CSDL-C-5738

AIPS SYSTEM REQUIREMENTS

(Revision 1 (Supersedes CSDL-AIPS-83-50, same date))

by

Malcolm W. Johnston, James E. Kernan,
Jaynarayan H. Lala, and James G. Allen

August 30th, 1983

Approved: _____
Philip G. Felleman, Program Manager

The Charles Stark Draper Laboratory, Inc.
Cambridge, Massachusetts 02139

ACKNOWLEDGEMENT

This report was prepared by The Charles Stark Draper Laboratory, Inc. under Contract NAS9-16023, Task Order 35, with the Lyndon B. Johnson Space Center of the National Aeronautics & Space Administration.

This Revision 1 of the document was published in September 1984 by the Charles Stark Draper Laboratory, Inc. under Contract NAS9-16023, Task Order 84-18, with the Lyndon B. Johnson Space Center of the National Aeronautics & Space Administration.

Publication of this report does not constitute approval by the NASA/JSC of the findings or conclusions contained herein. It is published for the exchange and stimulation of ideas.

PRECEDING PAGE BLANK NOT FILMED

INTENTIONALLY BLANK

PREFACE

This Revision 1 of the original document (CSDL-AIPS-83-50) differs from the original only in the document and revision numbers, the indication of authorship, the Acknowledgement page, this Preface page, and the belated indication of NASA clearance for unlimited public dissemination. The original Preface follows:

This AIPS System Requirements document reflects responses to the NASA AIPS Working Group inputs at the July 13, 1983 System Requirements Review (SRR), late arriving NASA responses to the circulated questionnaires, and additional material gathered during follow-up conversations with the participating NASA Centers.

The significant changes relative to the SRR presentation are reflected in the Application Summaries of Figure 3. as follows:

COMMERCIAL TRANSPORT AIRCRAFT

- Maximum Cycle Rate: 200 Hz changed to 100 Hz
- Mass Memory: 20M bytes changed to 15M bytes

TACTICAL MILITARY AIRCRAFT

- Mass Memory: 1M bytes changed to 100M bytes

MANNED SPACE PLATFORM

- Throughput: 3 MIPS changed to 15 MIPS
- Online Memory: 4M bytes changed to 20M bytes
- Peak I/O Rate: 200K bits/sec changed to 15M bits/sec

UNMANNED SPACE PLATFORM

- Mission Duration: 10 years changed to 5 years

UNMANNED DEEP-SPACE PROBES

- Mass Memory: 100M bytes changed to 1M bytes
- Maximum Cycle Rate: 100 Hz changed to 20 Hz

PRECEDING PAGE BLANK NOT FILMED

TABLE OF CONTENTS

Section	Page
1.0 Introduction	1
2.0 Approach	3
3.0 Application Survey Results	7
3.1 Response Context	7
3.2 Excluded Capabilities	7
3.2.1 Processing Throughput	8
3.2.2 Online and Mass Memory	8
3.2.3 Input/Output	9
3.2.4 Cycle Rate	9
4.0 Projected Growth Requirements	13
5.0 Common System Requirements	15
6.0 AIPS System Requirements	17

Appendix	Page
Appendix A. Performance Matrices	23
Appendix B. Example Questionnaire	33
Appendix C. Application Summaries	53

PRECEDING PAGE BLANK NOT FILMED

LIST OF ILLUSTRATIONS

Figure		Page
1.	Application Survey Questionnaires	4
2.	AIPS Requirements Generation Process	5
3.	Application Summaries (Performance Requirements)	10
4.	Application Summaries (Design Objectives)	11
5.	Common System Requirements	16

PRECEDING PAGE BLANK NOT FILMED

X

1.0 INTRODUCTION

The system requirements itemized in this document constitute a major deliverable of the Advanced Information Processing System (AIPS) Program being performed for the NASA by The Charles Stark Draper Laboratory, Inc.

This program will develop and demonstrate a system architecture and the associated design, evaluation, and testing methodologies to serve the need for advanced information processing across a broad spectrum of future NASA missions. The architecture will incorporate relevant advanced hardware and software technologies to provide economically for integrated operation, reliability and fault tolerance, testability, manageability, and flexibility for growth and change. The last of these is of particular significance because the architecture must be adaptable to a range of applications for both space and aircraft missions. Also, mission requirements are expected to change with time, and the system design developed by the AIPS effort must provide the flexibility to accommodate such changes with minimum redesign, reverification, and revalidation.

