NASA Contractor Report 2985

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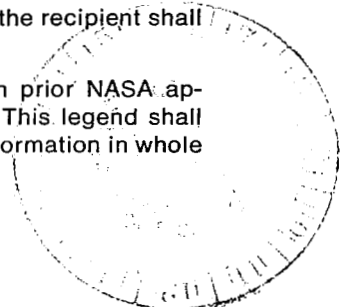
Development of Integrated Programs for Aerospace-Vehicle Design (IPAD) - IPAD User Requirements

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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 2984   Integrated Information Processing Requirements (D6-IPAD-70012-D)

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These Boeing engineers, managers, and computer specialists contributed directly to the development of the document: E. Chang, H. A. Crowell, R. L. Dreisbach, S. H. Gadre, D. D. Meyer, C. D. Mounier, D. D. Redhed, J. W. Southall, and the IPAD computing team.

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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 (U.S. to S.I.) is included in appendix C.

CONTENTS

1.0 SUMMARY

This document presents the IPAD requirements which address the user's functional needs. This document and others listed in the Foreward are used to produce the IPAD requirements.

The user's basic needs are those connected with the generation, modification, storage, retrieval, communication, reporting, and protection of information. The running of computer programs plays an integral role in the generation and manipulation of information.

In addition to the data manipulation considerations, controls on the system and the information are required.

Human needs must be addressed and the requirements are designed to accommodate the individuality of users and inspire acceptance and confidence by both the designers and technical managers. Learning is an important human need which is also addressed.

Individual company requirements are considered by providing flexibility where appropriate, and also by recognizing the need for step by step implementation.

Frequently used, specific needs relative to the product design process are recognized and listed as a set of utilities including CAD/CAM needs.

2.0 INTRODUCTION

The Integrated Programs for Aerospace-Vehicle Design (IPAD) system is envisioned to be a total system, oriented to the support of the product design process. The system design must address the following major requirements:

Integrated information processing requirements (CR 2984)

User requirements (this document)

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2.1 FORMAT

Each requirement in this document is expressed in three parts in the following manner.

Requirement No. xx-x: Contains a statement of a problem that IPAD design must address

Explanation (Optional--included if justified): Contains the reasons and basic intent of the requirement

Suggestions (optional--included if justified): Contains suggestions for implementation to illustrate the requirement

In general, the suggestions represent ideas that have been developed during the process of formulating the requirements and may prove helpful. In some cases they represent the acceptable level of "user difficulty" in using IPAD and in this respect need to be addressed. Alternate, more efficient approaches which achieve the same end result as viewed from a level of "user difficulty" criteria may be substituted.

Figure 1 illustrates the relationship of this document to other documents developed in task 1 of the IPAD program.

REFERENCE DESIGN PROCESS
CR 2981

PRODUCT MANUFACTURE
INTERACTIONS WITH THE
DESIGN PROCESS
CR 2982

PRODUCT PROGRAM
MANAGEMENT SYSTEMS
CR 2983

INTEGRATED INFORMATION
PROCESSING REQUIREMENTS
CR 2984

IPAD USER REQUIREMENTS
CR 2985
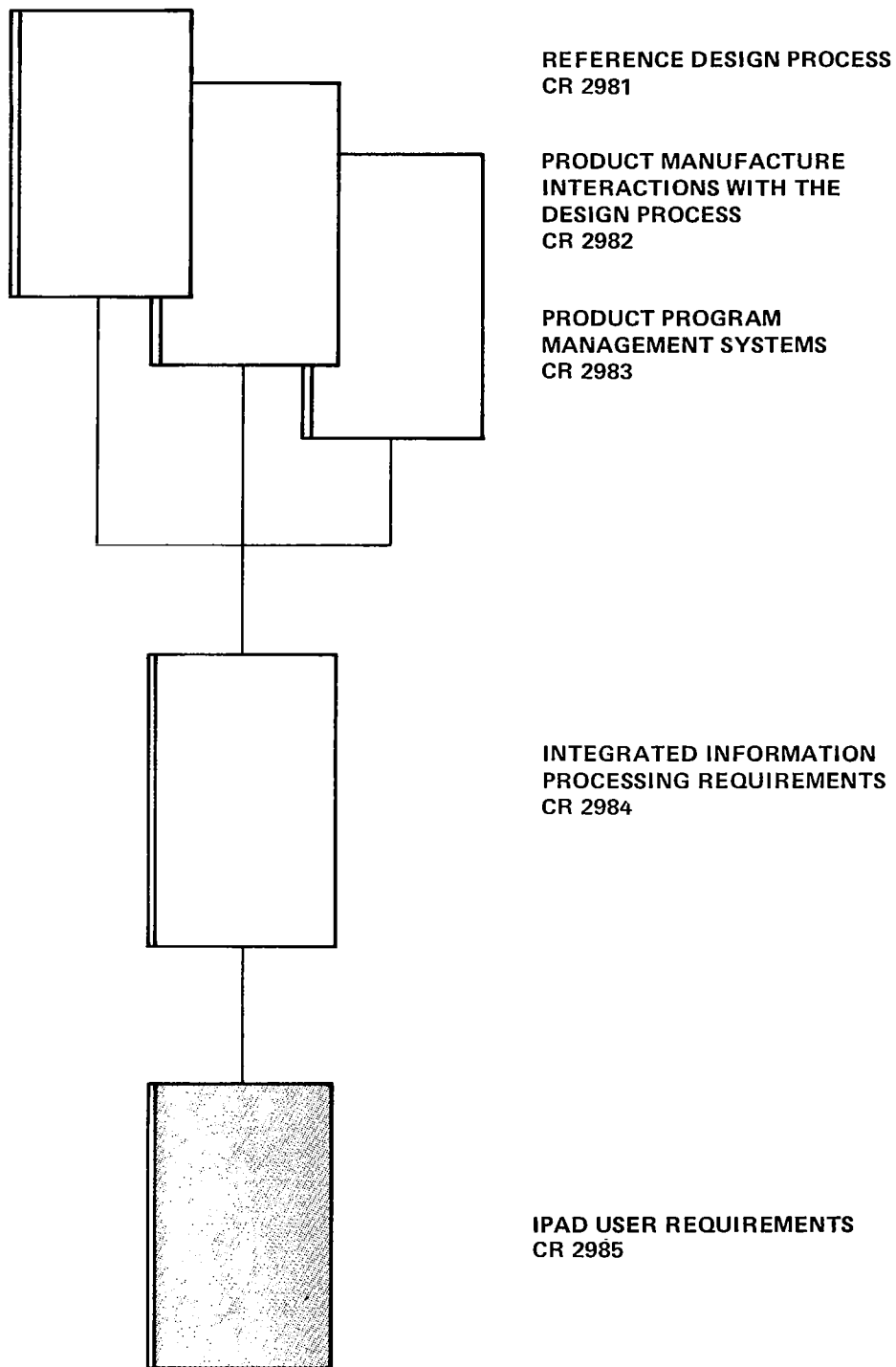
Figure 1.—Relationships of Task I Documents (Shaded block indicates this document.)

2.2   INTERPRETATION

The requirements in this volume address the NASA Statement of Work 1-15-4934A and the IPAD Feasibility Study documents. If any conflict exists in interpretation between this document and the statement of work, the latter should be considered as the authority. Also, in the event that compliance with part of a requirement proves impracticable, the remaining part of the requirement is in force.

The third person pronoun "he" is used for expediency only and is not intended to restrict the gender of the user.

2.3   OVERVIEW OF REQUIREMENTS

The IPAD system functional requirements involve four basic elements: human (users), information, communication, and performance needs. The needs of these four basic elements comprise the functional requirements.

2.3.1 HUMAN INVOLVEMENT

The IPAD functional requirements addresses the following user categories and needs:

User categories

   Managers

   Engineers

Characteristics

   Variation in skill level

   Psychological factors:

      Confidence in IPAD
      Problems frustrating users

As indicated above, there are two categories of users, engineers and technical managers, involved in the use of IPAD. Each of these categories has separate concerns that must be addressed if IPAD is to be accepted as a product design tool.

Managers are concerned with establishing design criteria and cost and schedule constraints. These functional requirements are addressed in this document and provide the means to monitor and control progress. Special applications provided for management

include automatic reporting (for meeting and monitoring cost and schedules) and management type graphics.

Engineers are concerned with:

Having established information readily visible

Transforming known information into desired new information, either by editing or output from a computer program

Making the new information visible through reporting and/or graphics capabilities

Transfering data from the private to the public (shared) domain

Complying with the overall cost and schedule constraints

All these factors are addressed in these functional requirements. User characteristics in these requirements are skill variation and psychological factors.

The benefits that IPAD offers to the product design process are achieved through a total company-wide involvement. Hence, engineers with all kinds of skills and levels of computer expertise will be involved in the use of IPAD. This concern is taken into account in these requirements.

Psychological factors require that the user be provided at all times with the means for continuing his task, irrespective of his level of expertise. In addition to the confidence builder just described, the requirements provide means to avoid frustration in the use of the system. The problems of system overload and inability to access the system are addressed, together with user priority needs.

2.3.2 INFORMATION

The IPAD information functional requirements address the following needs relative to data and/or computer programs:

Creation
Modification
Storage
Retrieval
Transfer
Reporting
Deletion
Protection

Control

The means to supply these needs are addressed and are expressed in a manner that caters to the various levels of computer expertise.

2.3.3 COMMUNICATION

Communication in IPAD involves user-machine and user-user interfaces. User-machine communication needs are addressed in the command and data definition languages, interactive dialogue, and system messages.

Communication is closely tied to the variation in user skill. Language characteristics address this problem.

User-user communication is provided through a message capability.

2.3.4 PERFORMANCE NEEDS

Computer hardware is not discussed in the IPAD functional requirements in this document. The section on performance describes the expected performance from the hardware chosen.

2.3.5 DESIGN TO COST

Requirement 13-1. The level of system excellence in meeting any and all of the requirements in this document is constrained by the need to design to cost. The distribution of costs to individual requirements must be balanced in the best interests of the total IPAD system.

3.0 ABBREVIATIONS

ANSI	American National Standards Institute
APT	Automatically programmed tools
ART	Average response time
CAD	Computer-aided design
CALCOMP	California Computer Products Company
CAM	Computer-aided manufacturing
CDC	Control Data Corporation
CG	Center of gravity (or centroid)
CL	1. Command language 2. Center line
CL FILE	Command language file
CM	Coding Module
COLIST	Corporate-like organizational lists
CRT	Cathode-ray tube
FEDD	For early domestic dissemination
FORTRAN	Formula translator
GNAME	Group name
IBM	International Business Machines Corporation
INAME	Individual name
I/O	Input/output
IPAD	Integrated Programs for Aerospace-Vehicle Design
IPEX	IPAD executive
IPIP	IPAD information processor
JEQ	Job execution queue
K/B	Keyboard

KRONOS	A CDC operating system
LCGT	Low cost graphics terminal
MART	Maximum acceptable response time
MTBF	Mean time between failures
MTTR	Mean time to repair
NASA	National Aeronautics and Space Administration
N/C	Numerical control
OM	Operating module
OS	Operating system
RJE	Remote job entry
SC4020	Stromberg-Carlson 4020 plotter
SD	Short duration
SGHS	Specialized graphics hardware systems
SGS	Standard graphics software
SLRT	Standard limiting response time
SOW	Statement of work
UNIVAC	Sperry-Rand Univac
WBS	Work breakdown structure
2-D	Two-dimensional
3-D	Three-dimensional

4.0   USER/SYSTEM FUNCTIONAL REQUIREMENTS

This section discusses the user needs without concern for
software, hardware, or other constraints except a consideration of
what might be "reasonable and proper" to expect.

The section is structured in a chronological order consistent
with the development of the user in his understanding of the IPAD
system.

4.1   GENERAL CONSIDERATIONS

The total information management function of IPAD shall
include storage, cataloging, and retrieval of data, created or
verified at an interactive terminal, for use by the design process
and by company processes that interface with it, such as
manufacturing and product servicing.   IPAD will not provide
utility programs to support individual tasks for those interfacing
processes but will provide the integrated information management
capability for the design process and its interfaces.

4.1.1   HUMAN FACTORS

The successful use of the IPAD system implies a total company
commitment to its use.   The advantages IPAD offers (e.g.,
elimination of duplication, ready access to any and all data) are
dependent on this commitment.   Hence, the IPAD user community will
consist of many people with different interests, skills, and
needs; some will possess little, if any, previous expertise in
computer use.   The IPAD system must be designed throughout to
enable such a community to use the system.   This problem cannot be
solved by slowing down the expert user to the level of the novice
but by designing so that all skill levels will feel equally at
ease in its use, for it will be of little use to develop a highly
efficient system if, for one reason or another, the user community
refuses to accept it.   Some considerations of user acceptance
follow.

There are two basic groups to consider in the user community,
the managers and the technical users.   Of the two, the managers
have the most influence on whether the IPAD system will be
accepted and used.   Managers are concerned with costs and
schedules, visibility of technical quality, and ability to control
these factors.   The ability of IPAD to address these concerns
should be a major consideration throughout the design.   The
manager's attitudes are felt by the engineers who support him and
a manager's disenchantment will quickly be displayed by a
reluctance among the engineers to use the system.

The technical user's concerns spring mainly from insecurity and IPAD must be designed so that at all times he understands and controls what he is doing. The computer type language must be eliminated or kept to a minimum and replaced with functional type language with which the user is familiar. The emphasis should be placed on what he is doing in the product design sense, not on what he is doing in the computer sense.

Requirement 21-1. The IPAD system must be designed to address two groups of users, managers and design engineers. Managers must feel no loss of control over the key factors of cost, schedules, and quality of data. Design engineers must feel confident that they can successfully accomplish their tasks with a minimum of computer knowledge and that use of the IPAD system will improve their ability to do their work.

Requirement 21-2. IPAD shall address the problem of variations in user expertise in the use of computers and IPAD itself. The user shall be able to select his skill level, which will remain in effect until he changes it. A minimum of three categories of skill level shall be available for selection as follows: A. EXPERT, B. INTERMEDIATE and C. NOVICE (default value). The selection of skill level will invoke IPAD responses appropriate to the particular skill level selected by the user. In addressing this requirement IPAD shall not favor the lowest level of skill but shall minimize frustration at all levels by optimizing guidance and protection. Examples of guidance and protection aspects of IPAD affected by this requirement are diagnostics, prompts, defaults, abbreviations, etc.

