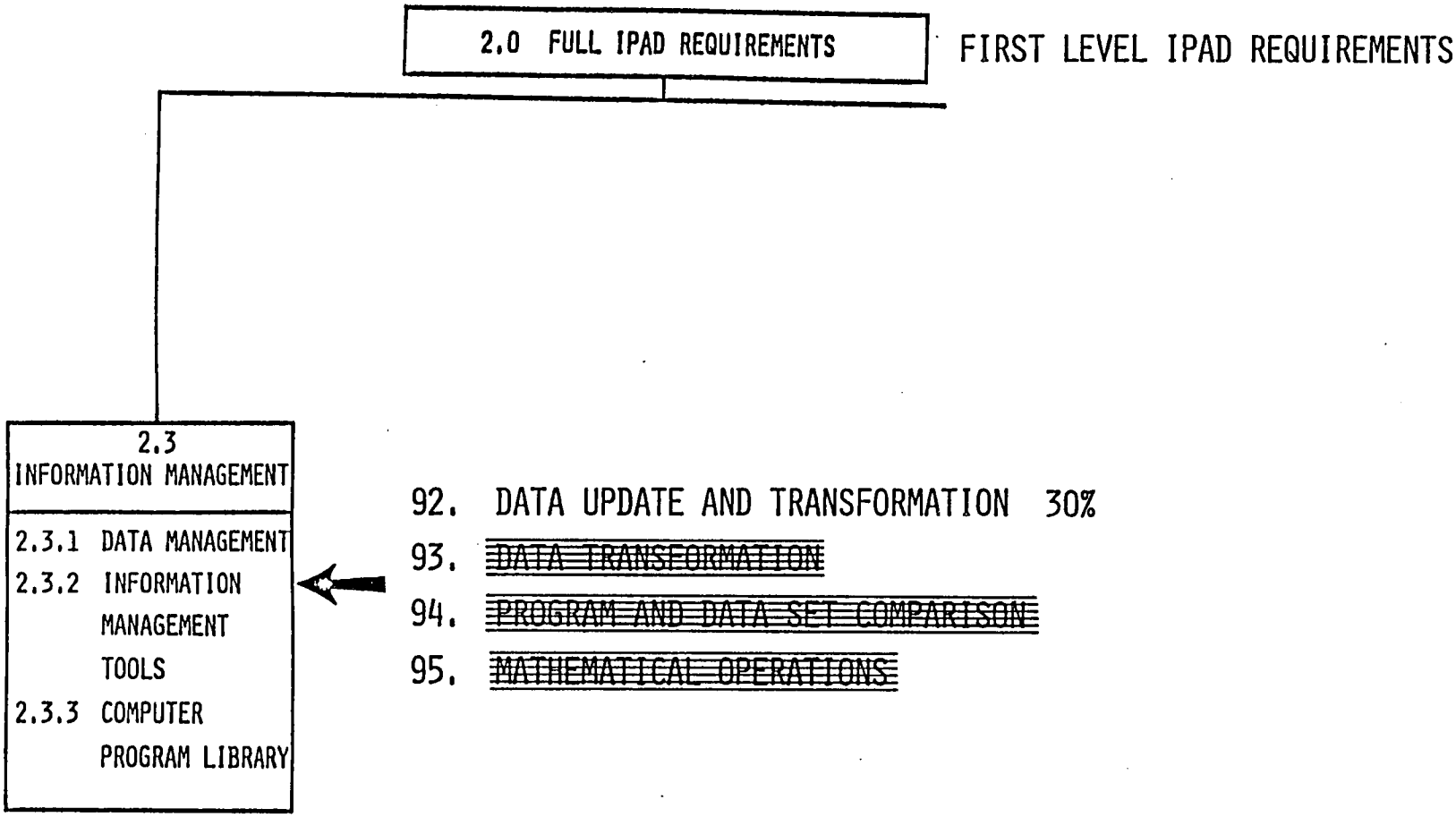


Figure 2.3-3 Information Management Tools Requirements

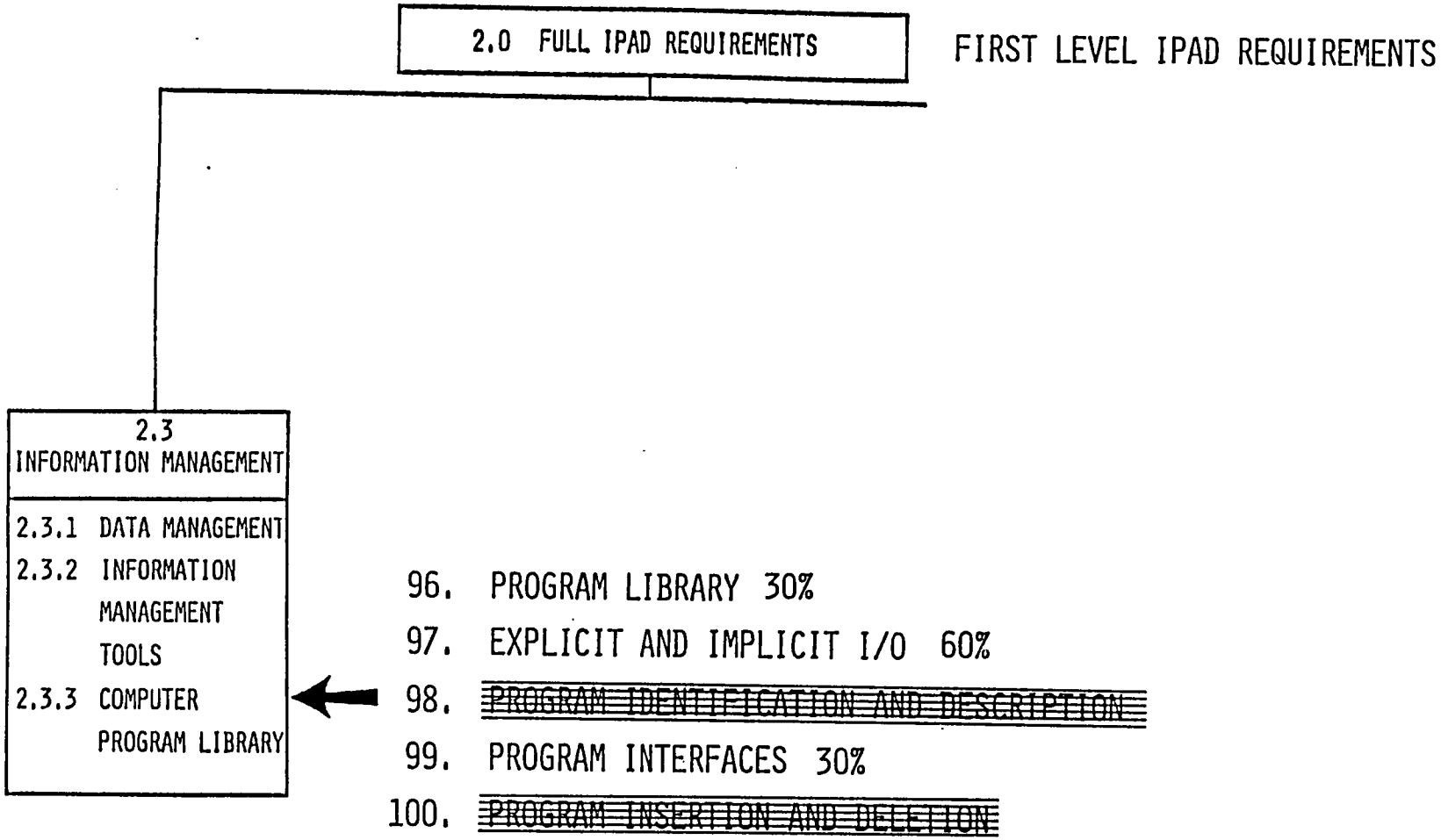


Figure 2.3-4 Computer Program Library Requirements

REQUIREMENT 60 DATA SET HEADERS

SOURCE 1.3/3.1.4.3, 1.3/3.2.2, 1.3/3.3.7.1, 1.3/3.1.1

DESCRIPTION

IPAD shall provide the capability to logically associate header data with each data set. Header data may be classified into three categories:

1. IPAD System Data - This data is required by IPAD to maintain data set integrity:

   a) Unique Data Set Name

   b) Creation Date

   c) Creation Time

   d) Storage Relationship

   e) Storage Format

   f) Other

2. Installation Control Data - This data is used by an installation to control data access and retention.

   a) Security - National, Company, Project and/or User Security Information.

   b) Owner I.D. - Creator of data set.

   c) Retention Classification - How long should data set be retained (see requirement 79).

   d) Version I.D. - The information is used if multiple versions of a data set are stored (see requirement 77).

3. Project/User Controlled Data - This data is used to determine how the data is to be applied.

   a) User Qualifier - For Example: Airplane Model, Case No., etc.

b) Approval Category - Prepared, Checked or Approved (see requirement 81).

c) Quality Categories - Preliminary or Final

d) Classification Code.

e) Project I.D.

f) Process I.D.

g) Other (such as date due).

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

For First-Level IPAD, definition, generation, and manipulation of data set headers is accomplished via user defined schema. The data set headers provide for configuration control of data by the users and allows for indirect access of data via a data set name. Automatic accessing of data by data set name directly is not supported.

REQUIREMENT 64 DATA GROWTH

SOURCE 1.3/4.0

DESCRIPTION

IPAD shall support an orderly growth of data set (elements, relationship formats) definitions within an IPAD information bank without impacting the availability of the existing information. In addition, IPAD shall support an orderly growth of occurrences of data corresponding to the definitions.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD supports an orderly growth of element and relationship definitions within an IPAD information bank without impacting the availability of the existing information. In addition, First-Level IPAD supports an orderly growth of occurrences of data corresponding to the definitions.