The three phases of the projected program are to be accomplished sequentially. The program will have decision points at which it could be directed toward various applications. The Phase I effort is concentrating on the determination of application requirements (the subject of this document), a survey of technology, the development and definition of a suitable system architecture, and the definition of development methodologies. The second phase will proceed with hardware, software, and system design, and the construction and testing of breadboard and prototype systems. The third phase will continue validation of hardware, software, and system designs and will apply the generic design to the construction and integration of a mission-specific flight test article. A follow-on proof-of-concept flight test program is anticipated.

The objective of this document is to characterize the expected range of common requirements across applications and to identify the top-level system requirements for the AIPS. At this level, these requirements are intended to be application and implementation independent. They include subjective design objectives, quantifiable performance ranges, and selected functional characteristics. The detailed hardware, software, interface, environmental, and testing requirements will be developed during the design process and will be contained in a specification document that will be prepared in form and content subject to MIL-STD-490 Type A.

This report contains:

- A description of the approach used to generate the AIPS requirements, including the initial performance matrix development ("Approach" and "Appendix A. Performance Matrices").

- The results of the AIPS application requirements survey including a discussion of excluded capabilities ("Application Survey Results").

- A description of the dimensions of growth anticipated and how they will be accomodated ("Projected Growth Requirements").

- A summary of the spectrum of common application requirements that were derived from the survey ("Common System Requirements").

- The top-level AIPS system requirements ("AIPS System Requirements").

The emphasis in this requirements definition effort has been on what the AIPS must be able to do, not how it should be designed to do it. The application surveys were utilized to characterize the range of possible functions to which an AIPS architecture might be applied, and not to constitute a definitive statement of that application's detailed requirements. The goal was to develop AIPS top-level system requirements that reflect the advanced processing and control requirements for major aerospace applications in the early 1990's.

NOTE: The Application Summaries of Figure 3, and Section 6: "AIPS System Requirements", contain the key material of this report. The other sections essentially record how it was generated.

2.0 APPROACH

The approach to the generation of the AIPS requirements is illustrated in Figure 1 and Figure 2. The first step was to identify applications, functions, and design parameters of interest (the three "performance matrix" dimensions approved by the AIPS Working Group at Langley Research Center on April 14, 1983, "Appendix A. Performance Matrices"). Questionnaires were then developed to acquire the data necessary to fill in these matrices. The questionnaires differed slightly between applications due to the different functions required by each. ("Appendix B. Example Questionnaire" contains an abbreviated version of one of the questionnaires used.) They were distributed on April 29, 1983 to the various NASA Centers as shown by Figure 1. The Working Group members from these Centers were asked to function as expediters to ensure that their respective Centers' questionnaires were completed.

Concurrently with these NASA Center efforts, CSDL completed questionnaires in-house for four applications (Manned Space Platforms, Unmanned Space Platforms, Manned Space Vehicles, and Commercial Transport Aircraft).

Both the internally and externally generated questionnaire responses were then entered into a computerized data base for ease of modification. The responses were summarized faithfully (as to respondees' interpretation, metrics, etc.) with the intention of gathering as complete a raw data base as possible. ("Appendix C. Application Summaries")

At this point in the process CSDL began to analyze these raw requirements data. A single summary version was generated for each application, with metrics converted to a common set, and only extreme, application-unique ("long pole") requirements eliminated ("Application Survey Results," and Figure 3).

Common system requirements were then itemized, reflecting the range of requirements encompassed by the application responses and the projected growth requirements that had already been built into the survey data by the respondents. ("Projected Growth Requirements" ; "Common System Requirements")

Finally, AIPS programmatic factors (e.g. budget, schedule, demonstration goals) were used to focus this range into a set of top-level AIPS System Requirements ("AIPS System Requirements").