Requirement 21-3. The IPAD user language shall be functional in nature. It must be consistent in vocabulary, syntax, and format. Defaults shall be employed when practical and directed towards the experienced user.

Requirement 21-4. IPAD shall require little or no user awareness of computer hardware. The user's data and programs have logical meaning to him, but he should not have to concern himself with their computerized representation, place of storage, etc.

4.1.2 INTERACTIVE COMPUTING

Requirement 21-5. The interactive terminal is to be the primary interface between the IPAD system and the user. IPAD shall permit use of interactive terminals to perform design tasks through use of textual (alphanumeric) and graphical display devices. IPAD shall be designed to accommodate the number of terminals described in section 6.6. Response times must be adequate to maintain the user's thought continuity. Response time is defined as the time elapsed between the last user input and the

first character displayed by the computer at his terminal. (See section 4.3.1.4, Response Time Criteria, and requirement 23-6.) When excessive waiting periods occur during interactive computing, the IPAD design shall include provision to notify the user of continued computer activity. The frequency and conciseness of such notification shall be subject to adjustment by the individual user.

4.1.3 INTERRUPTING COMPUTER ACTIVITY

Requirement 21-6. The user must have the capability to interrupt his interactive terminal session at any point for the following reasons:

Quit and cancel results of current session

Interrupt and resume at a later time

Interrupt execution and review results to that time

Interrupt execution and obtain HELP (see requirement 24-3)

The user must also be able to interrupt a batch execution for the following reasons:

Review intermediate results

Abort the job

It is desirable not to have to repeat the whole job in the event of system interruption, machine failure, or error. It should only be necessary to run the work from the last checkpoint, not from the beginning of the program. Therefore, checkpoints must be built into the run at appropriately spaced intervals.

In a batch mode operation, when a checkpoint is reached, the batch totaling up to that point will be recorded along with other information necessary to restart the run. Any checks that can be performed to test the accuracy of the run up to that point will be completed.

4.1.4 RECORDING OF ACCESS AND CHANGES

Requirement 21-7. IPAD shall monitor all instances of data and computer program access and provide a history of all data transactions under project control. Such a history shall contain details of who accessed the data and the date and time of access.

Explanation: This requirement is needed to provide a means of reporting to users changes in data or computer programs. This may be done by the message capability (see sections 5.3.9 and requirement 21-9).

Requirement 21-8. IPAD shall keep a record of all revisions to data and computer programs. These records will contain information on who changed the data, when it was changed, and what was the nature of the change. This will facilitate the reconstruction of the information bank in the event that data is destroyed or modified.

Requirement 21-9. IPAD shall provide the means of reporting instances of data changes to affected users using the system records described in requirement 21-7 and the message capability described in requirements 27-3 and 27-4. This reporting shall be either automatic or initiated by the owner (creator) of the data set at his option.

4.1.5 COMPANY PRIORITIES AND IMPLEMENTATION OF IPAD

This section addresses individual company problems in installing IPAD. The transition from the current design environment into the IPAD environment will, of necessity, be a step-by-step process.

Part of the product design process will be implemented in IPAD and part will continue to exist in the pre-IPAD environment. Hence, a need arises to permit the product design process to proceed smoothly in this two-part environment.

The priorities of initial IPAD selection will differ from company to company, which precludes the formalizing of an IPAD modular transition approach. The problem, therefore, is to provide a means of linking the initial company-selected capabilities in IPAD with the remaining capabilities outside IPAD in a manner that will ensure smooth continuation of the product design process.

Requirement 21-10. IPAD shall address individual company problems in making the transition from the current product design environment into the IPAD environment. The solution will be aimed at ensuring smooth continuation of the product design process during and subsequent to the transition period. The transition should be considered a step-by-step process.

Requirement 21-11. The IPAD system shall permit individual company flexibility in selecting priorities for incremental implementation into the IPAD system.

4.1.6 SYSTEM FLEXIBILITY

Requirement 21-12. The size of the information bank, number
of integrated or interfaced computer programs, number of users,
number of terminals, etc., will vary considerably from company to
company. It is thus essential that IPAD be able to efficiently
support a wide variety of uses. In some instances, such
variations have been estimated and bounds given in this document,
in others the variability and bounds are not known and no specific
indication made in the document. It is anticipated that further
analyses of these requirements by the Computing Staff will cause
variations to be discovered and bounds estimated.

It should also be understood that the impact of the software
on the users and the consequent amount of use of the various
capabilities are difficult, if not impossible, to predict. This
is the case with most sophisticated software. Thus, new or
modified requirements will be discovered as a result of the use of
the software, and the software must be designed and built so that
ensuing modifications or additions are accomplished as easily as
possible. Furthermore, various parameters defined in this
document should be changeable by each using company to suit its
own requirements. These would include the period of time for
messages to be automatically erased, the arrangement for user
appointments, etc. In general, the total system must have this
flexibility for individual tuning.

4.2 LEARNING IPAD

This section is not aimed at the contracted formal IPAD
training courses, though the capability described here could be
used for that activity. The primary intended function of learning
IPAD is to provide a means for an individual to obtain tutorials
potentially ranging from an overview of IPAD to instruction in the
use of a particular utility or a new capability that a specific
company has introduced. The user needs might be the reviewing of
forgotten sections of IPAD or learning of new ones.

It is intended that this will be a stand-alone type activity
and not an emergency aid used during the running of IPAD.

Requirement 22-1: When the user is in the learning mode he
will have options available to him consisting of at least the
following:

      Texts

      Programmed learning

      Example problems

New command

Exit IPAD

4.2.1 TEXTS

Requirement 22-2. This requirement calls for a menu listing of available short texts on various IPAD user functions to be displayed to the user. The list will take the form of a letter followed by a description.

Example: A. Log-on procedure

B. ...

C. ---

.

.

.

X. Log-off procedure

Y. Enter new command

Z. Exit IPAD)

Selection of a letter will cause the appropriate text to be displayed to the user followed by a "Next selection?" query.

4.2.2 PROGRAMMED LEARNING

Requirement 22-3. This requirement calls for a menu type selection similar to the instructional program the user wishes to study (as described under 4.2.1 above). In addition, a facility for writing programmed learning instructional courses is required and is described under section 5.3.16, Learning Utilities.

4.2.3 EXAMPLE PROBLEMS

Requirement 22-4. This requirement calls for a menu for selecting the desired example problem. Example problem programs and data will be developed and installed in IPAD. The intent of these problems is to provide the learner with a series of

progressively more difficult tasks, each of which will support some aspect of what has been learned in a paired program learning course. Decisions made by the learner while carrying out his assigned task will be monitored, and mistakes analyzed, by the system.

4.3 ACCESSING IPAD

This section describes the functional requirements that apply during the accessing phase and is broken into the following parts:

Overload considerations and user priorities

User identification

User direction

4.3.1 OVERLOAD CONSIDERATIONS AND USER PRIORITIES

The following overload considerations in IPAD must be addressed:

Communication Overload—Defined as lack of available communication lines between the terminal and the computer.

System Overload—Defined as the level of activity within the IPAD system at which response times are increased to an unacceptable level.

Both of these problems prove to be extremely frustrating to a user. The following requirements are intended to minimize such problems.

4.3.1.1 Communication Overloads

Communication overload is caused by all the communication lines being occupied, with one or more users still dialing and getting a busy signal. Under these conditions, access to the system is a matter of chance.

There are two ways of addressing communication overload. One is hardwiring each terminal directly to the computer, another approach is to provide the user with options to enable him to work around the problem.

The work around approach introduces different types of user needs, which are briefly described in the following section and in more detail later in requirements 23-1 through 23-6.

The various user needs introduce several user categories. This will become more apparent in section 4.3.1.3, System Overload.

4.3.1.2   User Categories

The detailed requirements affecting user types are presented in section 4.3.1.5, the following is a brief description.

The following categories of users are recognized:

Privileged users:

Emergency

Appointment

Short duration (SD)

Standard Users

Emergency User--This type of user has a top priority job to execute in the system and will have the following special privileges, penalties, and restrictions.

Special access

Special priorities

Premimum charges

Demonstrated need

Management approval

Appointment User--This type of user has a schedule commitment. He must be assured that he can complete his task by a given date and time. Alternatively, he may not have an immediate need to use the system, and in the event that the system is overloaded he can reschedule his immediate tasks relative to the appointment time.

This user will have the following privileges and restrictions:

Special access

Limited number of appointments

Short Duration User--This type of user has a need to perform tasks of short duration and having value only if performed immediately, e.g., determining the current status of a batch job or system load, send messages, abort a job. This user will have the following privileges and restrictions.

Special access

Limited hook-up time

Restricted functional use of the system

Standard User--This type of user will comprise all other users. He has no special priviledges and is penalized in the event that communication and/or system overload exists. These penalties are explained in more detail in section 4.3.1.5.

At this point a discussion of the second problem--system overload--is appropriate.

4.3.1.3 System Overload

System overload results in unsatisfactory response times and generally inefficient use of the computer. Satisfactory computer response time is clearly a user requirement. This implies that once a response time criterion is reached, additional users should be excluded from processing their work. If this condition is reached, the system should permit users to continue to access (assuming a communication overload does not exist) and place them in a job execution queue (JEQ). The system response time will be monitored and compared to accepted response time criteria. Waiting users will be allowed to process their jobs in an orderly manner as the response time permits. When a user is placed in the JEQ he will be informed of his position in the queue initially and each time it changes. In addition, he will be given the opportunity to terminate or make an appointment.

The actual application in IPAD is somewhat more complex than the foregoing and is explained in section 4.3.1.4.

4.3.1.4 Response Time Criteria

An exact control of system response is not possible. The proposed approach is that some value of system response, "standard limiting response time (SLRT)," will be selected so that when that response time is reached, privileged users may continue to be accepted and to execute their jobs while additional standard users

are deferred to the JEQ. The increase in system response time caused by the additional privileged users will be accepted and the nominal setting chosen (and possibly continuously controlled) to ensure that degradation due to privileged users does not exceed a "maximum acceptable response time (MART)" criterion.

The difficulty in attempting to control response time accurately is that when the nominal setting is reached, the mix of privileged and standard users is not necessarily constant; there may, in fact, be a full complement of privileged users already in the system. The tolerance between the SLRT and MART must, therefore, be flexible and may be decided by individual company experimentation. It is also not inconceivable that software could be written to provide automatic control of the SLRT to ensure that the MART is not exceeded.

4.3.1.5 Requirements

This section presents the set of requirements addressing overload considerations and user priorities.

Requirement 23-1. The IPAD system shall recognize the following categories of users:

Priviledged users:

Emergency

Appointment

Short duration

Standard Users

These categories are addressed in detail in the following requirements 23-2 through 23-5.

Requirement 23-2. The emergency user shall be recognized by the IPAD system to have the following capabilities.

He will communicate to the system through a dedicated line, either hardwired or through a special phone number and password provided by an IPAD system administrator (see requirement 27-1). The control procedures for obtaining an emergency priority will be left to the product design management.

He will have top priority over all other categories of user during job execution.

He will be penalized with a premimum charge.

Requirement 23-3. The short-duration (SD) user shall be recognized by the system to have the following capabilities and restrictions.

a)   He shall be able to access the computer with a minimum chance of frustration from communication overload, and the following criterion shall apply: 95 percent of the SD user's attempts to communicate with the computer will be successful within 30 seconds of his commencing to establish communication. The system design should consider the following possibilities:

   (1)   Some hardwired terminals with direct communication to the computer would be dedicated SD user terminals.

   (2)   If normal telephone lines are used, some kind of hold device will accept user calls and process them in the order received, but with sufficient lines to meet the 95-percent, 30-seconds criterion specified above.

b)   The SD user shall be restricted to a limited connect time. This limit shall be adjustable to suit individual company needs. The range should address 0-30 minutes if system design requires the range to be set.

   The SD user shall be restricted in activity so that he may not perform functions that would affect the integrity of information in the data bank in the event the time expired before the user completed his task. This applies to any kind of data access for the purpose of generation or modification.

c)   The SD user shall be permitted to perform at least the following functions:

   (1)   Determine:

      System load (JEQ status)
      Job status

   (2)   Review and query data in information bank

   (3)   Make, change or cancel an appointment (see requirement 23-4)

   (4)   Receive and send messages

(5) Check on resources

(6) Abort a batch job

d) In the event that the SD user reaches his time limit he shall be unconditionally logged off.

Requirement 23-4. The appointment user shall be recognized by the IPAD system to have the following capabilities and restrictions.

a) The appointment user is defined as a user who has requested and been granted, by the IPAD system, a specified work period or periods on the computer for a defined date.

b) The IPAD system shall be designed to recognize a daily cycle of appointments. The cycle shall consist of an

appointment starting time (S) and a given number of appointment periods (N) each having a duration time of T minutes. S, N, and T may be selected by the company using the system and should have the following range of values: $0 \leq S \leq 1440$ minutes, $3 \leq N \leq 288$, and $5 \leq T$ minutes ≤ 480 (where $T = 5 \times I$, $I =$ integer). The condition that $TxN + (1440-S)$ must also be satisfied. For example, if a company requires appointments to start at 8 a.m. and have 24 periods of 15 minutes (i.e., 6 hours of appointments) then $S = 480$, $N = 24$, and $T = 15$.

c)   The system shall be designed so that a company can remove the appointment capability if it so desires.

d)   The IPAD system shall be designed to limit the number of users (U) who can make appointments in an appointment period. The range of U shall satisfy $0 \leq U \leq T$. The value of U shall be selected within the specified range to satisfy individual company requirements.

e)   Any user may make an appointment when the computer is in the COMMAND mode. When making or changing an appointment the user may enter the date for which he requires the appointment and the system will display to him the appointment periods (in hours and minutes) still available to him. He then selects an appointment period. The system then displays a unique password which he must use when filling his appointment.

f)   Each IPAD user shall be limited in the number of appointment periods (L) he may use in any four-week period. The number of appointment periods and the specific four-week cycle dates are flexible and may be selected to suit individual company requirements. For example, if a company selects $A = 15$ appointments as the maximum number allowed in an appointment period and $N = 30$ appointment periods each working day for 20 working days (in a four-week period) and supports 500 users (U), then $L = (20 \times A \times N)/U = 18$, assuming 100 percent perfect use of the appointment option. The company would probably limit L to 12 appointments per user over a four-week period to cover changed and cancelled appointments.

g)   A user can request an appointment up to D days ahead of the appointment date and may change or cancel that appointment up to H hours ahead of the appointment time without forfeit of his allotted appointment periods. Where $0 \leq D \leq 28$ and $0 \leq H \leq 48$ may be selected by the using company.

h) An appointment user must use his appointment during the time the appointment period is in force or his appointment will be dropped from the system and he will forfeit his allotted appointment period.

i) An appointment user is not restricted in the manner in which he uses his allotted appointment periods. He may use them singly or any number in series up to the maximum allowed. He must designate the number of periods he requires when he makes his appointment.

j) The appointment user shall be able to access the computer with a minimum chance of frustration from communication overload, and the following criteria shall apply:

(1) Ninety-five percent of the attempts to communicate with the computer by an appointment user shall be successful within 30 seconds of commencing to establish communication (dialing).