REQUIREMENT 67 DATA STRUCTURES

SOURCE SOW/5.2.1.1, SOW/5.2.1.2, 1.3/4.4, 1.3/4.3.4

DESCRIPTION

IPAD shall provide and support those data structures used by Engineering. The capability to have logical structure independent of physical structure shall be provided. In this case, alteration to the physical structure must not affect the user or his programs.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD supports a network and hierarchical logical data structure. The capability to have a logical structure independent of physical structure is provided. In this case, alterations to the physical structure does not affect the user or his programs.

REQUIREMENT 68 DATA ELEMENTS AND RELATIONSHIPS

SOURCE SOW/5.2.1.1, 1.3/4.1.2, 1.3/4.3.2

DESCRIPTION

IPAD shall provide the user with the capability to define data elements and to introduce relationships between them.

Data element definitions shall include such attributes as name, type (integer, real, character, vector, matrix, tensor, etc.), synonyms, textual definition, engineering use description, unit(s), default value, external representation format, etc.

A data relationship is a logical grouping of data elements, possibly expressed in terms of other relationships. The user shall have the capability of expressing relationships for the purpose of storing and retrieving data. Relationships will in general be expressed at the time of use, but it shall be possible for the user to define and store relationships for future usage.

Accompanying the data relationship shall be the ability for a user or a user's program to specify the format in which the data is to be delivered from IPAD or presented to IPAD. A format shall define such things as: display format (e.g., FORTRAN format capability), external media type, and external units (which if different from units defined with an element will cause unit conversion). Formats may be expressed at time of usage and may also be stored for future use. One format may be used in conjunction with several relationships.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD provides the user with the capability to define data elements and to introduce relationships between them.

Data element definitions include three attributes: name, type (integer, real, character, vector, matrix, tensor, etc.) and units.

A data relationship is a logical grouping of data elements. The user has the capability of expressing relationships for the

purpose of storing and retrieving data. It is possible for the user to define and store relationships for future usage.

Accompanying the data relationship is the ability for a user or a user's data description to specify the format in which the data is to be delivered from IPAD or presented to IPAD. A schema shall define such things as: display format (e.g., FORTRAN format capability) and external units. Schemas will be stored for future use. One schema may be used in conjunction with several applications.

REQUIREMENT 70 DATA ELEMENT NAMES

SOURCE 1.3/4.2.1, 1.3/4.4.1.1, 1.3/4.2.2

DESCRIPTION

Data element names shall be unique within the data area in which the elements are defined and in any of its dependent data areas. It shall be possible to designate data areas for which data element definitions are not allowed.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

In First-Level IPAD, data element names are unique within the schema in which the elements are defined.

REQUIREMENT 74 PROGRAM DATA ACCESS

SOURCE SOW/5.2.1.1, 1.3/4.4.2

DESCRIPTION

IPAD shall provide the ability for user programs to work within a subset of a data area or with data from more than one data area.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD provides the ability for user programs to work within a subset of a data base.

REQUIREMENT 83 DATA DISTRIBUTION CONTROL

SOURCE BCAC-NASA

DESCRIPTION

IPAD shall permit both automatic (IPAD initiated and controlled) and manual (IPAD user initiated and controlled) distribution of data and programs throughout the IPAD computer complex. IPAD shall retain knowledge of the location of and access control to all data and programs within the IPAD system.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD permits distribution of data and retains knowledge of the location of all data defined to IPAD.

REQUIREMENT 87 DATA VALIDATION

SOURCE 1.3/3.0, 1.3/3.3.6.2

DESCRIPTION

IPAD shall provide for validation of user data including a range of values check. The set of validation operations will be extendable and user definable. Validation will be performed on values when entered and on selected contents of a data set at user request.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD provides for type checking of display code or ASCII data. Type checking is performed on values when entered.

REQUIREMENT 92 DATA UPDATE AND TRANSFORMATION

SOURCE SOW/5.2.1.4

DESCRIPTION

The following update and transformation capabilities shall be provided:

a) Altering existing values and data structures, adding new data structures and values, and deleting old values and data structures.

b) Restructuring existing data by means of special commands, without loss of existing content.

c) Creating a file from information in the data base with data format specification by the user extending to the bit level.

d) Decomposing a file and inserting information into the data base with data format extending to the bit level.

e) Saving command sequences used to create or decompose files for subsequent execution.

f) Creating files for transfer to an external medium in any national standard, e.g., binary, BCD.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD provides the ability to add and delete data and data structures.

REQUIREMENT 96 PROGRAM LIBRARY

SOURCE 1.3/5.1, SOW/5.2.1.1

DESCRIPTION

IPAD shall provide for a single application program library which shall consist of programs in either source or executable form and which have been directly supplied by the user or generated by software processes.

Standards for program integration, data handling, and program catalog procedures shall be developed. The IPAD system shall check programs for conformity to these standards and shall not allow insertion of programs which do not meet these standards.

The IPAD computer program library shall be subject to the same requirements for security, integrity, version control, and access control as generally applied to the IPAD information bank.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

For First-Level IPAD, standards are provided for program integration, interfacing programs, and data handling. Protocol and procedures are provided. In addition, scenarios demonstrate program integration and interfacing programs with the IPAD data management system. There will be no management of programs (source or object) beyond that provided by the system.

REQUIREMENT 97 EXPLICIT AND IMPLICIT I/O

SOURCE 1.3/5.3, SOW/5.2.1, SOW/5.2.1.5

DESCRIPTION

It is required that IPAD support several modes of program interfaces with the information bank. The primary purpose is to make provisions which allow simple installation of existing application programs into IPAD.

IPAD must provide for installation of the following types of application computer program:

- Programs for which the contents of all input and output data sets are defined to IPAD and for which all data management is "implicit" (IPAD controlled).

- Programs for which the contents of some input and output data sets are defined to IPAD, and for which IPAD I/O is both "implicit" (IPAD controlled) and "explicit" (user program controlled). If data reformatting is needed for "explicit" I/O, IPAD shall support preparation of a data translation program.

- Programs for which the contents of input and output data sets are undefined to IPAD, and for which all data management is "explicit" (user program controlled).

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.

FIRST-LEVEL IMPLEMENTATION (PERCENT 60)

First-Level IPAD supports the following two modes of program interfaces with the information bank. The second mode allows simple installation of existing application programs into the IPAD prototype.

- Programs which are fully integrated into First-Level IPAD, access data from an IPAD data base via subroutine calls to IPIP. The data for these programs is defined and is under IPIP's management.

- Programs not integrated into First-Level IPAD process existing files without changes to the program itself. The user manages the headers for these files using IPIP, and performs any required file operations to process the data.

REQUIREMENT 99 PROGRAM INTERFACE

SOURCE SOW/5.1.27, 1.4/3.3.19

DESCRIPTION

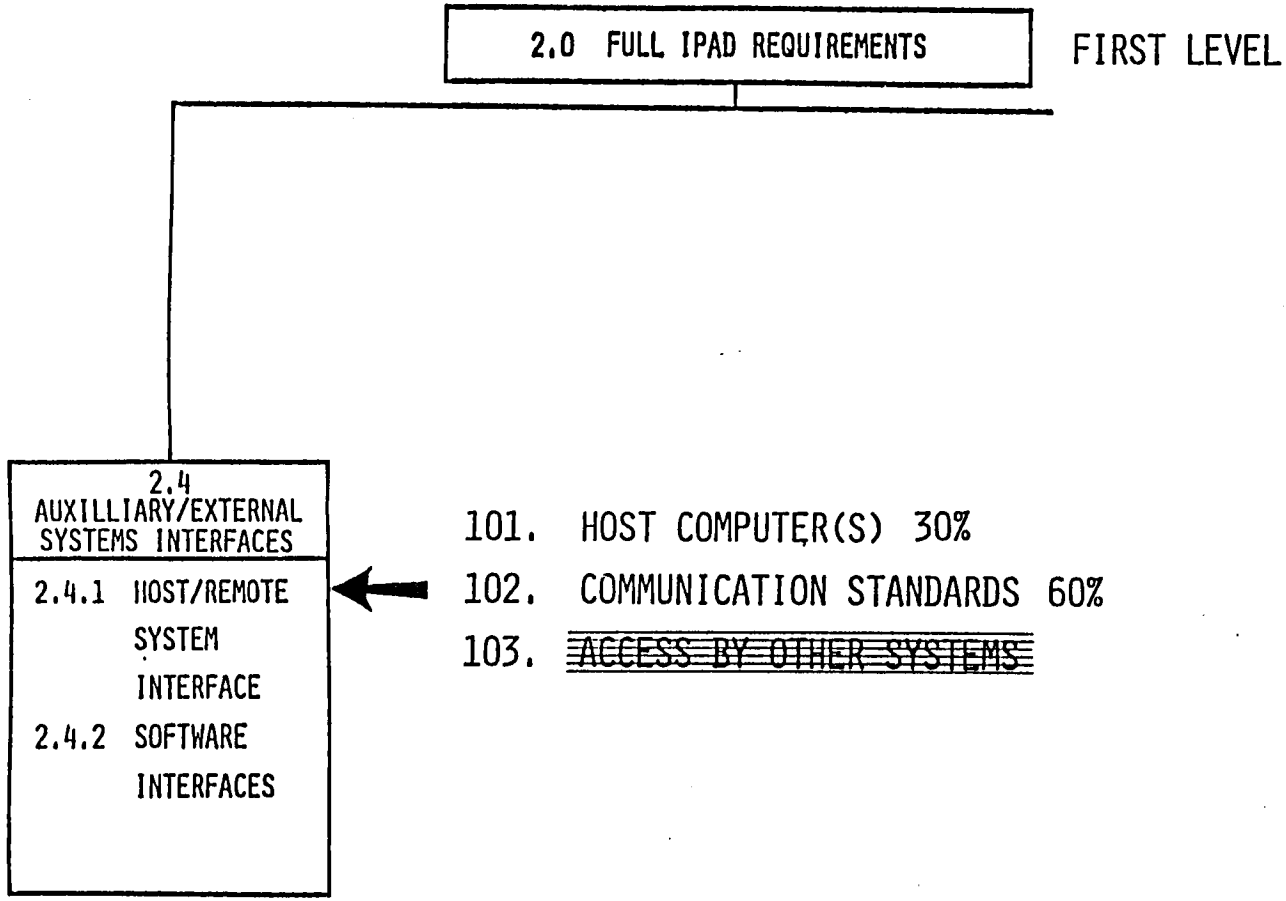
IPAD software shall include features and user aids to facilitate interfacing existing computer programs with each other. Such features shall make use of IPAD data transformation facilities (requirement 93). IPAD shall also supply user aids to facilitate integration of existing programs into IPAD. Such aids may include automatic identification of I/O statements in source programs and assistance in converting them to an IPAD compatable form.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD documentation includes procedures and examples demonstrating the interfacing of existing aerospace design computer programs with each other.