APPLICATION SURVEY QUESTIONNAIRES

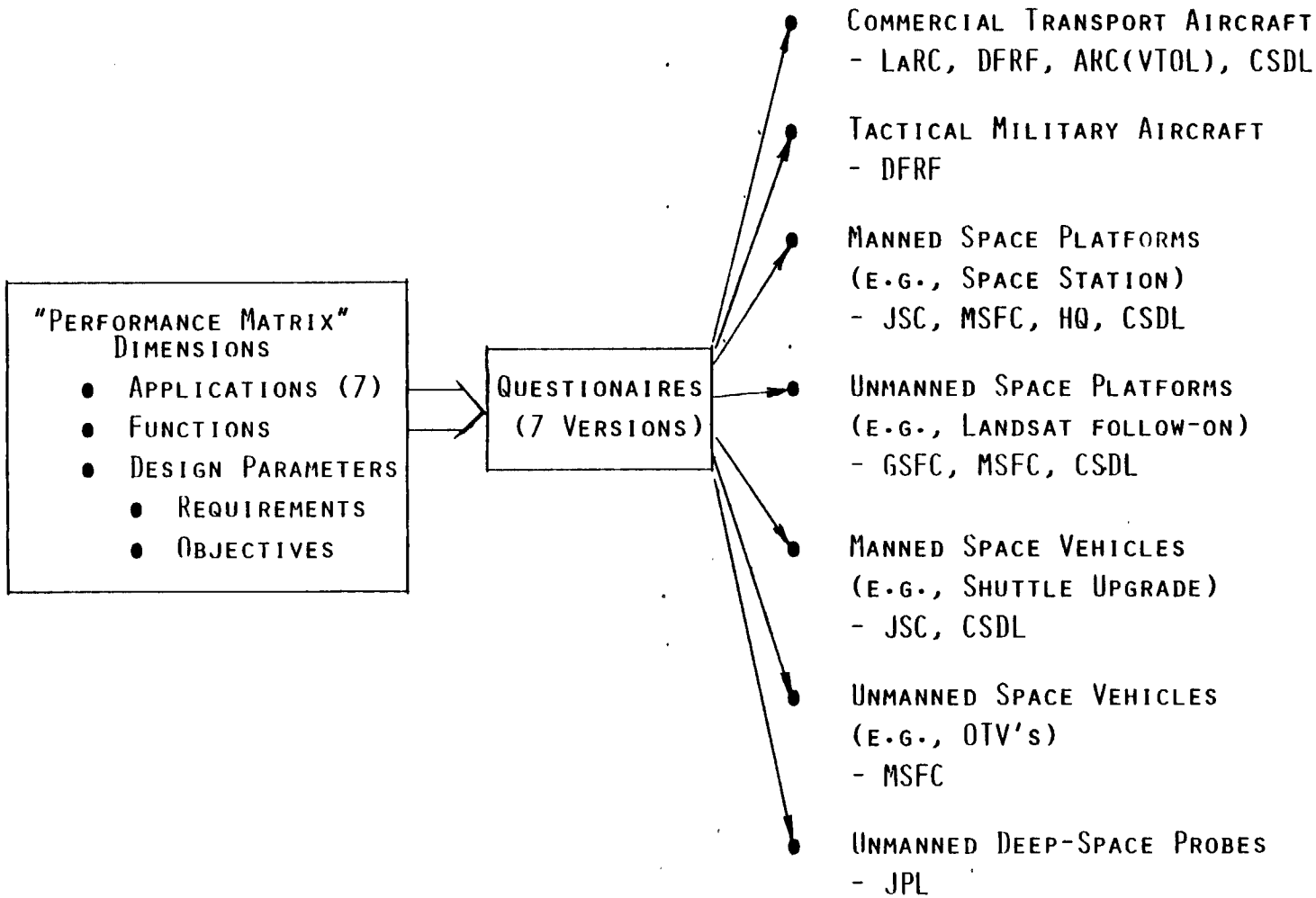


FIGURE 1

AIPS REQUIREMENTS

GENERATION PROCESS

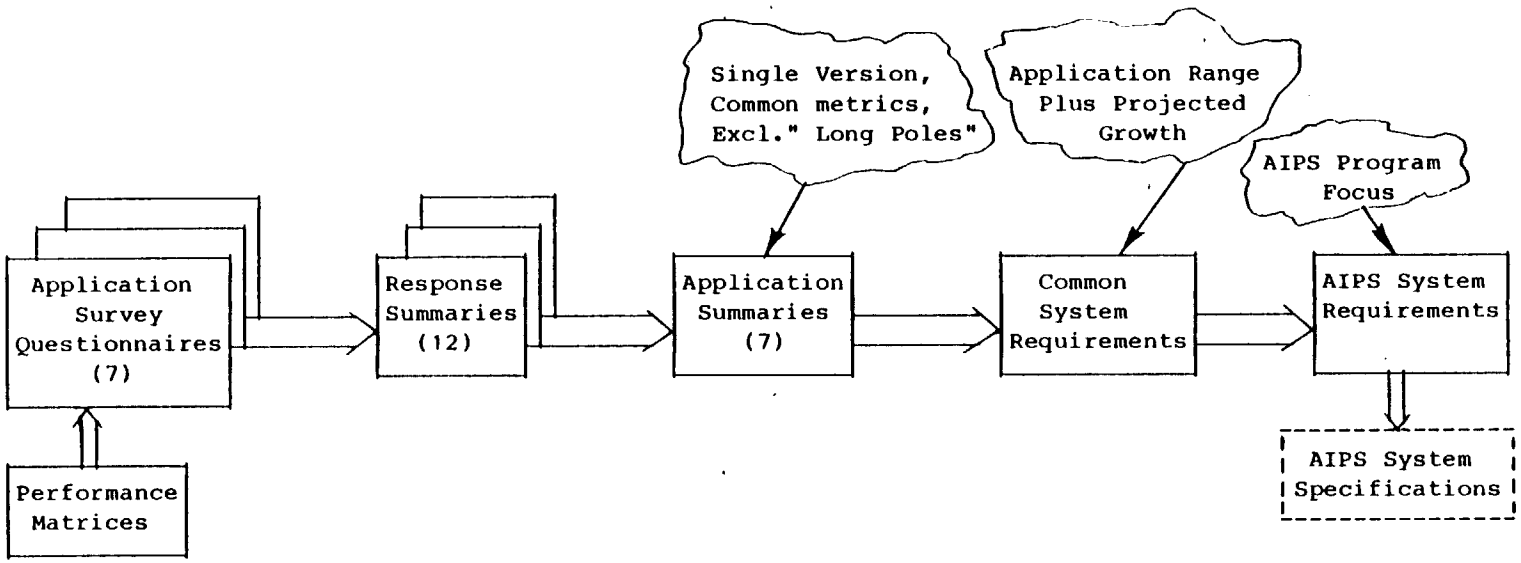


FIGURE 2

3.0 APPLICATION SURVEY RESULTS

The application requirements information collected via the questionnaires is summarized in "Appendix C. Application Summaries." In some cases several questionnaires were filled out for the same application. Each summary reflects as closely as possible the inputs of the respondents and does not always refer to identical parameters or metrics. This section records the results of reducing the various inputs to common interpretation and metrics and combines the several function-by-function response summaries per application into a single higher level summary version per application. This step also deleted extreme capability requirements that were not shared across the several applications and/or were not yet firm ("long poles"). The results are summarized in matrix form by Figure 3 and Figure 4. In general, these requirements and those in "Appendix C. Application Summaries" represent worst-case values.

3.1 RESPONSE CONTEXT

The quantitative performance data summarized in Figure 3 and "Appendix C. Application Summaries" represents rough extrapolations into the future on the part of the respondents and, therefore, reliance on the accuracy of any specific number should be appropriately tempered. However, the credibility of the characterizing ranges reflected by the composite summary is felt to be quite high.

The ratings of the nonquantifiable design objectives in Figure 4 are intended only to indicate the range of priorities given to each objective by different respondees for different applications. A wide disparity between respondees and between applications can be seen among most of these design objectives as to relative importance. Affordability was most often near the top in priority and integrability (i.e., the ability to integrate all elements of an avionics suite) was most often nearest the bottom.

For the AIPS program, adaptability will be an especially important design objective in that the AIPS architecture must be adaptable across applications as well as within a single application.