(2) The system design should consider the following possibilities:

(a) Some hardwired terminals with direct communication to the computer; these terminals would be dedicated appointment user terminals;

(b) If normal telephone lines are used the system shall be designated to reserve sufficient lines (with password protection see e) of this requirement) during each appointment period to accommodate the number of appointment reservations.

k) If the appointment user has not completed his task by the end of the requested appointment period(s) the system will take the following steps:

(1) The system will enforce a normal INTERRUPT (see requirement 21-6) and so inform the user.

(2) The system will check and list the appointment periods available for the rest of that day and inform the user. The user may then elect to:

(a) Take a new appointment, and if it runs concurrently, continue with his work.

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(b) If he has a job in execution, transfer to a batch job.

(c) Log-off the system.

Requirement 23-5. The standard user shall be recognized by the IPAD system to have the following capabilties and restrictions.

a) The standard user has no special privileges. If all the communication lines are occupied he has no recourse but to keep dialing. He can check on the system load through SD capability and decide on his next course of action.

b) In the event of system overload he will be unable to commence his task even though he is able to communicate with the system. He will be maintained in the JEQ (see section 4.3.1.3 and 4.3.1.4) until the system response level permits him to use the system.

c) During the period in which a standard user is held in the JEQ he will be informed on a regular basis of his position in the queue and will be able to make an appointment or log-off.

Requirement 23-6. The system shall recognize a quantity called standard limiting response time (SLRT). The value of SLRT shall be variable and controlled by each individual company using the system. If a range needs to be implemented in the design the following shall apply $0 \leq SLRT \leq 15$ (seconds).

The system shall monitor the average actual response time (ART) and take the following action:

a) If ART > SLRT the system will block standard users from performing their task in IPAD and place them in the job execution queue (JEQ).

b) If ART $\leq$ SLRT the system will not block standard users from performing their tasks in IPAD and will process users in order from the JEQ. If the JEQ is vacant, standard users may be processed directly.

Privileged users (emergency, short duration, and appointment) are not affected by SLRT and will be permitted to access the system without constraint. The resulting degradation in actual response time will be absorbed by the system. It is anticipated that in practice the value of SLRT may be set to accommodate the degraded response time at an acceptable level.

4.3.2 USER IDENTIFICATION

Requirement 23-7. The input required from the user in order to identify himself to the IPAD system shall be as brief as possible commensurate with the establishment of unique identification, which, in this context, establishes user personal identification and the discipline or group to which the user is assigned. A password or other means of verification is required to protect the person being identified from impersonation.

Explanation: This information will be used for complying with other requirements as follows:

Data security and integrity (sec. 4.8)

Usage statistics (secs. 5.3.11 and 5.3.14)

Data ownership (sec. 5.3.11)

Suggestion:

Enter: Clock no./organization no./options

Personal password: XXXXXXX

Requirement 23-8. The establishment and subsequent changes to the PASSWORD (described in requirement 23-7) shall be accomplished with a minimum of user inconvenience.

Requirement 23-9. The password shall be protected from discovery as a result of its normal use.

Requirement 23-10. The system shall recognize unacceptable identification and indicate to the user the source of the inaccuracy and subsequently permit him to re-enter the identification data. After three such attempts without successful acceptance of the identification data he will be terminated from IPAD after being forewarned prior to a third attempt.

4.3.3 USER DIRECTION

As a last step in the process of accessing the computer the user requires an indication that he may now proceed to use the IPAD system.

Requirement 23-11. The IPAD system shall present the user, on request, with a message or display of the choices open to him to accomplish his task. The choices will address the various levels of user expertise in working with the system.

Explanation: See section 4.4, ASSISTANCE IN USING IPAD.

Suggestion: The system might display the following:

       O >   indicates the IPAD system display
       U >   indicates the user input

Subsequent to log-on the following (optional) user direction
is given (see sec. 2.3).

       O > Do you need "DIRECTION"? Yes or No

       U > Yes

       O > At any time in the command mode (C) you may enter
                an "ACTIVE COMMAND" or a "PASSIVE COMMAND"

            "HELP" will enable you to get a list of ACTIVE
               and PASSIVE COMMANDS and other information.

            "WORK" will direct you by subsequent selection to
               the task you wish to perform.

            "EXIT" will enable you to log-off the system

4.4   ASSISTANCE IN USING IPAD

This section outlines the provisions needed in IPAD to assist
the user in completing his task.   These provisions are memory aids
rather than teaching aids.   However, in the sense that they also
address the variation in level of user expertise, the aspect of
training is also addressed.   It is assumed that the user is
familiar with the method of operation of an interactive terminal
and has successfully completed an IPAD training course.   He will
have knowledge of the structure and capability of IPAD and his
deficiencies will, therefore, be memory lapses and lack of
exposure to the IPAD system.

This section addresses two categories of help as follows:

Functional help (sec. 4.4.1)

Factual help (sec. 4.4.2)

4.4.1 FUNCTIONAL HELP

Functional help consists of IPAD features that are introduced to assist the user by guiding him, maintaining his confidence, and enabling him to short-cut repetitive procedures.

Two IPAD features are required to assist in functional help. These are:

Passive commands (sec. 4.4.1.1)

Procedures (sec. 4.4.1.2)

These features are discussed in detail below.

4.4.1.1 Passive Commands

Requirement 24-1. Passive commands are mnemonic names which, when entered at the terminal, result in a printed text or message that the user has stored under the passive command name.

The text may consist of any useful material related to the chosen mnemonic name that will lead to a successful implementation of the user's task in IPAD. The text might comprise, for example, procedural description, a relevant selection of other passive commands or a description of an active command.

Passive commands are used in the active command mode and are distinguishable by name choices or other means which make them unique and distinguishable from the list of active commands.

Two categories of passive commands are recognized:

General Passive Commands are used by the whole IPAD community and are created by an IPAD System Administrator.

Local Passive Commands are created and used by a local group data area or individual to meet specific needs.

Explanation: An example of the use of general passive commands when used at the terminal follows:

      0 > indicates the IPAD system display

      U > indicates the user input

Subsequent to log-on the following (optional) user direction is given. (See also sec. 4.3.3.)

O > At any time in the command mode (C) you may enter an "ACTIVE COMMAND" or a "PASSIVE COMMAND"

The ACTIVE command "HELP" will enable you to get a list of ACTIVE and PASSIVE commands and other information.

The PASSIVE command "WORK" will direct you, by subsequent selection, to the task you wish to perform.

The ACTIVE command "EXIT" will enable you to log-off. (See section 4.6.)

U > WORK

O > The subset of available PASSIVE commands for work are:

PLAN, PREPARE, SOLVE, REPORT, DISPOSE

Select one

U > PR (prepare)

O > The subset of available passive commands for PREPARE are:LOAD, LOCATE, REVIEW, GATHER, CREATE, ASSEMBLE, VALIDATE, DEFINE

Select one

U > CR (create)

O > The subset of available passive commands for CREATE are DEFINE, PRINTDEF, ASSIGN

In order to assign data there must exist a data definition. If a data definition does not exist, one must be created. The passive command DEFINE will explain how to do this if you are not sure. Once a data definition exists, data may be entered in the following manner.

U   >   (Either enters data as described above, or asks for
                information about other passive commands or
                continues on with other job functions.)

By using this approach the experienced user is not forced to
accept the lowest level of expertise. The solution provides the
user with graded alternatives, which he selects according to his
knowledge. The more the user knows about IPAD, the less he needs
to do to accomplish his task. The system is, therefore, in a
sense defaulted towards the experienced user.

4.4.1.2 Procedures

Requirement 24-2. It is anticipated that tasks performed in
IPAD will become procedurized. In some cases, users will find
themselves performing the same sequence of tasks at frequent
intervals. Their work can be accelerated by providing the means
to group a sequence of control commands under a procedure. A
procedure is, therefore, a mnemonic name assigned to a defined
sequence of control commands. IPAD shall provide the means to
construct and implement PROCEDURES, which may be nested within
control commands and within other procedures to any level desired.

4.4.2 FACTUAL HELP

Factual help is initiated by the user and is described in the
following requirement.

Requirement 24-3. The IPAD user must be able to INTERRUPT
(see requirement 25-13) his work session without losing the job he
is working on. During the interruption period he shall be able to
perform other functions available to him in IPAD including "HELP."
He must then be able to proceed with his job. It is desirable
that the "HELP" and "PROCEED" commands be accessible as function
buttons (red for "HELP," green for "PROCEED") in order to
eliminate the confusion of even the most unskilled user and to
facilitate the use of "HELP."

Explanation: Even the most highly trained user of IPAD will have
a lapse of memory concerning a job procedure. It is inconvenient
to refer to the user's manual when in the middle of a terminal
work session. The use of a "HELP" button should interrupt the
session and save the job up to that point. After obtaining the
assistance required, the user hits the "PROCEED" button and
continues his job steps. After returning to his job in process,
the user has some options, such as scrapping the session and
starting over, or backing up to an earlier step.

Suggestions: When the "HELP" button is hit, the system should take the necessary steps to save the job, including the latest transaction, and then display a menu, such as the one shown below.

WHAT DO YOU NEED HELP WITH?
ENTER THE LINE NUMBER

1. IPAD COMMANDS
2. TERMINAL PROCEDURES
3. ERROR DIAGNOSTICS
4. APPLICATION PROCEDURES
5. DO YOU WANT A LIST OF ALL CATEGORIES?
6. SUMMARY OF WHAT YOU HAVE DONE IN THIS SESSION

If the user typed in number "1," a listing of all IPAD commands, passive and active, would appear on the screen. The user would then work his way through a hierarchy of commands until reaching the level where assistance is required. He could then get a concise explanation of the use of the command on the terminal screen. This procedure would be available for all the categories on the menu. Note: The system should initiate "HELP" when a series of errors has been detected.

4.4.3 ERROR DIAGNOSTICS

Requirement 24-4. Comprehensive error diagnostics are required to tell the user why a job won't run and how to rectify the problem. These will be described in detail in the IPAD user's manual and will be callable at the terminal in a summarized version.

Explanation: Error diagnostics will be one of the categories available to the IPAD user when he presses the HELP button (sec. 4.4.2). There will be a unique number associated with each diagnostic; when the user types that number, a display describing that diagnostic and corrective action to be taken should appear on the screen. The number should correspond to the numbers in the user's manual.

The error diagnostics should be developed to a level that will allow the user to correct his job during a terminal session until it will run. If his data is at fault, or if a system malfunction causes the problem, this should be indicated to the user. If all else fails, the system should give the user information for contacting a consultant for assistance.

Suggestion: The best-structured error diagnostic system fails if it is not readily usable. The terminology must be in layman's terms for clarity and must be quickly accessible.

Syntax errors should be reported as each line is entered so they can be corrected immediately. Procedure and logical errors should be reported as soon as possible after compilation or execution so corrections can be made and the job resubmitted. System malfunctions should be reported promptly to the user, who should also be advised in the event the job must be resubmitted.

4.4.4   STANDARD PROCEDURES

Requirement 24-5. The IPAD system must assist the user in finding standard design and processing procedures in addition to the IPAD standard operating procedures. Pointers or references to such information should be accessible at the terminal.

Explanation: Each aerospace company has developed standard procedures for design guides and process specifications. It is not intended that these reside in the IPAD system in their entirety, but the user should be able to find assistance at the terminal in locating a specific procedure. What will reside in the system are keywords, abstracts describing procedures, and references to the applicable procedures.

IPAD operating procedures will reside in the user's manual in detail and in the system in summarized form. This is a category that will be summoned by hitting the "HELP" button. These are guides for the user to properly run an IPAD job.

4.4.5   STANDARD TERMINOLOGY AND DIMENSIONS

Requirement 24-6. The IPAD system must accommodate standard terminology and dimensions that are compatible with the IPAD user. Keywords and synonyms will be used to access the terminology. The system will convert input dimension units to the standard for internal computation, storage, and output (unless user preferred output dimensions are requested).

Explanation: The IPAD Engineering Standards Handbook will describe standard engineering terminology as a tool for common communication. These standards will include notation, nomenclature, and dimensional units (including International System of Units). The IPAD system must accept variations of standard terminology, for example, by means of keywords and synonyms for that terminology. Individual user companies may introduce variations to suit their own operations.

4.5 DOING WORK

User needs related to data and computer programs in solving work problems are described in this section. A convenient breakdown of these requirements has been chosen, which describes the work process as PLAN, PREPARE, SOLVE, REPORT, DISPOSE. A separate subsection is denoted to each.

4.5.1 PLANNING WORK

Data and computer-program-related requirements which fall under the planning activity are described in detail below.

Requirement 25-1. IPAD shall provide the means whereby managers can plan the tasks defined by the design process networks described in CR 2981.

"Plan," in this sense, includes scheduling and assigning manpower and computer resources to tasks and subtasks and indicating the dependency of tasks upon each other. To this end the following requirements apply.

The planner shall be able to schedule, by project, tasks, and subtasks (as defined in CR 2984, section 5.3.1 and 5.3.3 and depicted in CR 2981) and assign names and commit schedule dates to them.