2.4 AUXILIARY/EXTERNAL SYSTEM INTERFACES

Three of the 5 requirements for interfacing systems to IPAD are selected for First-Level IPAD. The planned implementation includes 1 at 60% and 2 at 30%. See figures 2.4-1 and 2.4-2.



SHADED REQUIREMENTS EXCLUDED FROM FIRST LEVEL IPAD

Figure 2.4-1 Host/Remote System Interface Requirements

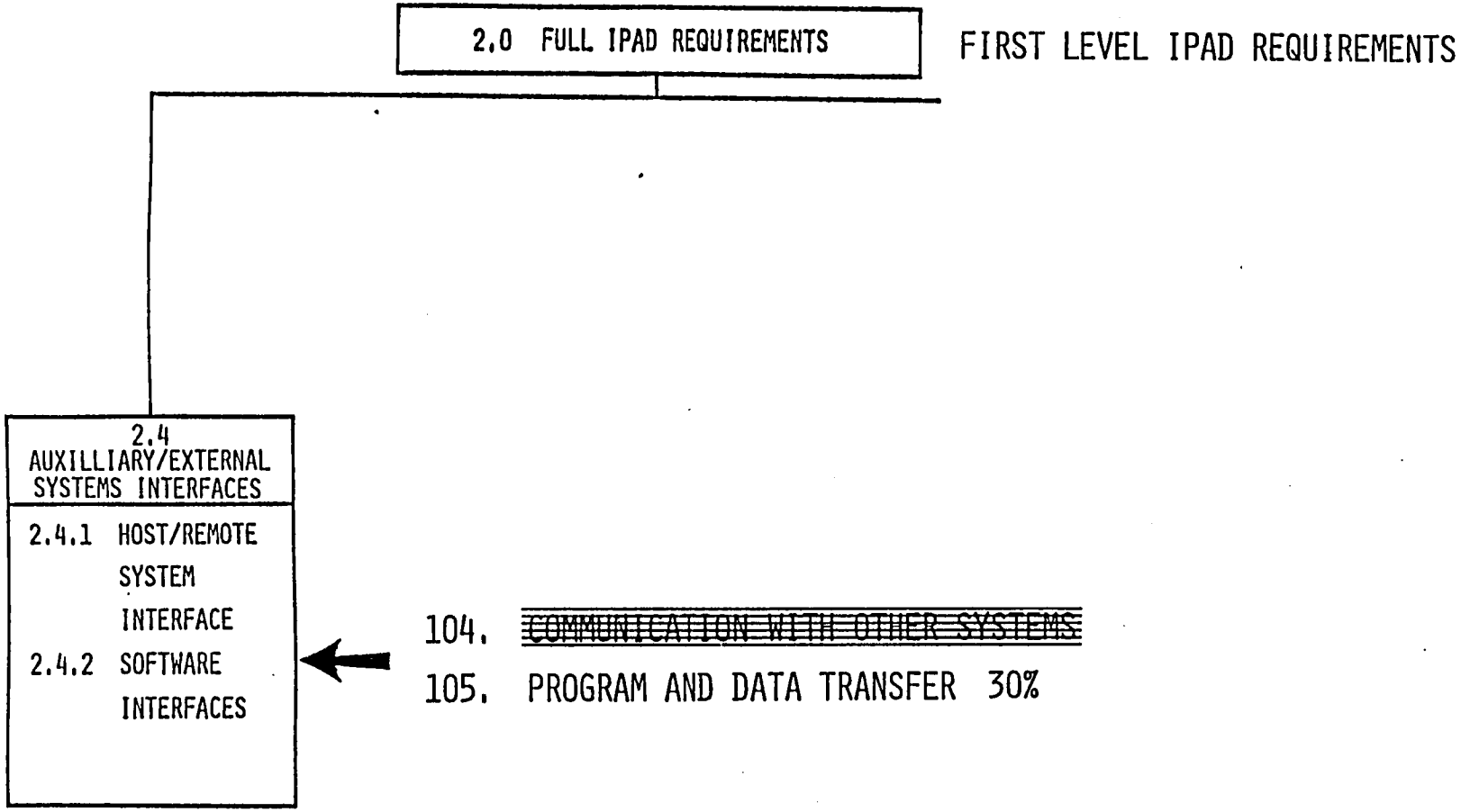


Figure 2.4-2 Software Interface Requirements

REQUIREMENT 101 HOST COMPUTER(S)

SOURCE SOW/5.3, SOW/5.3.2, 1.4/3.5.2, 1.3/3.4.2

DESCRIPTION

IPAD must be able to operate on either a single computer or on a distributed computer complex. The computing facility may be dedicated solely to IPAD use or IPAD may execute as part of a job mix. A computer complex may consist of CPU's with shared data storage units processing under single or multiple control and may include remotely connected computer facilities. The user interface to IPAD must be independent of the computing complex configuration although it may be restricted at some parts of the complex.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD operates on a two host computer complex connected by a high speed local network. All data managed by IPIP will reside at a central site computer but access will be provided to this data from the second host using the local network.

Executive functions and control will not be distributed. In general, the IPAD user is aware of the distributed nature of the system and his interface is dependent on the computing complex configuration.

Distribution transparency is not maintained for non-IPAD data or IPAD and non-IPAD functions, such as access to a subsystem or function which resides on another host.

REQUIREMENT 102 COMMUNICATION STANDARDS

SOURCE 1.3/3.4.3.1

DESCRIPTION

Communications standards should be selected to facilitate IPAD's communication between computing systems and between aerospace companies. Existing standards should be used whenever possible.

FIRST-LEVEL IMPLEMENTATION (PERCENT 60)

In First-Level IPAD, the local network uses a modified version of the ISO standard when specifying the layers of the communication protocol. First-Level IPAD specifies protocol standards for the local network. This is necessary because no standard currently exists for communications using the local network.

REQUIREMENT 105 PROGRAM AND DATA TRANSFER

SOURCE SOW/5.1.26, 1.4/3.3.10

DESCRIPTION

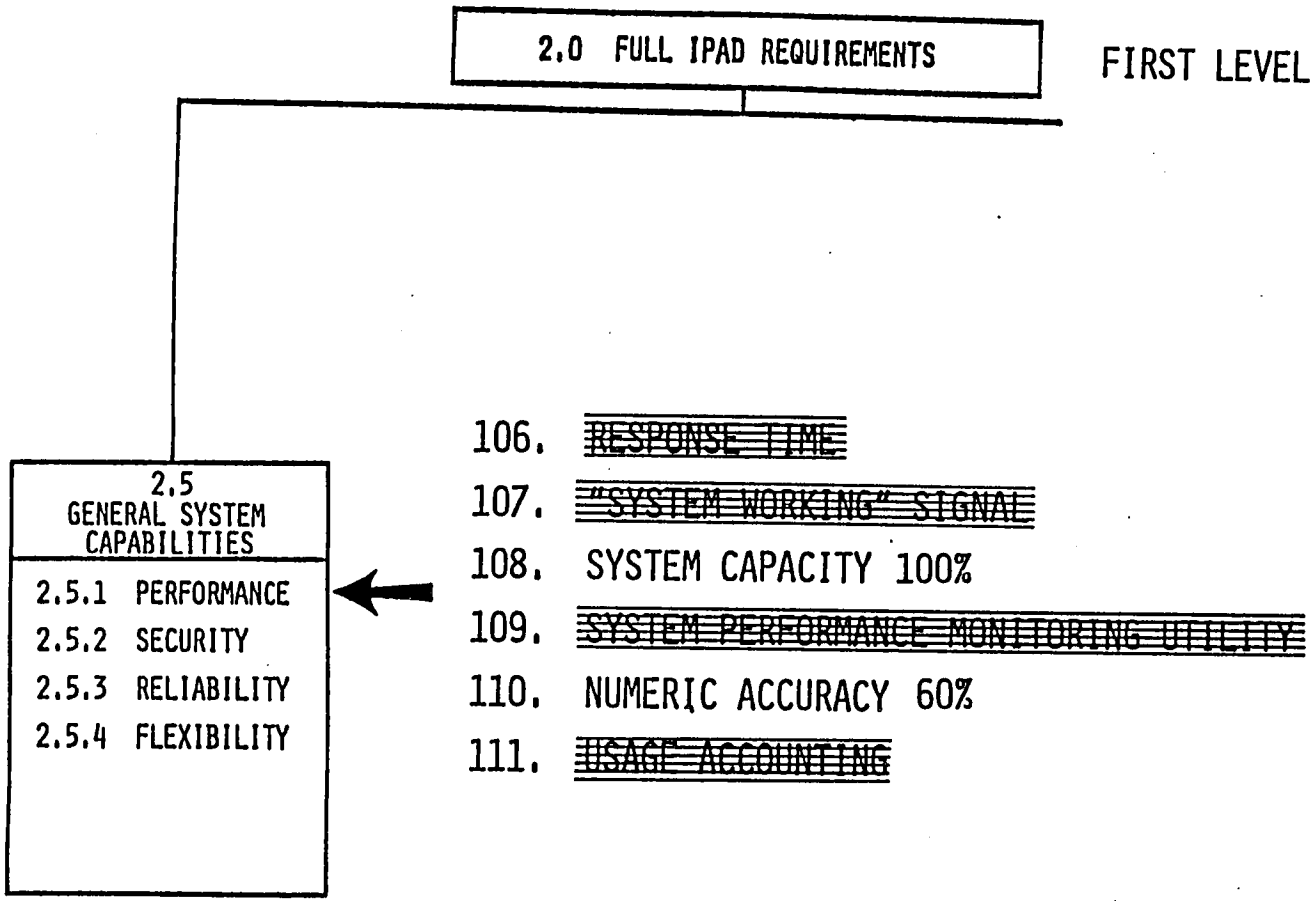
IPAD shall facilitate transfer of program modules, data, etc., between IPAD installations. Support software and user aids shall be provided to perform such data transfers and to account for differences in computer word sizes.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD supports transfer of data only in the form of character files. No resolution of different word sizes or other machine incompatibilities are made. Program modules are transmitted in source form only.