The system will provide the means to name subtasks and tasks by project to address various levels of planning and enable the planner to assign task and subtask dependency.

The means to assign manpower and computer resource constraints to named tasks and subtasks shall be available.

Review of information on scheduling, manpower, and computer resources shall be available at the terminal or off-line by display or hardcopy. The input shall consist of project, task, or subtask name and a selection of any combination of schedule, manpower, computer resources, and dependency. The means to select bar chart or tabular display of information shall be available.

Bar chart display will have available a standard set of symbols to denote key activities. The set of symbols shall be open ended and will have the purpose of denoting such activities as:

    Start/complete project
    Complete key tasks
    Decision milestone

Begin milestone
End milestone

The planning information shall be stored along with the "header" (see CR 2984, sec. 5.1.1) which applies to all data and programs.

Requirement 25-2. To assist in planning work activities, IPAD shall provide the means to query data and program headers (see CR 2984, sec. 5.1.1) to determine the status and location of needed programs and data to perform the intended subtasks.

4.5.2   PREPARING TO SOLVE PROBLEMS

Requirements addressing the user's needs in preparing to solve problems are presented in this section.

Requirement 25-3. The system shall provide the means whereby a user can locate and display definitions of the data he needs.

Requirement 25-4. The system shall provide a user with the means to select and display the data and program descriptions needed to solve his problem.

Requirement 25-5. The system shall provide the user with the means whereby he can copy data and computer programs into his own subtask and/or data area from other subtask or data areas.

Requirement 25-6. The system shall provide the means whereby a user can create new computer programs or data in IPAD. "New," in this sense, means new to the IPAD community and includes data created or modified through an EDIT procedure in IPAD or transferred from outside IPAD.

Debugging needs of on-line programming shall be considered, including the needed capability to:

Determine the value of any program variable

Change program parameters while the system is running

Determine the status of the information bank

Change the information bank as the system runs

Stop the action then proceed

Execute stepwise

Requirement 25-7. The system shall provide the means whereby a user can assemble data and programs into desired arrangement that a subsequent IPAD activity might require. Features that perform or at least facilitate interfacing of existing aerospace design computer programs with each other must be included.

Requirement 25-8. The system shall provide the means whereby a user can check the consistency of data and the compatibility of data flow among programs in sequence.

Requirement 25-9. The system shall provide the means whereby a user can create and modify data definitions applying to data in the information bank.

Requirement 25-10. The IPAD system shall provide the user, on request, with the classification for accessing and manipulation of data that management has assigned to him.

4.5.3 SOLVING WORK PROBLEMS

The process of solving work problems in IPAD may be defined as the process of making desired information (output) visible through a process of transforming information that is already visible (input), the output having different significance from the input. Implied in this definition is the fact that the user recognizes the set of input definitions needed by the transformation process and knows the set of output definitions the process will produce. The ways in which IPAD can assist in developing the input information are described in requirements 25-1 through 25-9. The ways in which IPAD deals with the output information are described in requirements 25-16 through 25-20. This section deals with the process of transformation, namely, running a job.

Requirement 25-11. The system shall provide the means to assist a user in running a job. In this context, a job may be part of a computational task and involve more than one computer program linked in sequence. The following are examples of activities available while running a job:

Reviewing intermediate results

Overriding pre-established sequences

Reviewing final results

Selecting final results

Comparing results of two similar runs (see requirement 25-12)

Requirement 25-12. IPAD will compare two or more programs or data sets and inform the user of differences with meaningful diagnostic messages. The comparison shall cover:

    a)   Data that was inserted (or deleted) in one data set or program and not in the other

    b)   Taking a) into account, the remaining data items in sequence. These are checked for those items that are different.

Requirement 25-13. A job may be run in an interactive mode or submitted for batch processing. A job may be interrupted in the interactive mode and submitted for batch processing at the point of interruption.

Requirement 25-14. Once a job is executing (on-line or batch) it shall be possible to monitor progress as well as to view the output in progress.

Requirement 25-15. The system shall provide the means for the user to create and modify sketches and drawings at a graphical terminal and/or to prepare the control media for off-line drafting equipment. It will include the capability to define and refine dimensions, create and modify labels, and use all the capabilities described in detail in section 5.4 (requirements 34-1 through 34-9).

4.5.4 REPORTING

Reporting refers to the set of activities that assist the user in making existing data visible to all or any of the members of the IPAD community of users.

Requirement 25-16. The reporting of information is an essential part of the product design communication process. Some of the major needs to be addressed are presented below.

A general reporting capability is needed for use in documentation, regular reporting, and real-time displays.

An English-like display capabilty will enable nonprogrammers to form visual displays for on-line reports.

IPAD software shall incorporate the facility to easily and rapidly transmit designs created at an interactive console to more precise computerized drafting machines.

IPAD shall include comprehensive capability for conversion of numerical data into graphical format such as multiple x-y plots, bar charts, contour plots, and carpet plots.

IPAD shall include aids for project management, including displays of task assignments, progress, resources expended and available, and milestone schedules.

IPAD shall provide the capability for automatic reporting, e.g., data due in the data base to meet a schedule date and all data overdue in the data base.

Requirement 25-17. The IPAD system shall provide the user, on request, with a report on the current status of his computer resource account.

Two levels of reports are required. The first consists of an overall accounting which should list the computer resources and corresponding dollar value against a) the original budget, b) the adjusted budget, c) total (a + b), d) resources used, and e) resources remaining.

In the event that this report produces questions involving a more definitive breakdown, a second report may then be selected. This report will list every access of the user's account between specific dates and will list for each access the I/O of the user accessing the data, the computer resources used, and the corresponding cost in dollars.

Explanation: This will enable a user to better control his budget, ensure that there are sufficient resources to complete the work he is planning to do, and check to ensure that his budget is not being raided by unauthorized users.

Requirement 25-18. The IPAD system shall provide the user on request with a report on the classification for accessing and manipulation of data management has assigned to him (see requirements 28-4 and 28-6).

4.5.5   STORING OF DATA AND COMPUTER PROGRAMS

This section deals with the set of activities that: a) assist the user in defining to the system the security requirements relative to storing data and computer programs and b) provide requirements to indicate the quality of the data stored.

The data security is maintained by the owner/creator of the data, and other users are only permitted access at the owner's discretion.

Requirement 25-19. IPAD shall provide the user with automatic personal data security. Data or computer programs created or owned by him are automatically stored in his private (subtask) area.

In addition, the means shall be available for the owner of data or computer programs to modify his personal data security by naming individuals or groups who are permitted (or excluded) from accessing specific data. (See also requirement 33-20). A special group name (e.g., "ALL") shall be available to define the entire set of IPAD users. This requirement is independent of national or proprietory data security (see sec. 4.8).

Management authorization may be required for release of data. The system shall provide, on request, the means for an appropriate printed form to be created at the terminal. This report shall consist of DATA NAME, DESCRIPTIVE TEXT, OWNER (CREATORS) ID, the list of individuals or groups who have been granted access, effectivity date, and a space for the manager's approval signature.

Attachment of the permitted user names to the specific data does not of itself provide these users with access unless followed by the word "APPROVED." The approval may be added at any time.

Explanation: This approach is very much akin to current practice and provides the manager with the same degree of control of data that exists in a non-IPAD environment.

In opposition to this approach is the concern of slowing down the design process for data where the manager's approval is not required. In this case, the user himself will issue the APPROVED command at the time of defining the data transfer; no report will be issued; and the responsibility for the data and the transfer action becomes the creator's. A record showing whether the authorization report was issued will be in the office file for later reference.

Requirement 25-20. IPAD shall provide the means for the creator or modifier of data to qualify the data for the benefit of other users. This facility shall be available at the time of storing data. The appropriate qualifying label shall be shown on each page of data printed or displayed. The number and character of the qualifier shall be optional in order to satisfy individual company requirements, but a basic set might look like this:

OPTION	LABEL	DEFINITION
R1	Information only	Best current data; will definitely change
R2	Preliminary	Best current data and likely to change
R3	Final	Best current data and unlikely to change

4.6 EXIT IPAD

This section defines the user requirements after completion of a work session and prior to discontinuing computer contact.

Requirement 26-1. Use of the command EXIT will cause the system to perform the following activities:

a) A report will be available on the status of the data or programs which have been affected by the current work session. Printing of the report is optional. (Suggestion: EXIT/S/ for status.)

In the event that the status report shows a need for action on the user's part prior to ending the session, the system will indicate a command mode situation following the status report.

b) In the event that the user's message file contains any messages, a suitable reminder such as "MESSAGE ON FILE" will be displayed. (See requirement 27-3.)

c) An appropriate command END will terminate the work session and a suitable message such as "END OF SESSION" will be displayed.

d) A report on resources used during the session will be available but optional. (Suggestion: EXIT/S/R.)

4.7 SPECIFIC HUMAN REQUIREMENTS

This section discusses requirements beyond the normal user needs that have been described earlier. This includes special interest users who interface with the IPAD system uniquely and special needs that the normal user has for reinforcing his system

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support. The special interest users include the information bank administrator(s) and secretarial accessories. The special needs of the normal user includes system and personal messages to and from other users.

4.7.1 INFORMATION BANK ADMINISTRATION

Requirement 27-1. The IPAD system must accommodate the special requirements of data administration. The information bank administrator is a person or organization responsible for exercising control over IPAD data areas. This control includes content, access, storage, definitions, inactive status, integrity, etc. The system must recognize the authority of the information bank administrator(s) as he accesses the system and must allow him to perform his functions.

Explanation: Both system and written procedures must be developed for the data administrator function. He must be able to access the IPAD system quickly and easily--more so than the normal user. The system must recognize his authority and allow him to perform tasks that other users cannot. The written procedures must fully describe the functions and authority of the information bank administrator(s).

4.7.2 SYSTEM AND PERSONAL MESSAGES

Requirement 27-2. The IPAD system must provide the capability for messages to be displayed at a user's terminal. This includes system messages to users and personal messages from one user to another. The user can access the messages in his personal file at any time in the command mode by inputting an appropriate active command such as "MESSAGE, (options)". He will then receive a copy of the message(s) at the terminal, or he may elect to have a hardcopy sent off-line by adding an appropriate option. Messages may only be read once and are subsequently purged automatically.

In the event that a user has not read his message file within a period of "d" hours, a hardcopy will be printed off-line and mailed to him. The value of d may be chosen by companies to suit their individual needs, and if a range of d is required for IPAD design, $0 \leq d \leq 500$ hours shall apply.

System messages will be displayed automatically at time of access. Important system messages concerning impairment of data should be displayed as soon as possible after the impairment is discovered.

Requirement 27-3. IPAD must provide the means for a user to write and transmit a message to designated user(s). This facility must be available at any time in the command mode. Receiving users may be designated by user name(s) and/or mailing list. A copy of the transmitted message and the list of recipients will be automatically retained in the sender's message file.

Requirement 27-4. IPAD shall provide the means whereby a mailing list can be constructed from an input list consisting of users and groups of users, etc., to any level. Such lists can be input directly by a user or constructed from recorded data such as those who have accessed a given data set, own overdue data, used a specified IPAD utility, etc.

4.7.3 CONFERENCE REVIEW OF DATA

Requirement 27-5. IPAD shall provide the means for multiple or conference viewing of data. To this end, concurrent display of data at more than one terminal shall be available. In addition, IPAD shall provide the means to send real-time messages and to edit the data being viewed by all members of the conference.

4.7.4 SECRETARIAL

Requirement 27-6. IPAD shall provide a complete capability to enter and maintain and print documents.

4.8 SECURITY AND INTEGRITY OF THE IPAD SYSTEM

Within the context of this document, "security" and "integrity" shall have the following definitions:

Security is the protection of company and/or national assets where these assets are information and computer programs.

Integrity is the means whereby the quality of the information and computer programs stored in IPAD is maintained.

The implications of security and integrity are fundamentally important in any computer system; IPAD is no exception. A company that has committed its product design data to the IPAD system has committed one of its major assets. Failure of the security system could mean failure of the company, and in the case of Department of Defense contracts, national security can be threatened. Threats to computer system security arise from the unpredictability of environmental conditions and people. Data-processing facilities and assets must be protected against natural catastrophe and hostile activity so that the impact on the operations of the organization are minimized.

4.8.1 SOURCES OF DATA IMPAIRMENT

There are three major sources of data impairment: environmental, mechanical and/or software failure, and human activity. Of these, the first two (i.e., environmental factors such as fire, flood, earthquake, etc. and mechanical and/or software failure) are outside the scope of these requirements. Human activity is considered to be a prime concern of this document and will be addressed more fully in the following sections.

The level of attention given to security of data is further regulated by the sensitivity of the data relative to company proprietary and national security concerns.

4.8.2 MEASURES TO MINIMIZE BREACHES OF SECURITY AND INTEGRITY

This section provides the requirements to minimize security and integrity breaches.

Requirement 28-1. In the event that the IPAD system, or any agent other than the user in the normal course of using the system, causes loss or modification of data in the IPAD information bank, the system shall be designed to identify and report the affected data (see requirements 21-8 and 27-3) and advise all users of the nature of the problem.

Requirement 28-2. The system shall record a history of transactions and data surveillance and whatever other means are needed to recreate data that has been willfully or inadvertently destroyed or modified.

Requirement 28-3. Failure of the IPAD system shall not result in a degradation of the security controls provided by the system. The system shall be fail-safe from the security viewpoint.

Requirement 28-4. IPAD shall provide permission codes whereby a manager or person in authority can restrict selected activities of an individual user.

Permission codes may take the form of:

USER ID, PERMITTED FUNCTIONS (COMMANDS)/EXCLUDED FUNCTIONS

DEFAULT IS ALL PERMITTED/NONE EXCLUDED

Explanation: Permission codes are a set of "keys" authorizing permissible information-processing activities assigned an individual by his manager.

Requirement 28-5. IPAD shall provide the means to protect the disclosure of information that would be detrimental to the proprietary interests of the company.

Suggestion: This can be achieved through security codes levied against individual users. These codes will address the various levels of sensitivity of protection required of different information. The number and character of the protection levels shall be optional to satisfy individual company requirements.