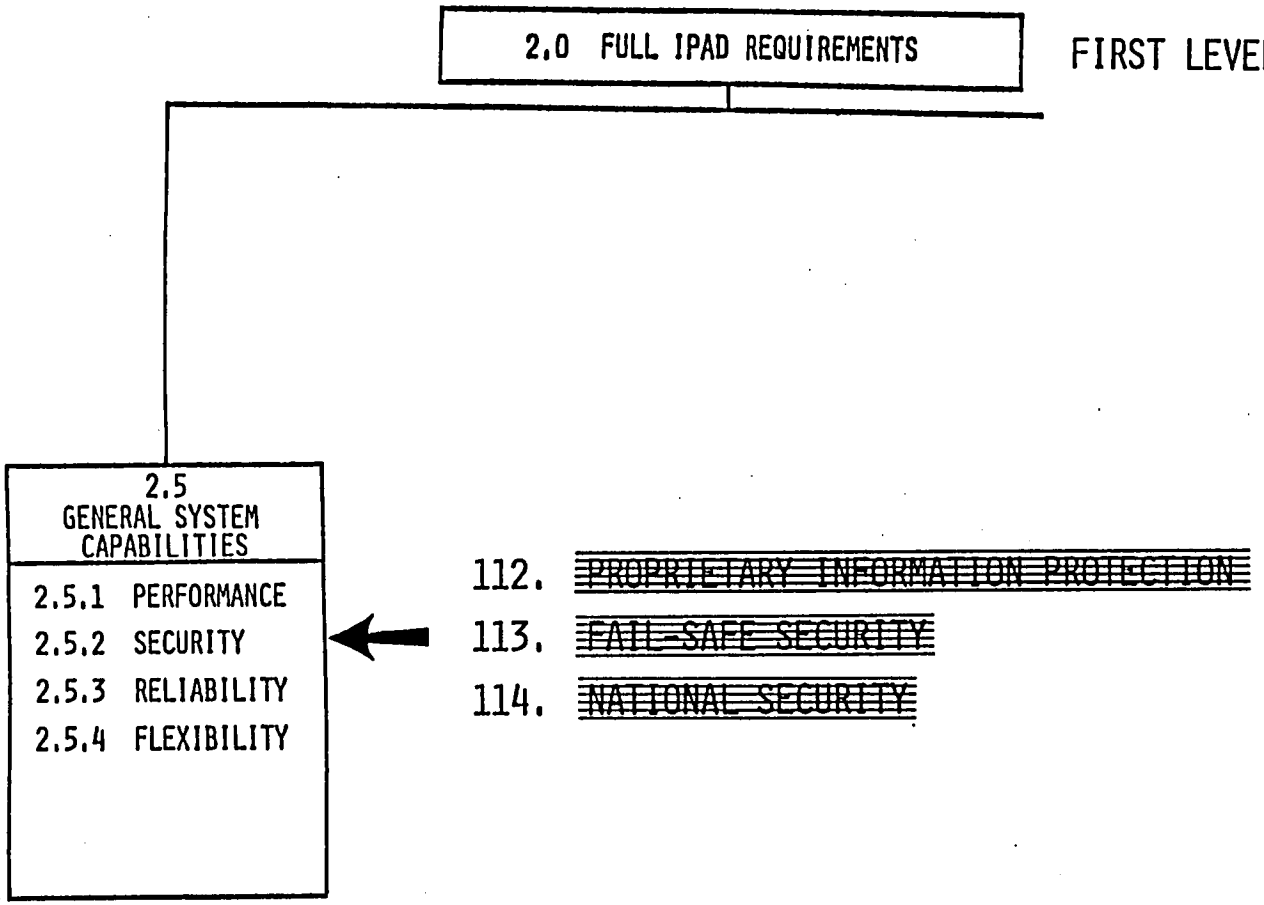
2.5 GENERAL SYSTEM CAPABILITIES

Five of the 13 general requirements are selected for First-Level IPAD. The planned implementation includes 2 at 100% and 3 at 60%. See figures 2.5-1, 2.5-2, 2.5-3, and 2.5-4.



SHADED REQUIREMENTS EXCLUDED FROM FIRST LEVEL IPAD

Figure 2.5-1 Performance Requirements



SHADED REQUIREMENTS EXCLUDED FROM FIRST LEVEL IPAD

Figure 2.5-2 Security Requirements

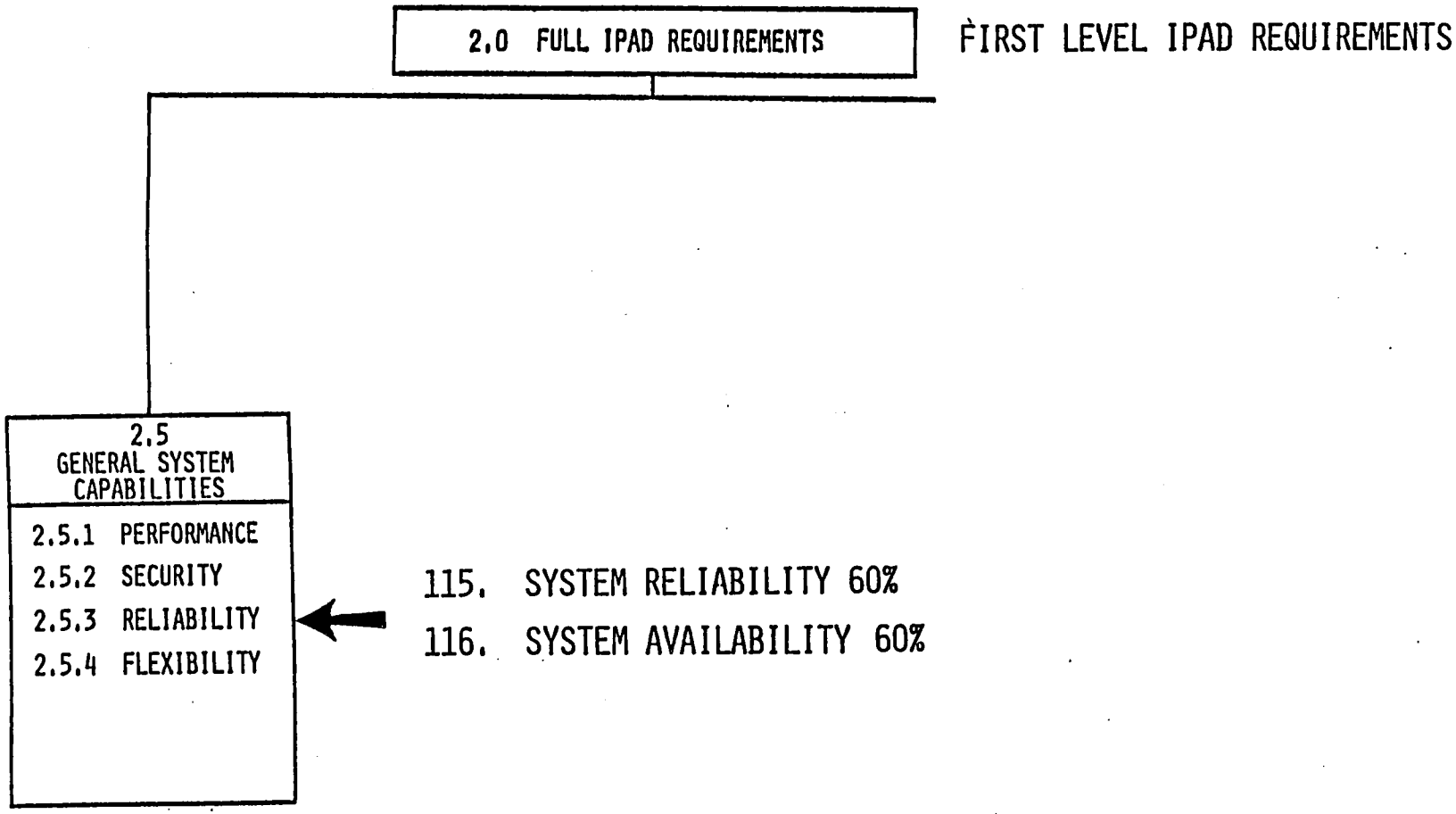


Figure 2.5-3 Reliability Requirements

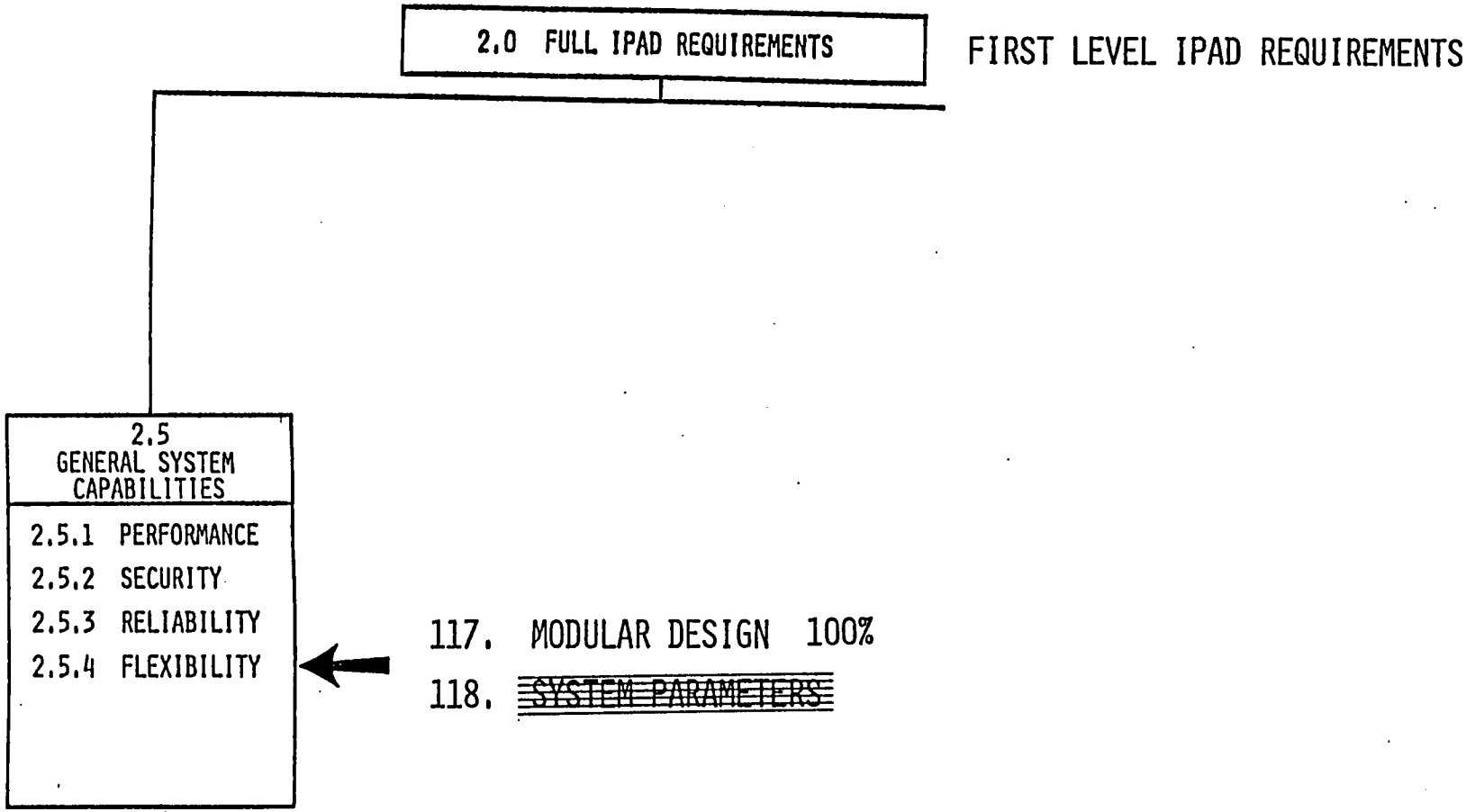


Figure 2.5-4 Flexibility Requirements

REQUIREMENT 108 SYSTEM CAPACITY

SOURCE SOW/5.1.1, 1.4/4.6.1, 1.4/2.1.2

DESCRIPTION

The IPAD System capacity shall be considered to be "hardware configuration limited" with no actual restriction placed on the IPAD System.

Capacity here refers to computer memory capacity, size of information bank, the number of interactive terminals simultaneously in use, etc.

Explanation: The capacities envisioned are very large. For example, the number of interactive terminals simultaneously in use is expected to be very much greater than 100, likely to exceed 400, and may grow to several thousand.

FIRST-LEVEL IMPLEMENTATION (PERCENT 100)

First-Level IPAD executive and network software puts no more stringent restrictions on the IPAD user than the hardware and vendor operating systems.

REQUIREMENT 110 NUMERIC ACCURACY

SOURCE 1.4/4.4.1

DESCRIPTION

The system shall have the ability to store numerical data with at least 10 significant digits and to perform arithmetic operations with no additional loss of accuracy other than that imposed by purely mathematical considerations.

FIRST-LEVEL IMPLEMENTATION (PERCENT 60)

The First-Level IPAD system has the ability to store numerical data with at least 10 significant digits. The precision of the computation (IPAD geometry display utility, IPIP, and AD-2000 postprocessor) is limited to that available on the host (hardware, software) selected by the user.

The hosts selected for First-Level IPAD implementation are the CDC CYBER 170/720 and the DEC VAX 11/780. The precision of integer and floating point calculations are as follows:

	CDC CYBER 170/720	DEC VAX 11/780
Integer	60 bits	64 bits
Floating Point		
Exponent	12 bits	8 bits
mantissa	48 bits (single precision)	55 bits (double precision)

Note: All integers and floating point mantissa include sign bit.

REQUIREMENT 115 SYSTEM RELIABILITY

SOURCE 1.4/3.1.3

DESCRIPTION

The reliability of the IPAD System, hardware, and operating system will be such that system reliability need not be a specific planning consideration for IPAD users or the system administrator.

FIRST-LEVEL IMPLEMENTATION (PERCENT 60)

Extensive review and testing of the IPAD prototype is done by the computing staff during system design and construction.

No computing system can be exhaustively tested to ensure that it is 100 percent reliable. This would require a test of every path through th system using all possible data cases. Instead, the computing staff tests each path through the system with sample data selected as test cases. Certain critical paths are more thoroughly tested than others. These paths are selected on the basis of the system design and the user scenarios developed by the engineering staff.

REQUIREMENT 116 SYSTEM AVAILABILITY

SOURCE 1.4/4.2.2

DESCRIPTION

During any consecutive four week period, the minimum average user availability for the IPAD system shall be 97.5% of the total available host computing time allocated to IPAD. The IPAD system is considered available when a user is able to productively perform his desired objectives.

FIRST-LEVEL IMPLEMENTATION (PERCENT 60)

First-Level IPAD and its components are placed under configuration control when made available to users. Such software is available to users at their request with availability limited only by the software reliability (see req. 115-102).

REQUIREMENT 117 MODULAR DESIGN

SOURCE 1.4/3.5.4, 1.4/2.1.5

DESCRIPTION

IPAD shall be designed so that the functional capabilities are modular, allowing a company to gradually adopt IPAD to their needs. Specialized interfacing facilities shall be provided by IPAD to aid users in designing interfaces to systems outside IPAD.

FIRST-LEVEL IMPLEMENTATION (PERCENT 100)

2.6 GRAPHICS

Three of the four graphics requirements are selected for First-Level IPAD. The planned implementation includes 1 at 100%, 1 at 60% and 1 at 30%. See figures 2.6-1 and 2.6-2.