Requirement 28-6. In addition to requirement 28-5, IPAD shall provide the means to protect information the disclosure of which has been classified to be detrimental to the interests of national security.

Suggestion: This can be achieved in a similar manner to requirement 28-4 for company proprietary protection. The number and character of the protection levels shall include the following basic set: LIMITED, CONFIDENTIAL, SECRET, and TOP SECRET. Further, the requirements presented in the Industrial Security

Manual for Safeguarding Classified Information shall be addressed, particularly, section XIII, "Security Requirements for ADP Systems."

Requirement 28-7. Access to all data, including classified and proprietary data, is permitted on a need-to-know basis.

The IPAD system must provide a means to enable a designated authority to establish a user's need-to-know rights relative to specific sets of data.

Suggestion: Data may be assigned a name or list of names of users having need-to-know authority. Only persons whose names are on the list may access the data.

Requirement 28-8. Access to classified and proprietary data shall require stringent user identification.

Suggestion: At the first attempt to access such data, the user shall be required to identify himself in a manner corresponding to the classification or proprietary level. Once access has been made to a "higher" level (i.e., one requiring more stringent identification), he shall automatically be allowed to access "lower" levels.

Requirement 28-9. Attempts by unauthorized persons to access classified and/or proprietary data shall be reported to the system administrator.

4.9 CONTROL PROVISIONS

The primary benefit of IPAD is that the system takes over tedious routine tasks from the user without forcing him to relinquish control over his work and data. To assure that he keeps control, IPAD must provide him with status information and the means by which he can exercise the desired control measures. The controls include management, quality, communication, cost, and security; the information is provided as a result of these controls. In some instances, IPAD can only provide the means to control; the parameters that establish how the controls operate are supplied by the user. This section describes the information and control requirements.

4.9.1 MANAGEMENT CONTROLS

Requirement 29-1. Control room type information reflecting cost and schedule status for each discrete task is required for the responsible managers from a computer-based master schedule.

Explanation: A master schedule must be developed initially to represent the project activities and their interdependencies and costs and flowtimes associated with the activities. When the starting date is established, the critical path(s), slack times, and completion dates can be computed. The system must accept status and cost reports from the users to maintain the master schedule.

4.9.1.1 Product Design Management

Requirement 29-2. Responsible managers in all project design disciplines must have the capability to evaluate and report progress on their activities and must be informed of exceptions to the existing master schedules when their schedules are impacted. The system shall have the capability to limit job execution based on subtask schedule.

Explanation: Each discipline in the project design community, beginning with preliminary design, either develops data for its own or other disciplines' use or is dependent on data from other disciplines. It may also be involved with a combination of these situations. The master schedule that has been developed is assumed to prevail unless an exception (e.g., a missed milestone or a report that an activity will be completed late) has been posted. The system would analyze the impact of the exception and print out a report for distribution to each affected organization. It is then the responsibility of each organization to develop a work-around or to confirm the impact. Any changes to the master schedule must be reported as inputs to the system.

4.9.1.2 Manufacturing

Requirement 29-3. The interactions with the master schedule must be extended to manufacturing users of IPAD with the same capabilities as the design users available to them.

Explanation: Manufacturing data is provided to project designers on a committed basis just as design information is provided to manufacturing organizations. This begins in preliminary design and extends to formal engineering releases and to support design changes during production and test phases. The manufacturing user must get the same systems support as the design user.

4.9.2 DATA CONTROLS

Requirement 29-4. The system must support surveillance over the information to assist in control of quality and to provide statistics concerning volume and usage of data.

Explanation: Surveillance of data in a computer system supports several functions, such as computing operations and audits. The user of the system is primarily concerned with the quality of data: Is it valid? Is it the latest version? Is it going to change? If there is a change, the person responsible for the data may want to know where the old data has been used. If there has to be a restart after any kind of a failure, the user wants to know if the latest data has been reinstated. An audit trail (log of all changes made to data) is essential in order to trace the evolution of data, especially geometric definitions. If errors are discovered, the cause of the errors must be determined and recurrence prevented. The errors may be syntax (input error violation of input parameters) or system (a built-in program discrepancy). The syntax error should be checked at the time of input in an interactive mode so the user can correct it immediately. The system error should be debugged at the time the system is tested for acceptance (some may show up in situations that weren't tested.)

Some data (e.g., geometry) may have to be certified by a quality assurance function independently of the user or the user's organization. This does not impose additional requirements on the IPAD system design; however, it should be recognized that this type of user may be accessing the information bank. Any discrepancies would be reported to the responsible design unit.

Requirement 29-5. IPAD shall provide the means whereby a special qualifier may be assigned to data to indicate that the data is released or approved. It denotes management approval that the data is complete and correct and constitutes a completed schedule item. The means to designate and control the authority of individuals to approve data shall be available.

A procedure is required to notify users when they access data that released data is available.

4.9.3 COMMUNICATION CONTROLS

Requirement 29-6. Procedures will be required to instruct the user to interface with systems linked to IPAD. Detailed instructions would be contained in a user's manual, while a concise summary of instructions would be callable at the terminal. The procedures should include estimates of processing time based on the systems being used and the operations being performed.

Explanation: A user must be able to compute the time and cost of any complex job required to perform his task. He wants the option to select the optimum method for his job. He can plan his job on the basis of information in the user's manual. Once he begins his job at the terminal, he may require some assistance and should be able to get information on the screen without interrupting his session.

4.9.4 COST CONTROLS

Requirement 29-7. The operating costs for using IPAD must be made available to the user at his request and as a periodic report.

Explanation: The IPAD user should be able to request the cost at the end of a terminal session for that session. He should also be able to extract monthly costs or accumulated costs for the present month. Periodically (monthly, quarterly, etc.) a printed report should be distributed to the responsible manager to show total costs for that period charged against his account. The costs should be broken down to show costs for hook-up time, CPU time, storage, etc.

4.9.5 SECURITY CONTROLS

These are covered in detail in section 4.8.

4.9.6 PRIORITY CONTROLS

These are covered in detail in section 4.3.1.5.

5.0 IPAD SOFTWARE/HARDWARE REQUIREMENTS

This section deals with the software/hardware needs that address the user requirements of section 4.0.

5.1 GENERAL REQUIREMENTS

The following subsections outline the general software/hardware needs:

Geometry processing (sec. 5.1.1)

Interactive computing (sec. 5.1.2)

Reliability (sec. 5.1.3)

Cost effectiveness (sec. 5.1.4)

5.1.1 GEOMETRY CONSTRUCTION AND PROCESSING

Geometry construction and processing are the most important aspects of the design process. Practically all product design data is either directly or indirectly dependent on geometric data. Many existing computer-based geometry-processing packages are at a high level of development and continuing to develop. New and desirable packages will likely appear within the operational life span of IPAD.

While IPAD will supply its users with a standard set of geometry-processing utilities (see section 5.4), it must be recognized that some companies may prefer to use geometry-processing packages within IPAD that are tailored to their specific needs. The integration of these packages within IPAD, or the interfacing of them with other processors within IPAD, must be supported. The standard geometry format (CR 2984, section 5.4.3) provides the basis for such activities. However, it is also mandatory that IPAD supply a utility that aids in these integrations or interfacings.

Requirement 31-1. IPAD must supply a geometry integration package that will support interfacing and integration of geometry processing packages within the IPAD system. It is recognized that such activities may be hard or impossible to automate fully. It is therefore anticipated that a combination of user and software functions will be designed to meet this requirement.

5.1.2 INTERACTIVE COMPUTING

Requirement 31-2. The interactive terminal is to be the primary interface between the IPAD system and the user, for many user functions require interactive computing. IPAD shall permit use of interactive terminals to perform interactive computing tasks through use of textual (alphanumeric) and graphical display devices. IPAD shall be designed to accommodate the number of terminals described in section 6.6 for text editing, query processing, graphics display, interactive program execution, etc. User response times are functions of many factors including computer hardware and software, transmission rates, and demand. It is essential that response times be adequate to maintain the user's thought continuity, where response time is defined as the time elapsed between the last user input and the first character displayed by the computer at his terminal. When excessive waiting periods occur during interactive computing, the IPAD design shall include provisions to notify the user of continued computer activity.

The following interactive-computing capabilities (most of which are addressed in more detail elsewhere in this document) shall be provided by the IPAD environment.

Adequate response time (guidelines for desirable responses to be sought are presented in the feasibility study, CR 132390, vol. 4, section 6.4.)

Ability for the user to monitor program status and related system activities from an interactive terminal

Capability to maintain file continuity during: a) unintentional breaks or b) for disconnects of moderate duration, including intentional log-off while a job continues execution

Ability to create and submit batch jobs from a terminal

Capability for users to transmit information to each other via interactive consoles

Ability to stop computational activity in mid-job, review data, and resume job-execution at some time in the future without loss of work continuity

Facilities for easy transmittal of designs created at an interactive console to more precise computerized drafting machines

Automatic plotting for microfilm plotters and the standard aperture card drawing file format

5.1.3 RELIABILITY

Requirement 31-3. The reliability of the IPAD system, hardware, and operating system should be such that system unreliability need not be a specific planning consideration for IPAD users, including the system administrator. No definitive studies have been made to establish the precise parameters and ranges within which this criterion is satisfied; nevertheless, system reliability is an essential characteristic.

Requirement 31-4. The reliability of application modules is outside the control of the IPAD system. However, standards should be established and a rating system developed and implemented whereby application modules can be classified according to established levels of reliability. It is also essential that methods and standards be established for development of application programs within IPAD and for use in IPAD that encourages quality products.

5.1.4 COST EFFECTIVENESS

Requirement 31-5. The IPAD system must be productive and acceptable in major corporations in the U.S. aerospace industry. Therefore, it is essential that the IPAD system be developed to maximize its cost effectiveness within the framework of a representative company's design environment. Cost effectiveness issues to be used as a basis for IPAD development include user benefits provided, such as manpower or time savings, design procedure improvements, etc., versus the costs of development, installation, operation, and maintenance of IPAD software.

At all times, the active system configuration should be structured on a minimum system operating cost basis consistent with the user needs. The responsibility for efficient operation is a system design requirement, and the user should not be required to guide the system into its most cost effective support.

5.2 USER/SYSTEM INTERFACES

5.2.1 GENERAL CONSIDERATIONS

The user will interface with IPAD through a command language, which should be designed with the user environment as the prime consideration. The language should reflect the user's way of thinking and organizing the tasks that he would like to perform by using IPAD. The impact of the design of the system on the average user's mode of operation should be minimized.

5.2.2 USER/SYSTEM INTERFACE ORGANIZATION

The user interface for the IPAD system as a whole is varied and complex, with many dissimilar functions being executed for a variety of users. Since the basic aim of the IPAD system is considered to be information processing, this characteristic of all the categories of usage must be supported by the user interface.

The user interfaces for the various categories are bound to differ in some respects. Similarly, within each of these categories there must exist several tasks and subtasks to be performed that differ from those of other categories in certain respects. An individual user will, in general, carry out one or a few of the tasks and subtasks within one major category. Thus, a user will be required to be familar primarily with the part of the user system interface that addresses his particular tasks and/or subtasks. The interface (i.e., the language) must, therefore, be so designed as to recognize this aspect of the usage of IPAD and to lead a user to his desired area of operations through a minimum number of steps. Once his area is reached, the user should be able to use his set of active commands as desired. This approach will minimize the time required for the learning process and will make IPAD easily acceptable to the users.

5.3 UTILITY MODULES

Requirement 33-1. A number of utility modules shall be provided for performing services for IPAD users. The utility programs shall be available as part of the IPAD system and shall be accessible via the IPAD command language. The capabilities provided by the host operating system shall be used, to the maximum extent possible, in satisfying the utility functional requirements, with the IPAD utilities providing a machine-independent interface. Unless noted specifically in the following sections, the utility functions shall be accessible in either interactive or batch-mode processing.

The set of IPAD utility functions must be open-ended. During the operational life of IPAD, there undoubtedly will arise a need to add some utility not yet forseen.

5.3.1 EXECUTIVE AND DISPLAY LANGUAGE PROCESSORS

Requirement 33-2. The IPAD language processor shall interpret or translate IPAD commands into appropriate system functions, 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 command descriptions on request from the user. All user/system interfaces shall be via languages that are English-like, consistent, easy for the engineer or engineering manager to understand and use, and appear to the user to be independent of the host computer. Error diagnostics and warning messages shall be clear, concise, courteous, and shall specifically identify the problem sources. Brief modes shall be provided at the user's option to display only the most essential portions of diagnostic messages and descriptions of execution parameters.

The types of language facilities that shall be accommodated are:

Executive--The primary user interface to IPAD, providing access to the IPAD utilities, the IPAD information processor and the host operating system. It includes a sublanguage for learning IPAD and providing assistance to IPAD users.

Query--The information bank management system sublanguage for IPAD data definition, manipulation, interrogation, and control

Report--A sublanguage for formatting printed and graphical displays

Reference should be made to section 4.0 for descriptions of the functional requirements of the IPAD languages.

5.3.2 GRAPHICS AIDS

Requirement 33-3. A library of computer graphics functions supporting a wide variety of both passive and interactive graphics devices shall be provided for presentation of technical and management information. Use of these graphics utility modules by application programs will allow, for example, sketches and drawings to be created and modified at a graphic terminal, definition and refinement of dimensions, creation and modification of labels, symbols, etc., and performing related geometric calculations, unit conversions, data searches, etc. The extent of these valuable tools is presented separately in section 5.4, requirements 34-1 through 34-8.

5.3.3 TUTORIAL AIDS

Requirement 33-4. Tutorial aids shall be established to provide basic instructions on the use of IPAD for the new user, help to an infrequent user, and documentation and self-teaching aids for additional user training. Human psychological needs

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shall be considered in developing tutorial aids; in particular, ease of use and acceptability shall be of prime importance. Further descriptions of tutorial aids are presented in sections 4.2, requirements 22-1 through 22-4.

5.3.4 TEXT EDITING

Requirement 33-5. General text editing and update capabilities shall be provided to perform the following functions:

a)   On-line and batch editing of programs and data. IPAD shall permit changes to be made to stored computer programs or data by adding, altering or deleting statements. A chronological record of changes shall be kept automatically.

b)   On-line coding of new programs or generation of data. IPAD shall permit on-line development of programs or data by entering coding instructions or data from the keyboard and displaying them on an interactive console for easy and quick error corrections.