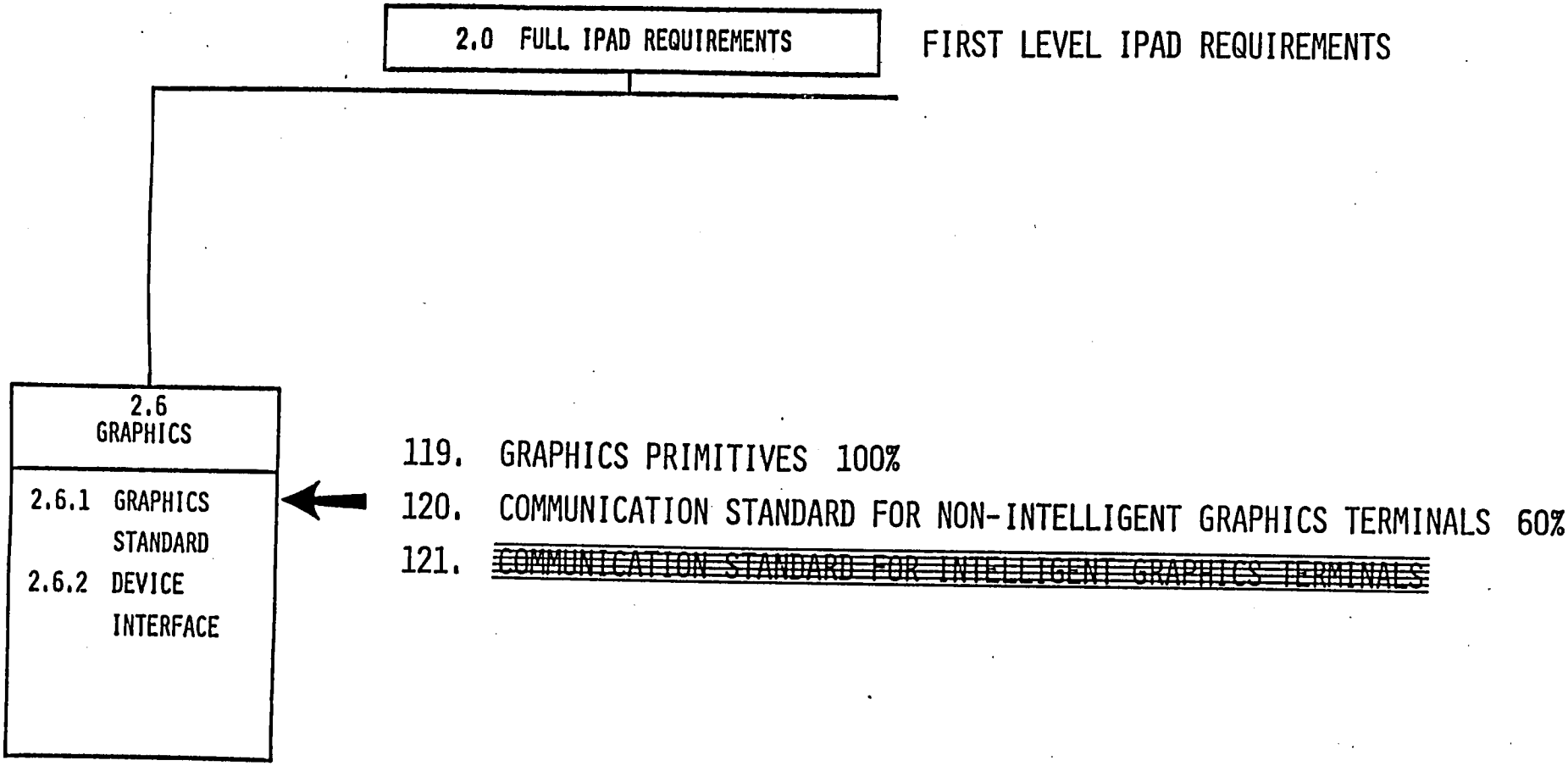


Figure 2.6-1 Graphics Standard Requirements

Figure 2.6-2 Device Interface Requirements

REQUIREMENT 119 GRAPHICS PRIMITIVES

SOURCE BCAC-NASA

DESCRIPTION

A standard graphics software package consisting of primitives which embody the concept of device independence will be provided in IPAD (similar to subroutine package being defined by SIGGRAPH). Examples of functions to be provided include:

1. Line drawing
2. Text drawing
3. Segments
4. View transformation
5. Attributes
6. Control
7. Input

FIRST-LEVEL IMPLEMENTATION (PERCENT 100)

REQUIREMENT 120 COMMUNICATION STANDARD WITH NON-INTELLIGENT TERMINALS

SOURCE BCAC-NASA

DESCRIPTION

IPAD shall establish standards for communication with dumb graphics terminals, which recognize coordinate data only, and provide for conversion of geometry data stored in IPAD's standard geometry format prior to transmitting them to such terminals.

FIRST-LEVEL IMPLEMENTATION (PERCENT 60)

First-Level IPAD provides a utility for display (on graphics devices supported by First-Level IPAD, see req. 122) of geometry data stored in IPAD standard geometry format.

REQUIREMENT 122 GRAPHICS INTERFACE SOFTWARE

SOURCE 1.4/3.1.1

DESCRIPTION

IPAD shall provide interface software for the following graphics devices:

Tektronics
VG3300
SC 4020
IBM 2250
763 Calcomp
Flatbed plotter
Scanning units
Digitizer
Microfilm plotter
Projection devices

This interface software shall provide the transformations and other capabilities required to make the graphics software independent of the graphics devices.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD provides interface software throgh GPGS-F for the following graphics devices:

	DEC VAX 11/780	CDC CYBER 170/720
Tektronics 4014	x	x
HP 7221 Pen Plotter	x	

This interface software provides the transformations and other capabilities required to make the graphics software independent of the graphics devices.

2.7 GRAPHICS RELATED TOOLS

Four of the 7 requirements for graphics related tools are selected for First-Level IPAD. The planned implementation includes 2 at 60% and 2 at 30%. See figures 2.7-1 and 2.7-2.

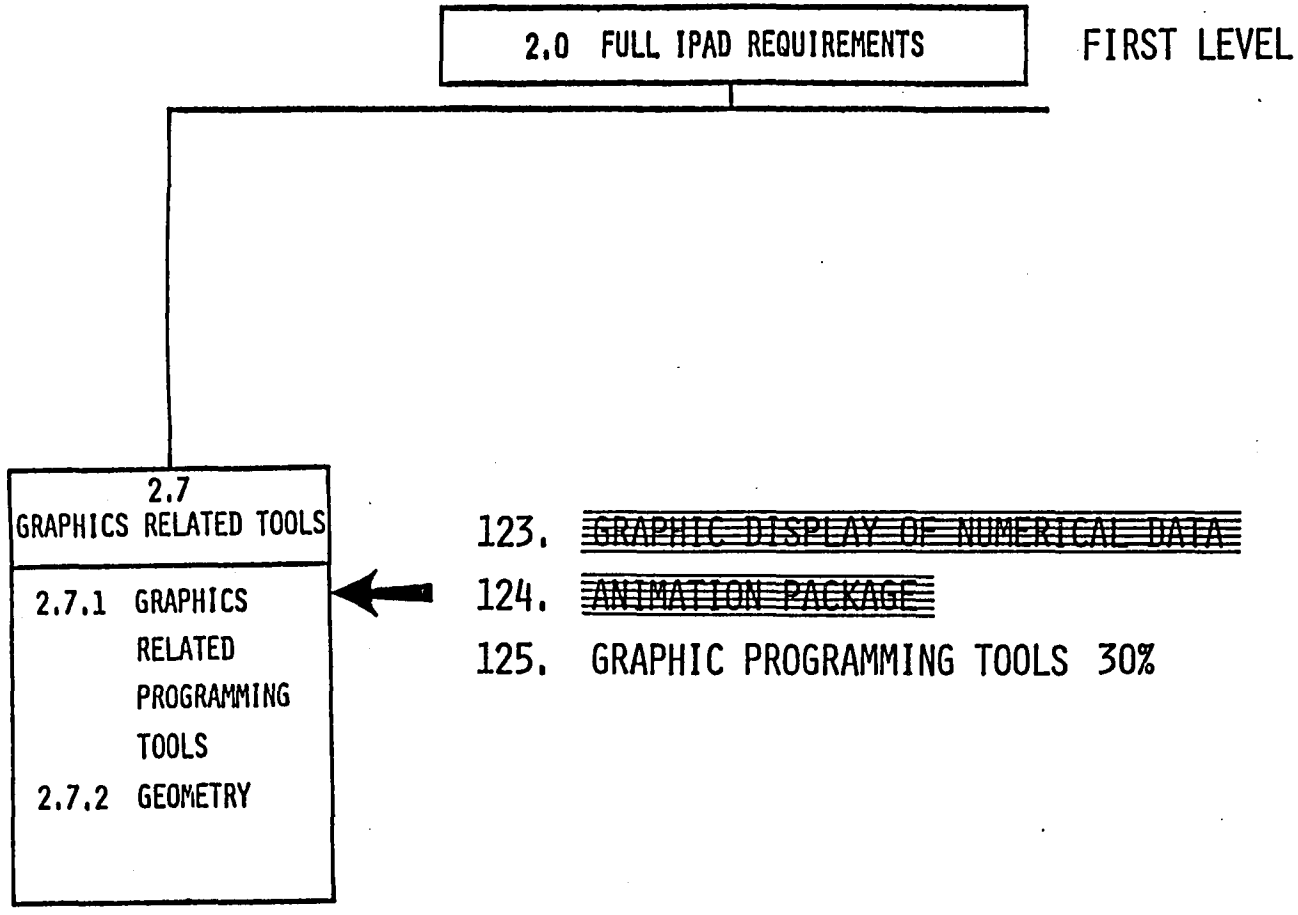
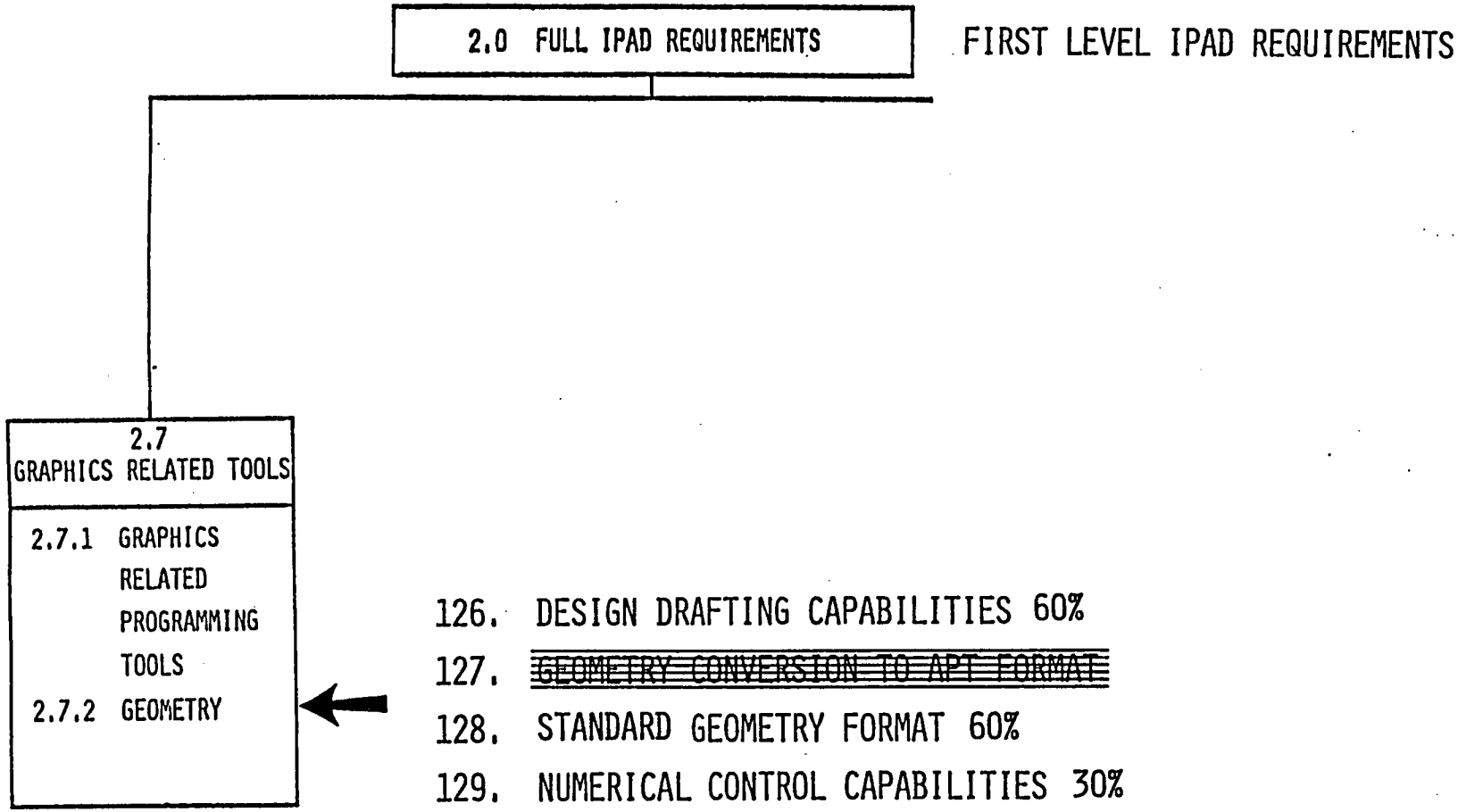