5.3.5 MENU BUILDERS

Requirement 33-6. IPAD shall provide aids for building menus of programs and procedures, subtask assignments, data transformation, information bank access authorizations, etc., in preparation for a computational task. A task is defined as a sequence of several computational subtasks and decisions that may involve one or more technical disciplines. Menus established during the work planning and preparation phases provide lists of selections to the users during the task working phases. The menu building utilities shall, for example, support the following subtasks:

Collecting computer programs

Assembling programs into a sequence

Setting up and checking consistent and compatible data flow among the programs in the sequence

Collecting data

Preparing and verifying input

5.3.6 PROJECT MANAGEMENT AIDS

Requirement 33-7. IPAD shall support management in storage and utilization of management computer programs such as critical-path determination or cumulative cost distribution and shall facilitate retrieval and display of project technical and management information for reviews of task assignments, work progress, schedules, and resources expended and available. A management query language shall permit interrogation of official project data and use of computer programs for work status reviews of scheduled dates for generation or update of critical data.

5.3.7 TASK STATUS UPDATE AIDS

Requirement 33-6. Update facilities for modifying the status of computational tasks shall be provided to:

Input current status of tasks in progress

Add, delete, or alter tasks and subtasks at any time during working phases of the tasks

Stop a task in progress, to be resumed at some time in the future without loss of work continuity

5.3.8 REPORT GENERATING

Requirement 33-9. General report generation capabilities shall be provided for use in documentation, regular reporting, and real-time displays. These facilities shall be supported by comprehensive capabilities for conversion of selected, numerical data in the IPAD information bank into user-specified tabular formats or graphical formats. Typical graphical displays would be via multiple x-y plots, bar charts including schedule charts, contour plots, and carpet plots. Facilities for automatic formatting and reformatting of text information shall be provided for generation of documents such as this one.

The IPAD data retrieval capabilities shall permit selected data corresponding to user-specified criteria to be extracted for display in a selected format. Examples might be the identity of all structural components exceeding a certain stress level under a given load or the identity of all project subtasks that are behind schedule.

Creation of general, tabular formats shall be provided by the report-generation utilities based on user input of titles, subtitles, column headings, and row headings. The formats of regular reports, status reports for projects, and standard reports

should be stored in the IPAD information bank for direct access during report-generation activities. Standard report formats such as the NASA Form 533 are defined, whereas status report format definition should be supported by routines that automatically interrogate computational task menus. Generation of graphical reports shall be supported in a similar manner. Other examples of report generation requirements are presented in section 4.5.4 and requirements 21-9, 28-9, and 29-2.

5.3.9   MESSAGE PROCESSOR

Requirement 33-10. IPAD shall provide features to maintain and disseminate user communications for information exchanges via the IPAD system. Examples of such functions are:

a)   Interactive communication among users via interactive consoles

b)   Access to IPAD level and task level message files upon request during interactive or batch mode processing

The message requirements are stated in requirements 27-2 and 27-3.

5.3.10   DATA TRANSFER AIDS

Requirement 33-11. IPAD shall be transferable to a new host computer without extensive rewrite and shall facilitate transfer of program modules and content of the information bank with minimum change. Support software and user aids shall be provided to perform such data transfers and include coordinate and unit transformations, alternate geometric descriptions, and transformations that account for differences in computer word sizes.

5.3.11   USAGE STATISTICS

Requirement 33-12. IPAD shall permit easy review of the existence, history, and status of programs and data in the data base including such information as the originator, official status, and date entered. An audit facility shall be provided to include pertinent information related to computer program and data accesses including most recent reference date, user identifiers, count of successful accesses, and a log of unauthorized attempts at access. For formal projects a trace of antecedents is required. (See CR 2984, sec. 5.3.7.) Facilities shall also be provided to maintain and interrogate logs of run times, base usage histories, and permanent storage utilization for generation of resource usage reports (sec. 5.3.8).

5.3.12 SOFTWARE MAINTENANCE

Requirement 33-13. A set of programs shall be available to aid in software maintenance of the IPAD system. These utilities shall include an update facility providing unique identifiers for each set of modifications, corrections, or extensions of capabilities. Automatic records of the changes shall be kept by the system. Facilities shall also be provided for performance measurement analyses to aid in the identification of improvements to the IPAD system operation.

5.3.13 BENCHMARK AND CERTIFICATION TESTS

Requirement 33-14. A set of benchmarks and certification tests including nonproprietary aerospace design computer programs and data bases shall be provided to permit verification of all or part of the IPAD system. The results of benchmark runs shall be compared automatically to benchmark standards stored in the information bank. The utility programs provided for file comparisons shall note any data discrepancies with meaningful diagnostic messages. These facilities shall also permit comparisons of data files, or partial files, generated by two or more computer programs or runs.

5.3.14 ACCOUNTING PROGRAMS

Requirement 33-15. Various accounting programs shall be provided by IPAD for computation of the information required by the project management aids (sec. 5.3.6), the report generation utilities (sec. 5.3.8) and the usage statistics programs (sec. 5.3.11).

5.3.15 ARITHMETIC AND LOGICAL OPERATIONS

Requirement 33-16. A set of utility programs shall be provided to perform arithmetic and logical operations on selected data . Functions such as unit conversions of data, scaling, summing, Boolean operations, and linear algebra shall be included.
Other functions such as numerical differentiation and integration of data arranged in tabular form are frequently performed by engineers. In general, these operations can be described as arithmetic operations on columns of a table. A utility to describe and execute such operations will be of great value.

The set of operations shall be open-ended.

5.3.16 COMPUTER-AIDED LEARNING

Requirement 33-17. IPAD shall support a computer-based learning utiility. This utility shall comprise:

A language permitting an author to prepare, maintain, and improve courseware

A means for the student to progress through the course material at a self-controlled pace by means of branching and immediate error feedback

A means for a teacher to maintain appropriate surveillance of the community of users of a given course. The access to this facility shall be limited

Such a system is described in "Control Data PLATO--System Overview," published by Control Data Corporation in 1976.

5.3.17 PROGRAM DEVELOPMENT

Convenient development of application programs to be integrated within or interfaced with IPAD is important for the success of IPAD. A fundamental characteristic of an integrated program is the fact that its I/O is done under the control and support of IPAD.

Requirement 33-18. For any programming language adopted as an IPAD language for development of application programs, there shall be available a facility that assists the application programmer with debugging his code. The capabilities of this facility include:

Execution with partial tracing

The ability to stop execution and then proceed

The ability to execute stepwise with user selected step length. While the program is in a halt mode, the user should be able to:

Query and update the data base

View and change program variable values

Requirement 33-19. For any IPAD application program language, a facility shall be available that can be used to evaluate application program performance. This facility will monitor the execution of such a program and identify computer resources that are used in selected subsets of the program.

5.3.18   ORGANIZATION CHARTS

Requirement 33-20.   IPAD shall provide the means to produce corporate-like organizational lists (COLIST). These lists shall consist of group names (GNAME), dependent group names (down to any level) and shall terminate with individual members of a group (INAME). Each individual member may have descriptors assigned such as supervisor, social security number, security classification, mail stop, and phone number.

In addition to using COLIST for organizational display, it may also be used functionally. It shall be possible to use COLIST as a means of indicating the receivers of messages or creating a mailing list. The use of any group name when using COLIST functionally implies that all the individuals in all the subordinate groups are included.

At least the following list of functions shall apply to COLIST. Given a GNAME or an INAME and a descriptor name, IPAD shall be able to:

a) Display the INAME and the assigned descriptor value or list the INAMES (defined by GNAME) and their assigned descriptor values. For example, if descriptor(s) = mail stop and organization number, a mailing list will be produced for everyone in group GNAME.

b) Compare the descriptor value(s) assigned to INAME's with a list of similar descriptors assigned to data to establish a key-lock relationship. This can be used for access permission to classified data when GNAME(s) and/or INAME(s) are assigned to data to denote access authorization.

c) Search and display the INAME(s) within the GNAME(s) that have any of the descriptor names assigned.

Note: GNAME could also be a descriptor.

5.3.19 INTERFACING AND INTEGRATING COMPUTER PROGRAMS

Requirement 33-21. IPAD shall provide support software and
user aids to facilitate interfacing existing aerospace design
computer programs with each other. The features of these user
aids and support software shall include coordinate and unit
transformations and data reformatting. IPAD shall also supply
user aids to facilitate integration of existing programs. The
features of these are analogous to those of requirement 31-1.

5.4 GRAPHICS UTILITIES

Graphic displays are essential for easy communication between
the designer and IPAD and may also be valuable tools for the
manager. Thus, IPAD graphics utility requirements are treated
separately in this section. IPAD must be capable of supporting a
wide variety of both passive and interactive devices, many of
which may be executed as a remote part (subset) of IPAD on
satellite computers (e.g., refresh and storage tubes, on- and off-
line flatbed plotters, and digitizers). IPAD shall support
several levels of graphic activities including interfaces to
graphics devices, basic program-callable graphics routines,
general-purpose graphics utilities, and specialized user-supplied
utilities. Graphics programming tools shall be provided for
graphics terminal use, application development, and graphic device
interface.

5.4.1 IPAD CAD/CAM INTERACTIVE GRAPHICS

This system will be used in a wide range of applications in
engineering and manufacturing organizations for designing and
manufacturing aerospace vehicles and components. The system shall
support the following three basic functions:

Three-dimensional construction and manipulation of geometric
quantities

Development of engineering and manufacturing data

Derivation of NC data

The common thread in the above three basic functions is the
geometry.

Requirement 34-1. The general categories of interactive
graphics design, drafting, and manufacturing functions required
are listed in the following requirements.

PLANE 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

FUNCTIONS SUPPORTING GRAPHIC DEVELOPMENT

Break away lines
Automatic cross-hatching
Generate array of entities
Entity group
Pattern of entities
General notes
Labels
True position symbols
Dimensioning (manual and automatic)
Balloon labels
Associative data structure
2-D section properties
3-D solid of revolution or projection properties
Examination of parameters
Mirror entities
Variable line fonts
English/metric conversions
Drawing management
Blank/unblank
Delete
Detail magnification
Z-clipping
View/depth modification
Variable-view point location (orthographic, auxiliary)
Automatic scaling
Entity translation and rotation
Entity duplication

Multiple view on CRT (parts geometry and cutter paths)
NC tool path development
Plotter output

The following requirements are essential to bridge the gap
between CAD and CAM by creating a common-structures geometric data
base.

Requirement 34-2. The system shall provide the following CAD
capabilities:

Composite surfaces with option for surface blending

Cross-sectioning island techniques

Interactive hidden line removal or truncation for "cleaned
up" views

Display and 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"

Capturing and naming a sequence of construction operations
via macro, allowing that sequence to be invoked by name

Slicing of any solid by any plane or surface so that the
resultant cross-section can be used for dimensions, analysis,
cross-hatching, and further construction

Both 2-D and 3-D non-montonic splines

Data plot system including generation, naming, filing, and
recall of graphs and histograms

Construction of normal areas with trim options

Chamfer line with trim options

Auto chamfer/fillet for open and closed figures

Translate, rotate, and duplicate to: 1) "repeat" n times, 2)
include scaling, 3) include tool paths, and 4) add depth to
translation

Provide 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

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

Lock out rejected entity until another entity has been selected

Provide COMMON to expand with added system capabilities without obsoleting old drawings

Extended spline analysis via line printer or CRT output (e.g., slope at each point)

Calculator-like capabilities including the use of named variables, evaluating expressions and functions to be input where numeric input only is now permitted

Extended analytic function including: c.g., 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

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 and machining applications and constructions

Associative graphics geometry data base which include the following relationships: inclusion, causality, and connectivity

Character recognition to input system commands with "teach" mode

Data unit attribute, when changed causes each change to be reflected throughout the drawing for all instances where it is used

Within a macro, provide FORTRAN capabilities such as GOTO, IF, and statement labelling

Batch mode capability

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 3-D curve, when given two coordinates, find the third coordinate

Chord-height-tolerance point matrix for any curve

Allow any curve to be generated from coefficient inputs

Annullment of curves, surfaces, and volumes (resultant curves must be continuous) e.g., a window "subtracted" from a surface

Define a 3-D curve as 2 2-D curves in different views

Label entities as they are created, e.g., P35 = X Y Z

Provide both function button and mnemonic input modes

Requirement 34-3. The system shall provide the following NC capabilities:

Constrain CL output to the configuration supplied by the MULTAX APT statement

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

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

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 feed rate statement when cornering (this will override any automatic system-generated feed rate)

Provide for machining around boxes while in the lace mode of 3-axis and 5-axis end-cutting

At any point on a surface provide the means to define the intersection of a line and the surface and the direction cosines to the normal at that point

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 nodes

Provide continuous check of cutter interfering with walls while machining a region bounded by surfaces in the 5-axes end-cutting mode

Provide graphic laths 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 lath 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 seven 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

Provide deep-hole chip removal sequence; user-defined drill cycle; piercing operation; G80 drill cycle output; and -3, -4, and 5-axis point-to-point operations

Provide user choice of simple or complex analysis; handles pockets of any depth and any planar bottom; provides cornering feed-rate control

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

5.4.2 STANDARD GRAPHICS SOFTWARE (SGS)

Requirement 34-4. Graphic programming tools shall be provided through standard graphics software routines that interface automatically to a variety of graphic devices. These basic functions will allow development of a sophisticated graphics capability from simplified building blocks. The IPAD user shall be provided with a comprehensive graphics library consisting of these basic functions. Basic functions that shall be provided for in the SGS library include:

Initialization and termination of display; this command shall include specification of hardware to be utilized

Move and draw commands, both absolute and incremental

Plotting of a single point or an array of points

Multiple view areas plotted simultaneously and controlled by user

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

Graphic input (via light pen, digitizer, cursor, or tablet)

Change of drawing scale, two- and three-dimensional windowing, and clipping

Variety of dashes for vector plotting

Variable plot intensity

Blinking, shading, hidden surface, and line removal

Three-dimensional graphic capability with rotation, translation, scaling, symmetry, and perspective

Carpet-plots

Contour-plot algorithms

Creation and manipulation of structured graphic data

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 graphic display device)

5.4.3   GENERAL PURPOSE GRAPHICS UTILITIES

Requirement 34-5. General-purpose graphics utilities will be used whenever the graphic object under consideration conforms to one of several standard IPAD formats so that it may be handled automatically by standard procedures. The following capabilties shall be provided by general-purpose utilities:

A simple data structure for graphical data, but reliance on IPIP for permanent data storage

Two- and three-dimensional object definition (with store, update, and delete) to relate to IPAD data base

File reformatting programs to allow graphic information generated for display on a particular device to be displayed on any other device

Cross-sectioning and partial object removal (peeling)

A grid and graph generator, including labels and titles

A generalized surface definition module for describing the mold-line geometry for aerospace vehicles

Design-drafting and manufacturing capability for two-dimensional and three-dimensional objects (refer to section 5.4.1 for greater detail)

Managerial graphics package for generating bar charts, organizational charts, schedules, etc.

An animation package to help display dynamic phenomenon, the result will be either viewed directly on a scope, or generated on a movie film for later display

Macro graphics language supported by the standard graphics software

Graphics processor that can be used by application programs to produce 2-D and 3-D graphical displays on Tektronix LCGTs

5.4.4 SPECIALIZED GRAPHICS HARDWARE SUPPORT (SGHS)

Requirement 34-6. General IPAD graphics requirements shall support specialized graphic devices and communication interface device. SGHS to be supported by IPAD shall include:

Scanning unit capable of copying an existing hardcopy drawing or microfilm version into a part file

Projection device for projecting large image picture using standard EIA composite video corresponding to CRT pictures for training, reviews, demonstrations

Graphics node communication interface support including cryptography, data compression, and user interface processors

5.4.5 GRAPHICS DEVICE INTERFACE ROUTINES

Requirement 34-7. The IPAD library shall contain a number of graphics device interface routines such as PLOT10 for Tektronix 4000 series LCGT's FDP for Vector General 3300 refreshed device, off line plotters including SC4020, COMP 80, 763 CALCOMP, and Gerber. In addition, devices to provide large, rapid, check prints (say 1 m x 1.5 m) is required. These routines shall interface the graphics software to devices such as passive CRT displays, interactive graphics terminals, digitizers, and drafting machines. It shall be possible to incorporate additional device interface routines to accommodate new graphic devices with no effect on the existing IPAD software

5.4.6 USER DEVELOPMENT FOR INSTALLATION OF SPECIAL-PURPOSE UTILITIES

Requirement 34-8. When the user has a specialized graphics requirement not directly satisfied by existing IPAD graphics software, IPAD shall provide support to facilitate user development of new customized utilities, utilizing IPAD graphics primitives.

Requirement 34-9. IPAD shall provide support for a user who wants to install into IPAD or interface with IPAD his specialized interactive graphics CAD/CAM system. Such a system may have its own private geometry formats and data storage and retrieval methods. A number of such systems exist within the aerospace industry today, and additional ones will undoubtedly be developed.

5.5 IMPLEMENTATION REQUIREMENTS

This section establishes the requirements on hardware and software on aids and procedures for installation and future development of the IPAD system.

Requirement 35-1. The choices of host hardware and software and user hardware facilities shall be determined and justified during system design.

5.5.1 HOST HARDWARE

The IPAD design and implementation must consider not only the existing computer hardware but also future developments.

Requirement 35-2. IPAD shall serve the U.S. aerospace industry and therefore must operate initially on or in conjunction with current computers including CDC 6600, IBM 370, and UNIVAC 1108. IPAD interactive graphics facilities may be based on a suitable minicomputer or minicomputers to achieve desired response characteristics.

Requirement 35-3. The full capabilities of IPAD will depend partly on future computer hardware developments and provisions for future use of or residence on such host hardware shall be made in the IPAD design.

5.5.2 HOST OPERATING SOFTWARE

Similar to hardware requirements, the IPAD design and implementation must consider not only existing systems but also future developments.

Requirement 35-4. IPAD shall be developed for operating systems currently in use in the U.S. aerospace industry. Because IPAD may reside on a non-dedicated computer, it shall be designed such that no modifications to the operating system are required.

Requirement 35-5. IPAD shall be designed with provisions for future developments of operating systems.

Requirement 35-6. The host operating system capabilities shall be accessible from IPAD.

5.5.3   USER HARDWARE FACILITIES

The interactive terminal shall be the primary interface between the IPAD system and the user but facilities must also be available for non-interactive computing.

Requirement 35-7. IPAD shall be designed to facilitate both textual and graphical (storage and refreshed) interactive terminals. Communication rates shall be limited only by hardware factors. Limitations, if any, on such devices shall be stated as a part of the system design.

Requirement 35-8. Non-interactive processing shall also be available in IPAD. This includes, but may not be limited to batch submittal on site or from remote entry points, submittal to batch processing from an interactive terminal as well as transfer of a batch job to interactive processing.

Requirement 35-9. IPAD shall permit generation of hardcopy plots on devices with varying precision and cost. The design shall be openended to support current and evolving systems.

Requirement 35-10. IPAD shall permit numerical input from digitizers. See requirement 34-4.

5.5.4 INSTALLATION AND IMPLEMENTATION

It is important that installation of IPAD by an aerospace company be as painless as possible. It is also imperative that a company be able to adopt IPAD in a gradual and orderly manner if it so desires.

Requirement 35-11. There must be installation manuals, etc., describing the packaging of IPAD, host computers hardware/software constraints, user facility hardware constraints and step-by-step instructions that will aid in IPAD installation.

Requirement 35-12. IPAD shall be designed so that the functional capabilties are modular, allowing a company to gradually adapt IPAD to their needs. Specialized interface facilities with systems outside IPAD may be required to accomplish this in an acceptable manner.

5.5.5 FURTHER DEVELOPMENT OF IPAD

Only an unsuccessful IPAD will be static. There will therefore be developments within individual aerospace companies to enhance the system to better meet its needs. Such developments should be recognized and anticipated.

Requirement 35-13. System implementors other than the IPAD development team should be recognized. Sufficient documentation and software aides must be provided to make their work as easy as possible.

6.0   PERFORMANCE REQUIREMENTS

This section describes the manner in which the IPAD system must perform in its production environment. The performance requirements must be demonstrable at first release. The requirements described here are for total system performance as experienced by the user. The user is concerned primarily with the following parameters:

a)   Terminal response time while running a job

b)   Availability of the IPAD system when needed

c)   Length of time required to restore operation if the system does go down, including job reconstruction with minimum duplicate work.

The IPAD system will be made up of an indeterminate (at this time) number of hardware and software components. Each of these will affect the overall system performance. The IPAD system design must specify for each component the following reliability factors, if applicable:

Mean Time Between Failures (MTBF)--It would be desirable to prevent downtime of any kind, but this is an unrealistic goal. However, the mean time between failures must meet the specified availability requirement (see requirements 42-1 and 42-2).

Mean Time To Repair (MTTR)--The users of the IPAD system cannot tolerate long periods of downtime. The MTTR includes all the time that the system is down, including the time it takes to inform the operator that the system is not functioning properly, the time it takes to correct the problems and the time it takes to restart the system. This parameter must be specified for each applicable system component.

Information Bank Protection--The integrity of the Information Bank must be maintained in the event of a system failure. Certain types of data will require audit trails for use by the Recovery Program. This has been discussed in section 4.0.

All three considerations (MTBF, MTTR, and information bank protection) carry equal weight for the IPAD system design.

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6.1 RESPONSE TIMES

Response time and accessing requirements are interdependent and are discussed in section 4.3.

6.2 RELIABILITY

Reliability of the total IPAD system is discussed here as availability of the system in terms of percentage of the normal work schedule. The normal work schedule is an eight-hour day, five days a week. There is a distinction made between the total system and the graphics utility and information bank because of the overall importance of the latter.

6.2.1 GRAPHICS UTILITY AND INFORMATION BANK

Requirement 42-1. During any consecutive four-week period, the average daily minimum system availability for the graphics utility and information bank shall be 97.5 percent of the working day (.975 x 8 = 7.8 hrs.).

6.2.2 TOTAL IPAD SYSTEM

Requirement 42-2. During any consecutive four week period, the average daily minimum system availability for the total IPAD system will be 95.0 percent of the working day (.95 x 8 = 7.6 hrs.).

Explanation: Availability of the system is a function of MTBF and MTTR, as explained in section 6.0. System availability is defined as functioning per the functional requirements as specified in this document.

6.3 SYSTEM MONITORING

Information processing is the most important aspect of the IPAD system. Therefore, provision to monitor data handling functions and performance must be available to the information bank administrator(s).

6.3.1 PERFORMANCE OF IPIP

Requirement 43-1. It is required that IPAD information processing performance be monitored by the information bank administrator.

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6.3.2 MONITORING TOOLS

Requirement 43-2. The software tools for the information bank administrator(s) shall include a software probe that can obtain a complete set of performance parameters over all of the information processing activities. It must be possible to relate software and hardware activities to user actions.

6.4 COMPUTATION ACCURACY

The IPAD utilities must meet accuracy specifications to provide the user with numeric accuracy while performing his design/drafting tasks. The accuracy requirements are defined below.

6.4.1 STATIC ACCURACY

Requirement 44-1. The system shall have the ability to store numerical data with at least 10 significant figures and to perform arithmetic operations with no additional loss of accuracy other than that imposed by purely mathematical considerations.

6.4.2 DYNAMIC ACCURACY

Requirement 44-2. The system must have the ability to perform any serial computations and meet the required static accuracy at all times.

6.4.3 INTERFACE ACCURACY

Requirement 44-3. The system must have the ability to communicate with existing software systems in data forms sufficiently accurate to preserve the original intent and useability.

6.5 SYSTEM DEMONSTRATION

Requirement 45-1. The IPAD system must be demonstrated for acceptance testing and for information and training sessions. It is necessary that a production environment be simulated as nearly as can be anticipated for any demonstration. In general, these sessions must demonstrate:

    Response times
    Reliability
    Use of commands

Editing
Security
Graphics

A sample work session that can encompass these features should be designed.

6.6 SIZE OF IPAD

This section is concerned with two aspects of size in connection with the IPAD system.

Maximum capacity of the IPAD system

Size for IPAD demonstration

6.6.1 MAXIMUM CAPACITY OF THE IPAD SYSTEM

The development of computer science and computer hardware is expanding rapidly. Attempts to predict available capacity to support the IPAD system are of doubtful value. Historically, software systems grow to absorb improvements in computer capability. It is felt that IPAD will be no exception. Any attempt, therefore, to place boundaries on the size of IPAD, even a lower boundary, would not only be pointless but also unnecessarily limiting.

Requirement 46-1. The IPAD system capacity shall be considered to be "hardware configuration limited," and no actual restriction is placed on the IPAD system. (Capacity here refers to computer memory capacity, 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.

6.6.2 DEMONSTRATION OF IPAD

The demonstration size of IPAD will be only a fraction of the production IPAD system capacity.

Requirement 46-2. The size of demonstration IPAD will be sufficient to demonstrate the following capabilities:

The effectiveness of the IPAD information bank

The effectiveness of the IPAD system to support selected
level(s) or parts thereof of the product design process

7.0 CONCLUSIONS

The 135 user requirements presented in this document cover the user's needs in an IPAD product design environment.

The requirements break down into 18 concerned with user assistance (variation in expertise), 37 IPAD system functional type requirements, and 84 directly concerned with the product design process.

The 84 product design process requirements break down into planning (2), preparation (8), problem solving (5), reporting (3), disposing (2), specific needs (6), security (4), controls (5), utilities (17), graphics (very detailed) (9), implementation (13), miscellaneous (10).

APPENDIX A

SUMMARY LIST OF REQUIREMENTS

REQUIREMENT NO.	DESCRIPTION
13-1	Design to Cost
21-1	Human Factors - Variation in User's Interest
21-2	Human Factors - Variation in User's Expertise
21-3	Human Factors - User Language
21-4	Human Factors - Transparency of Computer Problems
21-5	General - Interactive Response Time
21-6	General - Interrupting Computer Activity
21-7	General - Recording of Data Access
21-8	General - Recording Data Revisions
21-9	General - Reporting Data Changes to Affected Users
21-10	General - Individual Company Implementation
21-11	General - Flexibility in Company Implementation
21-12	General - System Flexibility
22-1	Learning IPAD - Options Available (Texts, Problems, etc.)
22-2	Learning IPAD - Menu of Texts
22-3	Learning IPAD - Writing and Using Programmed Learning Material
22-4	Learning IPAD - Menu of Sample Problems
23-1	Accessing IPAD - Categories of User
23-2	Accessing IPAD - Emergency User
23-3	Accessing IPAD - Short Duration User
23-4	Accessing IPAD - Appointment User
23-5	Accessing IPAD - Standard User

REQUIREMENT NO.	DESCRIPTION
23-6	Accessing IPAD - Standard Limiting Response Time
23-7	Accessing IPAD - User Identification
23-8	Accessing IPAD - Password
23-9	Accessing IPAD - Password Protection
23-10	Accessing IPAD - Unacceptable Identification
23-11	Accessing IPAD - User Direction
24-1	Assistance - Passive Commands
24-2	Assistance - Procedures
24-3	Assistance - Requesting "Help"
24-4	Assistance - Error Diagnostics
24-5	Assistance - Standard Procedures
24-6	Assistance - Standard Terminology & Dimensions
25-1	Planning Work - Planning Tasks
25-2	Planning Work - Status and Location of Information
25-3	Preparing - Locate and Display Data Definitions
25-4	Preparing - Select & Display Data & Program Descriptions
25-5	Preparing - Copy Data & Programs into Own Subtask Area
25-6	Preparing - Creating & Debugging New Computer Programs & Data
25-7	Preparing - Assemble Data & Computer Programs
25-8	Preparing - Compatibility of Data Flow and