Figure 2.7-1 Graphics-Related Programming Tools Requirements



SHADED REQUIREMENTS EXCLUDED FROM FIRST LEVEL IPAD

Figure 2.7-2 Geometry Requirements

REQUIREMENT 125 GRAPHIC PROGRAMMING TOOLS

SOURCE 1.4/3.4.2, SOW/5.2.4.1

DESCRIPTION

Graphic programming tools shall be provided through support routines. These routines will allow development of a sophisticated graphics capability from simplified building blocks. The following functions shall be provided:

- Superposition of text horizontally, vertically, or at an angle.
- Menu and message display.
- Decoding of integer and floating point variables for graphic textual display.
- Numerical data display with editing capability.
- Change of drawing scale, two- and three-dimensional windowing and clipping.
- Shading, hidden surface and line removal.
- Dynamic write protection for any part of the screen.
- Ability to obtain hardcopy of screen contents (e.g., on plotter or hardcopy unit attached to graphical display device).
- Grid and graph generation, including labels and titles.
- Graphic INPUT (e.g., keyboard, lightpen, function button, digitizer)
- Variety of dashes for Vector plotting.
- Variable plot intensity, including blinking.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

Graphic programming tools for First-Level IPAD are provided through support routines. These routines allow development of a sophisticated graphics capability from simplified building blocks. The following functions are provided:

- Superposition of text horizontally, vertically, or at an angle.
- Menu and message display.
- Decoding of integer and floating point variables for graphic textual display.
- Change of drawing scale, two- and three-dimensional windowing and clipping.
- Ability to obtain hardcopy of screen contents (e.g., on plotter or hardcopy unit attached to graphical display device).
- Grid and graph generation, including labels and titles.
- Graphic INPUT device supported for First-Level IPAD (see req. 122).
- Variety of dashes for vector plotting.
- Variable plot intensity, including blinking.

REQUIREMENT 126 DESIGN DRAFTING CAPABILITIES

SOURCE 1.4/3.4

DESCRIPTION

IPAD shall provide the following CAD entities:

PLAN FORMS IN ANY PLANE OF SPACE

- Point
- Line
- Circle or circular arc
- Fillet
- Ellipse
- Hyperbola
- Parabola
- General conic
- Cubic spline
- Rectangle
- Triangle
- Hexagon
- Entity string

NON-PLANAR FORMS

- Cubic spline
- Surface of revolution
- Ruled surface
- Developed surface (flat pattern)

- Curve mesh surface
- Fillet surface
- Surface intersection curve
- Draft curve
- Surface edge curve

IPAD shall further provide the following CAD functions:

FUNCTIONS SUPPORTING GRAPHIC DEVELOPMENT

- Break away lines
- Generate array of entities
- Entity group
- Pattern of entities
- General notes
- Labels
- True position symbols
- Dimensioning (manual and automatic)
- Balloon labels
- 2D section properties
- 3D analysis
- Mirror entities
- Variable line fonts
- English/metric conversion
- Blank/unblank
- Delete
- Detail magnification
- z clipping/peeling
- View/depth modification

- Variable view point location (orthographic, auxiliary)
- Automatic scaling
- Plotter output
- Composite surfaces with the option for surface blending.
- Cross-sectioning island techniques.
- Interactive hidden line removal or truncation for "cleaned up" views.
- Display and allow modification of the definition (canonical) form of all entities.
- Entity selection for all functions by cursor position, sequence number, pointer or "all within diagonal points."
- Provide macro capability for capturing and naming a sequence of construction operations allowing that sequence to be invoked by name.
- Provide capability where any solid can be sliced by any plane or surface. The resultant cross-section can be used for the following functions: dimensions, analysis, cross-hatching, and further construction.
- Both 2D and 3D non-montonic splines.
- Data plot system including generation, naming, filing and recall of graphs and histograms.
- Provide capability to construct normal areas with trim options.
- Chamfer line with trim options.
- Auto chamfer/fillet capability for open and closed figures.
- Translate, rotate, duplicate with following facilities: 1) "Repeat" n times, 2) Include scaling, 3) Tool paths are included, 4) Depth is added to translation.
- Provide the means to define and display up to 32 simultaneous view areas controlled by user with auto rescale.
- Provide for "remembering" entities selected for a series of operations without forcing a reselection.

- User defined symbol or character set.
- Provide capability to go directly to point, line or arc from anywhere using K/B commands.
- Allow user to change display tolerance (for curves) to speed display generation.
- Lockout rejected entity until another entity has been selected.
- Provide FORTRAN COMMON to expand with added system capabilities without obsoleting old drawings.
- Provide extended spline analysis via line printer or CRT output (e.g., slope at each point).
- Provide calculator like capabilities including the use of named variables, evaluating expressions and functions to be input where numeric input only is now permitted.
- Provide extended analytic function including: CG, AREA, CURVE LENGTH, distance between entities, etc.
- Provide loft conic.
- Allow a BASIC DIMENSION or REFERENCE BLOCK to be placed around any drafting LABEL or DIMENSION.
- Provide automatic text arrow control for linear dimension based on origin selection.
- Treat a set of contiguous curves as a single curve for purposes of surface definition, machining applications and construction.
- Associative graphics geometry data base which include the following relationships: inclusion, causality, and connectivity.
- Character recognition to input system commands with "teach" mode.
- Provide for data unit having the attribute which when changed causes the change to be reflected throughout the data base for all instances where it is used.
- Within a macro, provide FORTRAN capabilities such as GOTO, IF, and statement labelling.
- Provide batch mode capability.

- Provide capability for working in different coordinate systems, e.g., wing to body.
- Find slope and curvature of any curve at a specified point.
- For any 3D curve, given 2 coordinates, find the 3rd coordinate nearest the cursor position.
- Provide chord-height-tolerance point matrix for any curve.
- Allow any curve to be generated from coefficient inputs.
- Provide annullment of curves, surfaces, and volumes (resultant curves must be continuous) e.g., a window "subtracted" from a surface.
- Define a 3D curve as 2 2D curves in different views.
- Provide the capability to label entities as they are created, e.g., P35 = X Y Z.
- Provide both function button and mnemonic input modes.

FIRST-LEVEL IMPLEMENTATION (PERCENT 60)

First-Level IPAD provides its CAD functions using the design drafting system AD-2000 with the geometry output transformed into the IPAD geometry format.

REQUIREMENT 128 STANDARD GEOMETRY FORMAT

SOURCE 1.3/3.4.3.2

DESCRIPTION

IPAD shall provide a standard geometry format. The entities supported by IPAD will include those recommended by ANSI Y14.26.1. IPAD shall include ways to generate elements and shall allow a nonassociative coefficient format. The IPAD standard format should adhere to the following:

a) Be restricted to bounded geometry in parametric form;

b) Accommodate new element types and geometry techniques as they are developed;

c) Operate in multiple dimensions (e.g., 2D or 3D) according to the needs of the user;

d) Include a hierarchical structure for relating data.

IPAD shall include the ability to transform between its standard geometry format and the Y14.26.1 standard for communication. IPAD will allow the representation of entities in nonparametric form but will not support transformation between parametric and nonparametric representations.

FIRST-LEVEL IMPLEMENTATION (PERCENT 60)

First-Level IPAD provides a standard geometry format. The entities supported are listed below, some of which are recommended by ANSI Y14.26.1. The standard format will adhere to the following:

a) Be restricted to bounded geometry in parametric form:

Parametric form: (x(t),y(t));(x(u,v),y(u,v),z(u,v))

b) Accommodate new element types and geometry techniques as they are developed;

c) Operate in multiple dimensions (e.g., 2D or 3D) according to the needs of the user;

d) Include a hierarchical structure for relating data.

First-Level IPAD includes the ability to reduce the extended geometry to the Y14-26.1 standard for communication.

Supported entities are:

BASIC ENTITIES

Points
Lines
Planes

CURVES

Conics
Cubic Splines
Quintic Splines
Rational Cubics

SURFACES

Bicubic Patch
Biquintic Patch
Ruled Surface
Developed Surface
Surface of Revolution
Coon's Patch

REQUIREMENT 129 NUMERICAL CONTROL CAPABILITIES

SOURCE 1.4/3.4

DESCRIPTION

The system shall provide the following NC capabilities.