REQUIREMENT NO.	DESCRIPTION
	Computer Programs in Sequence
25-9	Preparing - Create & Modify Data Definitions
25-10	Preparing - Determining Assigned User Accessing Classification
25-11	Problem Solving - Running a Job
25-12	Problem Solving - Comparing Two Similar Data Sets
25-13	Problem Solving - Interrupt Interactive Mode to Run Batch Job
25-14	Problem Solving - Monitoring a Job in Progress
25-15	Problem Solving - Drafting and Graphics Jobs
25-16	Reporting - Reporting Needs
25-17	Reporting - Report on Computer Resource Account
25-18	Reporting - Report on Accessing Classification Assigned by Management
25-19	Storing of Data and Computer Programs
25-20	Storing of Data - Qualifying Data Quality
26-1	Exit IPAD - Exit Activities
27-1	Specific Human Needs - Information Bank Administrator
27-2	Specific Human Needs - System and Personal Messages
27-3	Specific Human Needs - Write and Transmit Messages
27-4	Specific Human Needs - Mailing Lists
27-5	Specific Human Needs - Conference Review of Data
27-6	Specific Human Needs - Secretarial Needs

REQUIREMENT NO.	DESCRIPTION
28-1	Security & Integrity - Identification of Lost or Modified Data
28-2	Security & Integrity - Re-creation of Impaired Data
28-3	Security & Integrity - Security Controls Unimpaired at all Times
28-4	Security & Integrity - Permission Codes
28-5	Security & Integrity - Company Proprietary Protection
28-6	Security & Integrity - National Security
28-7	Security & Integrity - Need to Know
28-8	Security & Integrity - User Identification
28-9	Security & Integrity - Report on Unauthorized Access Attempts of Classified Data
29-1	Controls - Control Room Cost & Schedule Information
29-2	Controls - Monitor and Report on Schedule Progress
29-3	Controls - Manufacturing Interaction with the Master Schedule
29-4	Controls - Quality Control of Data
29-5	Controls - Released Data Qualifier
29-6	Controls - Interfacing Instructions with Systems Linked to IPAD
29-7	Controls - Users Operating Costs
31-1	Geometry Process - Integrated Geometry Process
31-2	Interactive Computing
31-3	Reliability - General
31-4	Reliability - Standards

REQUIREMENT NO.	DESCRIPTION
31-5	Cost Effectiveness - General
33-1	Utilities - General
33-2	Utilities - Language Processor
33-3	Utilities - General Graphics
33-4	Utilities - Tutorial Aids
33-5	Utilities - Text Editing
33-6	Utilities - Menu Builder
33-7	Utilities - Project Management Aids
33-8	Utilities - Task Status Update Aids
33-9	Utilities - Report Generating
33-10	Utilities - Message Processor
33-11	Utilities - Data Transfer
33-12	Utilities - Usage Statistics
33-13	Utilities - Software Maintenance
33-14	Utilities - Benchmark and Certification Tests
33-15	Utilities - Accounting Programs
33-16	Utilities - Arithmetic and Logical Operations
33-17	Utilities - Computer Aided Learning
33-18	Program Development - Debugging Code
33-19	Program Development - Program Performance
33-20	Organization Charts
33-21	Interfacing and Integrating Computer Programs
34-1	Graphics - General Interactive Graphics
34-2	Graphics - CAD Capabilities

REQUIREMENT NO.	DESCRIPTION
34-3	Graphics - Numerical Control Capabilities
34-4	Graphics - Standard Graphics Software
34-5	Graphics - General Purpose Graphic Utilities
34-6	Graphics - Specialized Graphics Hardware Support
34-7	Graphics - Graphics Device Interface Routines
34-8	Graphics - User Development of Special Purpose Utilities
34-9	Graphics - User Development of Special Purpose Utilities
35-1	Implementation - Choice of Host Hardware and Software
35-2	Implementation - Hardware
35-3	Implementation - Future Considerations
35-4	Implementation - Operating System
35-5	Implementation - Future Development of Operating System
35-6	Implementation - Access to Host Operating System through IPAD
35-7	Implementation - Interactive Terminals
35-8	Implementation - Batch Processing
35-9	Implementation - Hardcopy
35-10	Implementation - Digitizers
35-11	Implementation - Installation Manuals
35-12	Implementation - Modular Functional Capabilities
35-13	Implementation - System Implementation
42-1	Reliability - Graphics Utility
42-2	Reliability - IPAD System

REQUIREMENT NO.	DESCRIPTION
43-1	System Monitoring - IPIP
43-2	Monitoring - Software Tools
44-1	Computational Accuracy - Static
44-2	Computational Accuracy - Dynamic
44-3	Computational Accuracy - Interface
45-1	System Demonstration - Acceptance Test
46-1	Capacity of IPAD
46-2	Demonstration of IPAD

APPENDIX B

GLOSSARY

ACCESS CODE

A code that will authorize an IPAD user to read or modify a
specific data set

ACCOUNTING PROGRAM

A program that maintains statistics on computer resource
utilization

ACTIVE COMMAND

Active commands cause the IPAD system to perform the desired
user function in pursuing his particular task

ACTIVITY

Actions that 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.

ANSI STANDARD

A standard formulated and controlled by the American National
Standards Institute (ANSI)

APPLICATION PROGRAMS

Programs developed for the purpose of solving a particular
problem

ARCHIVAL STORAGE

A repository for the storage of infrequently used data

AVERAGE RESPONSE TIME

A measure of the typical response time to be expected by a
user. This is usually estimated by observing many
transactions and is highly dependent on machine loading.

BATCH CONTROL CARDS

Cards that contain commands directing the operation of computer programs in the batch processing mode

BATCH PROCESSING

A mode of computer processing in which computer programs are executed with little or no communication with the user

BATCH SUBMITTAL

Submitting computer program(s) to a computer for batch processing

BINARY CODED DECIMAL (BCD)

A numeric code for representing each character of an alphabet with each character represented by a unique sequence of binary digits (0,1)

BENCHMARK

A point of reference from which measurements can be made to evaluate the performance of computers or computer programs relative to each other

CARPET PLOT

This plot is generated by intersecting a function of two variables by two families of planes and plotting the intersection line. It looks much like a "flying carpet."

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.

COMMAND LANGUAGE

A language for directing a computer in which each command corresponds to a function to be performed

COMMAND MODE

A mode in which the IPAD system is awaiting a command from the user

COMMUNICATION RATES

The speed of signals across a communication line expressed in Baud

Baud--Unit of signaling speed. The number of signal events per second. If each signal event represents only one bit condition, Baud is the same as bits per second. When each signal event represents other than one bit Baud does not equal bits per second.

COMPUTER AIDED DESIGN (CAD)

The application of computers to assist in conducting activities needed to get ideas and concepts defined, refined, and documented ready to transmit to manufacturing. Included are not only conception and definition of vehicles, systems, and hardware, but their evaluation through analysis.

COMPUTER AIDED DRAFTING

The adaptation of the computer for automated drafting. It provides a man-machine dialogue allowing construction and display of geometric entities using a graphics device.

COMPUTER AIDED MANUFACTURING (CAM)

The application of computers to assist in performing functions from the receipt of product definition to the completion of an acceptable hardware item, system, or vehicle

COMPUTER PROGRAM CERTIFICATION

The process of confirming that a computer program has been validated

COMPUTER PROGRAM VALIDATION

The test and evaluation of a computer program to ensure that all requirements have been satisfied and that the program is correct

CONFIGURATION CONTROL

A procedure for maintaining a document, program, or other entity to ensure its integrity by carefully controlling all changes

CONTOUR PLOT

The plot of contour lines, usually generated by intersecting a surface with parallel planes

CONTROL CARDS

Cards that contain control data for directing the operation of a computer or computer program

CRITICAL PATH

The longest time path of sequenced events and activities that has the least positive slack. Slack is defined as the difference between the latest allowable start time and the expected start time of an activity. If the latest allowable start time is later than the expected start time, slack is positive.

DATA ADMINISTRATOR

(See also information bank administrator) A person or organization responsible for IPAD data bases. This responsibility includes control over content, access, storage, format, status, integrity, etc. of the IPAD data bases.

DATA AREA

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

DATA BASE

    A collection of interrelated data with as little redundancy
    as possible to serve one or more applications in an optimal
    fashion

DATA BASE MANAGEMENT

    The function performed by a data base management system

DATA DEFINITION

    The means by which data is described through its physical and
    logical characteristics

DATA DICTIONARY

    A directory containing data element name, descriptions,
    security controls, physical location, etc.

DATA ELEMENT

    A named unit of data which is not defined in terms of any
    other named units of data, i.e., smallest unit of data

DATA FORMAT

    Defines the information bank access method for storage and
    retrieval of a corresponding occurrence of a data set

DATA INTEGRITY

    Ensuring that the data base is accurate at all times by
    protecting the data base against invalid alteration or
    destruction

DATA OCCURRENCE

    Actual value(s) of data corresponding to a particular data
    relationship

DATA PRIMITIVES

    The basic building blocks for data in the information bank

DATA RECORD

    An enumeration of data elements

DATA RELATIONSHIP

A logical grouping of one or more data records

DATA SET

A specific occurrence of data corresponding to a given data
format

DATA SET HEADER

Data 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.

DATA SET QUALIFIER

A version number or alphanumeric appendage to a generic name
to make a unique name for a data set

DATA SURVEILLANCE

Monitoring of data processing activities for the purpose of
reconstructing data which has been destroyed or modified and
informing the affected users

DICTIONARY

Compilation of definitions of data elements, data
relationships, data formats, coding modules, operational
modules, and jobs

DIGITIZER

A device that assigns digital numbers to analog measurements

DISPLAY FORMAT

A special class of data formats used for displaying data sets

DISPLAY LANGUAGE

The language interface between the programmer and a graphics
device

DISTRIBUTED COMPUTING

Computing performed within a network of distributed computing
facilities. The processors for this type of system usually

function with control distributed in time and space throughout the network. Associated with the distributed process are distributed storage facilities.

EXPLICIT INPUT/OUTPUT

Input/output action to or from a data set that is under the control of a user program

FLATBED PLOTTER

Plotting device that draws on a horizontal flat surface, (e.g., Orthomat, Gerber)

GEOMETRIC DESCRIPTION

The mathematical model describing a geometric entity

HIGHER LEVEL LANGUAGE

A computer programming language in which the instructions or commands may each result in many machine language instructions

HOST COMPUTER

The interactive computer complex upon which the IPAD system will be developed

IMPLICIT INPUT/OUTPUT

Input/output action to and from a data set under the direct control of IPAD

INFORMATION BANK

The collection of all data areas defined to IPAD

INFORMATION BANK ADMINISTRATOR

Information administration is a managerial function which includes responsibility over control, data integrity, security, and overall efficiency. The information bank administrator(s) is responsible for the overall organization of the information bank, its dictionaries, program libraries and security provisions.

INTERACTIVE GRAPHICS

A graphics capability allowing the user to communicate with the computer

INTERACTIVE PROCESSING

Execution of a computer program that communicates directly with the user by displaying information in response to new inputs, etc.

INTERACTIVE TERMINAL

A communication device that provides a hardware interface between the user and a computer

I-O LIST

A list of variables representing data to be read or written

IPAD COMMUNICATION NETWORK

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 shall include 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 SYSTEM

An interactive computing system being developed to support the aerospace vehicle design process

IPAD SYSTEM ADMINISTRATOR

One who has authority to administer the IPAD system. His responsibilities are to maintain the IPAD system (hardware and software) once it is installed; to assure system performance, integrity, and security; and to interface with the IPAD user community which he serves.

JOB

A sequence of executable operational modules

JOB EXECUTION QUEUE

A queue containing jobs submitted by IPAD users

JOB NETWORK

A set of logically connected jobs in the IPAD system whose
execution order is dependent upon user supplied parameters or
calculated results

KEY WORD LIST

The key word list is an important item for each dictionary
entry. This list will allow users to search and find
existing dictionary entries to fulfill their needs. This
capability will help to limit the number of redundant entries
in the dictionary which contain the same information or have
the same mathematical definition.

LANGUAGE SYNTAX

The structure of a language. The objects in a language and
the relationships between those objects.

LEVEL

Activities that are 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 for the purpose of establishing a predicted
confidence level that may be used by management for risk
evaluation.

LINKED PROGRAMS

Separately assembled program segments combined together
through a linkage processor to allow them to operate as a
single program unit

LOGICAL STRUCTURE

The structure of data as it is referred to by an application
computer program

MENU

A list of available choices displayed to an IPAD user at an
interactive terminal

MESSAGE FILE

A file of messages for IPAD users created by the IPAD system or other IPAD users

MICROFILM PLOTTER

A plotting device capable of producing microfilm output

NARRATIVE TUTORIALS

Educational material displayed at a terminal to instruct the user in the use of the system capabilities

OPERATIONAL MODULE

An executable collection of coding modules that contributes to one or more jobs

OPERATING SYSTEM

The operating system for the host computer or satellite computer within which IPAD or a remote subset of IPAD executes

PASSIVE COMMAND

A command that causes the IPAD system to inform the user of functions available to pursue a particular task

PERMISSION CODE

Constraints on the user's use of the IPAD command language

PROCESS

A series of continuous actions that are defined and planned within a hierarchical system of levels divided into activities that are 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.

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, subtasks, expected results, and the associated control in terms of a network which shows schedule dependencies

QUERY LANGUAGE

A language designed specifically for formulating data base retrieval requests

REMOTE JOB ENTRY

Entry into the host computer of a job from a remote input device

REMOTE SITE

Any computer processing system that is remote from the host computing system

RESPONSE TIME

Interval between the operator typing the character signifying the end of the input and the terminal typing the first letter of the reply

REQUIREMENTS TREE

A hierarchical structure for the IPAD requirements, the outline of the body of the IPAD requirements document

SATELLITE COMPUTER

Any computer remote from and in communication with an IPAD host computer

SECURITY CODES

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 step in a project

SUBTASK DATA AREA

A data area that is 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.

TASK

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

USER IDENTIFICATION

A unique identifier associated with each user of IPAD. It is
mandatory that this ID be associated with a person and not
with an activity or an organization.

UTILITY SOFTWARE

Programs aiding systems operations by performing services
frequently needed by users

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

X-Y PLOTS

A two-dimensional plot of one variable against another

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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15. Supplementary Notes

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Final Report

16. Abstract

This document is the product of the requirements analysis task, WBS 1.4, and contains the user requirements which, in part, will shape the IPAD system design.

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