- Constrain CL output to the configuration supplied by the MULTAX APT statement in support of 4 and 5-axes machining.
- Allow any postprocessor command to be inserted, for inclusion in the CLFILE, after each complete tool path.
- Display approximate machining time on demand for every complete tool path, or all tool paths generated.
- Provide CLFILE editor.
- Provide circular interpolation, if applicable, for any Pocket/Profile or /Lathe finish paths in which lines and arcs are the only entity types.
- Provide separate path generation with optional separate tool for 3-axis and 5-axis contouring to allow fewer paths and larger tolerance.
- Buffer Pocket/Profile/Lathe data so that the number of approximating segments is limited only by disk size.
- Allow user to enter a secondary feedrate statement when cornering. (This will override any automatic system generated feed rate).
- Provide for machining around bosses while in the lace mode of 3-axis and 5-axis end cutting.
- Allow a rough distance to be kept while in the 3-axis or 5-axis end cutting modes.
- Allow machining the resultant of any curve projected to any surface in either the 3-axis or 5-axis end cutting modes.

- Provide continuous check of cutter interferring with walls while machining a region bounded by surfaces in the 5-axis end cutting mode.
- Provide graphic lathes module with the following major functions: TURN, FACE, BORE, CONTOUR, GROOVE, TAPER, THREAD, TOOL.
- Provide dynamic tool display and positioning for cut vector insertion/modification or LATHE check surface creation.
- Place direction arrowhead on tool path display.
- Allow accessing individual cut vectors in order to modify, delete, or insert cut vectors.
- Provide a choice of tangent, secant, or chordal approximation for all curves used in pocket, profile, or lathe path generation.
- Provide INTOL and/or OUTTOL approximation for all surface used in 3-axis and 5-axis contouring.
- Incorporate the APT MACRO capability.
- Surface display control including number of paths, fineness and direction of path.
- Provide 10 standard APT vector definitions and display same with an arrowhead indicating direction.
- Provide the 7 standard APT plane definitions, planes are displayed as infinite entities.
- Provide standard APT definitions for surface and solids including: sphere, cylinder, core, torus, hexahedron, spheroid, ellipsoid, circular rod and toroid.
- The means to define the intersection of a curve and a surface (point x,y,z) also the direction cosines of the normal at that point.
- Provides deep hole chip removal sequence; user defined drill cycle; piercing operation; G80 drill cycle output; 3,4,5 axis point-to-point operations.
- Provides user choice of simple or complex analysis; handles pockets of any depth and any planar bottom; provides cornering feedrate control.

- Provide option to specify number of paths for display, allow for a pause to insert tool path motion, continue or quit and save.

FIRST-LEVEL IMPLEMENTATION (PERCENT 30)

First-Level IPAD supports NC functions with the design dratting system AD-2000.

3.0 REFERENCES

IPAD Document D6-IPAD-70012-D, "Integrated Information Processing Requirements," The Boeing Company, Contract NAS1-14700.

IPAD Document D6-IPAD-70013-D, "User Requirements," The Boeing Company, Contract NAS1-14700.

IPAD Document D6-IPAD-70040-D, "IPAD Requirements," The Boeing Company, Contract NAS1-14700.

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APPENDIX A

REQUIREMENTS IMPLEMENTATION BY IPAD LEVEL

The IPAD requirements from document D6-IPAD-70040-D are listed with columns at the right showing the approximate percent of the full requirement that is recommended for implementation at three IPAD user levels. First-Level IPAD user requirements implementation are selected by a team composed of IPAD engineering and computing staffs. Second and third level IPAD user rquirement implementation are selected by the IPAD engineering staff and are described in volumes 2 and 3 (D6-IPAD-70016-D-2 and -3) respectively. These levels are recommended as logical extension of the IPAD system.

		% of REQUIREMENT AT IPAD LEVEL		
		First	Second	Third
USER INTERFACE REQUIREMENTS				
1	User Language	30	100	100
2	User Skill Levels	30	30	30
3	Error Diagnostics	30	30	30
4	Command Language Functions	0	30	60
5	User Aids	0	0	0
6	Command Language	30	100	100
7	Access to Host O/S Function	0	60	100
8	Command Prompts	30	60	60
9	User Access Control	0	60	60
10	Exit Reports	0	0	30
11	Query Language	30	60	60
12	Header Data Query	30	60	60
13	Management Query Language	100	100	100
14	Utility Programs	0	30	30
15	Edit Utility	0	0	100
16	Documentation Utility	0	0	0
17	Reporting Utility	0	0	0
18	Menu Building Utility	0	60	60
19	Organization List Utility	0	0	0
20	Mailing List Utility	0	0	0
21	Message Utility	0	60	100
22	Document Reference Utility	0	0	0
23	Program Performance Monitoring Utility	0	0	0
24	Learning Utility	0	0	0
25	On-Line Instruction Utility	0	0	0
26	User Assistance Utility	0	0	0
27	User Interface Description Utility	0	0	0
28	Program Debugging Utility	0	0	30
29	Command Sequence Interpretation Utility	0	60	60
30	Interactive, Batch, and Program Commands	30	60	60
31	Interactive Terminals	60	100	100
32	Satellite Computer Support	0	0	0
33	Interrupt and Resume Capability	0	30	60
34	Batch Job Processing	0	30	60
35	Checkpoint and Restart Capability	0	0	0
36	Conference Viewing of Data	0	0	0
37	User Priorities	0	0	0
38	Standard Limiting Response Time	0	0	0
39	User Identification	0	100	100

40	Unacceptable User Identification	0	0	0
41	Password Protection	0	100	100
42	Password Control	0	0	60
43	User Classification Display	0	0	0
43.1	User Absence and Reassignment Control	0	0	0

DESIGN SUPPORT AND CONTROLS REQUIREMENTS

44	Process Planning and Definition	0	30	30
45	Job Preparation	0	30	60
46	Job Execution and Monitoring	0	30	60
47	Dynamic Reference to Data	30	30	30
48	Process Reports	0	0	0
49	Information Release	0	100	100
50	Project Planning	0	60	60
51	Management Support	0	30	30
52	Resource Reports	0	0	0
53	Subtask Monitoring	0	30	60
54	Subtask Modification	0	30	60
55	Project Resource Monitoring	0	60	100
56	Project Schedule Monitoring and Control	0	30	60
57	Optional Automatic Reporting	0	0	0
57.1	Application Program Certification	0	0	100
57.2	User Activity Checklist	0	0	100

INFORMATION MANAGEMENT REQUIREMENTS

58	Information Bank Structure	0	100	100
59	Data Set Association	0	60	60
60	Data Set Headers	30	100	100
61	Data Area Contents	0	100	100
62	Private Data Space	0	100	100
63	Data Element Types	0	100	100
64	Data Growth	30	60	60
65	Engineering Standards	0	0	0
66	Reorganizing Data Areas	0	0	100
67	Data Structures	30	60	60
68	Data Elements and Relationships	30	60	60
69	Operations on Data Relationships	0	100	100
70	Data Element Names	30	100	100
71	Data Quantification	0	0	0
72	Data Set Copying	0	100	100
73	Archival Data	0	0	0

74	Program Data Access	30	30	100
75	User Data Access	0	100	100
76	Data Set Access Records	0	100	100
77	Data Set Identification Control	0	100	100
78	Data Purge Permission	0	100	100
79	Data Retention Classification	0	0	0
80	Data Version Notification	0	100	100
81	Data Release Procedures	0	100	100
82	Shared and Private Data Sets	0	30	30
83	Data Distribution Control	30	60	60
84	Recovery and Backup	0	100	100
85	Modification or Loss of Data	0	0	0
86	Data Transaction History	0	0	0
87	Data Validation	30	30	30
87.1	Data Set Modification Log	0	100	100
88	User Read and Write Security	0	30	100
89	Program Read and Write Security	0	30	100
90	Classified Data Access	0	30	100
91	System Administration	0	60	60
92	Data Update and Transformation	30	60	60
93	Data Transformation	0	0	0
94	Program and Data Set Comparison	0	0	0
95	Mathematical Operations	0	30	30
96	Program Library	30	60	100
97	Explicit and Implicit I/O	60	60	60
98	Program Identification and Description	0	0	0
99	Program Interface	30	60	60
100	Program Insertion and Deletion	0	100	100

AUXILIARY/EXTERNAL SYSTEM INTERFACES REQUIREMENTS

101	Host Computer(s)	30	100	100
102	Communication Standards	60	100	100
103	Access by Other Systems	0	0	0
104	Communications with Other Systems	0	0	0
105	Program and Data Transfer	30	30	30

GENERAL SYSTEM CAPABILITIES REQUIREMENTS

106	Response Time	0	0	0
107	"System Working" Signal	0	0	0
108	System Capacity	100	100	100
109	System Performance Monitoring Utility	0	60	60

110	Numeric Accuracy	60	60	60
111	Usage Acounting	0	0	30
112	Proprietary Information Protection	0	0	0
113	Fail-Safe Security	0	0	0
114	National Security	0	0	0
115	System Reliability	60	60	60
116	System Availability	60	60	60
117	Modular Design	100	100	100
118	System Parameters	0	0	100

GRAPHICS REQUIREMENTS

119	Graphics Primitives	100	100	100
120	Communication Standard for Non-Intelligent Graphics Terminals	60	60	60
121	Communication Standard for Intelligent Graphics Terminals	0	30	60
122	Graphics Interface Software	30	30	60

GRAPHICS RELATED TOOLS REQUIREMENTS

123	Graphic Display of Numeric Data	0	0	0
124	Animation Package	0	0	0
125	Graphic Programming Tools	30	60	60
126	Design Drafting Capabilities	60	60	60
127	Geometry Conversion to APT Format	0	0	0
128	Standard Geometry Format	60	100	100
129	Numerica Control Capabilities	30	30	30