3.2 EXCLUDED CAPABILITIES

As mentioned earlier, certain application-specific or "long pole" capability requirements have been eliminated from the AIPS requirements. Because of the potential future importance of some of these extreme capabilities, they are discussed separately below. To the extent possible, the AIPS architectural evaluations will include, as an attribute, the ability of a candidate design to anticipate these presently excluded

PRECEDING PAGE BLANK NOT FILMED

requirements so that if or when their need becomes clearer, the AIPS concepts can be expanded to accomodate them.

"Long Poles" were considered to be those application-unique requirements that significantly exceeded the otherwise peak performance ranges across applications. Processing throughput, online and mass memory, input/output, and cycle rate requirements all experienced such excursions.

3.2.1 Processing Throughput

The processing throughput "long pole" requirements were associated with signal processing-type capabilities. For example, a Tactical Military Aircraft requirement was identified for 18 MIPS[1] (million instructions per second) to provide infrared, electro-optical and radar signal processing capabilities for aircraft weapons systems. Similar image processing demands could develop in the Manned and Unmanned Space Platform and Deep-Space Probe applications, though they were not explicitly identified. There also exists the possible need to augment or replace structural solutions to the large space structure flexure control problem with algorithmic solutions that provide real time mode identification and adaptive control. Again, a signal processing-like capability in the 10 to 100 MIPs range could be required.

These signal processing requirements were excluded from the summaries of Figure 3, although the AIPS will be expected to interface with and utilize mission-specific special processors of this type.

3.2.2 Online and Mass Memory

The most demanding online memory requirement identified was for 20 million bytes (MB) on a Manned Space Platform. Though very large in comparison to present systems, this requirement was not eliminated from the Figure 3 listing because no major architectural or technological impact was anticipated.

Various respondents for the Manned Space Platform also identified extremely high mass memory requirements, ranging up to a total of 400 MB. Again, these requirements were not eliminated from the Figure 3 summaries because no major AIPS design impact was anticipated.

Whenever possible, online memory requirements were distinguished from mass memory requirements. Where only online memory estimates were available, an equivalent amount of mass memory was postulated as a minimum nonvolatile requirement to back up the online memory.

A 12 MB Commercial Transport Aircraft requirement for TV display processing was excluded from the online memory summary and included under the

---

1 For the purpose of these rough estimates, MIPS and MOPS (million operations per second) are assumed to be equivalent.

mass memory totals. A 16 MB Tactical Military Aircraft online memory requirement in support of the application-unique Weapons System functions mentioned previously was excluded from both categories.

It should be noted that a third memory category, data recorders, was excluded from these Figure 3 summaries. These mission-specific devices would not normally contain code or interact directly with the AIPS processors or memory. An example was the 100 MB tape recorder for experiment data identified by the Deep-Space Probe respondent.

3.2.3 Input/Output

Unlike special processors that clearly involve a nearly open-ended series of custom responses to mission-specific demands, input/output resources, both between elements of the AIPS and between the AIPS and the external world (sensors/effectors, up/down link, etc), can be looked upon as general purpose. Furthermore, external I/O and the interconnection topology for the various AIPS elements are expected to be key AIPS architecture design drivers. Therefore, it was particularly troublesome to exclude potentially demanding requirements in the input/output area. Nevertheless, some performance bounds had to be delineated.

As expected, the Manned Space Platform again was the pacing application where the potential peak I/O demands, though not able to be well substantiated at this time, are several orders of magnitude beyond the 1-2 million (M) bits per second typical of the other applications. Communications, Payload Support, and Experiment Support each ranged to 300M bits/second (e.g., digital video transmissions). While an arithmetic summing of these bandwidths does not take into account the inevitable degree of non-simultaneous demand, a gigahertz bandwidth requirement could exist in the future.

The AIPS will, as with the special processors, be expected to interface with and utilize systems with bandwidths of this magnitude. However, because this requirement does not exist across other applications, and because its impact on the AIPS architecture and technology is potentially great, this bandwidth extreme was excluded from the present AIPS envelope of requirements.

3.2.4 Cycle Rate

Engine control was assumed to be under local or embedded processor control and, therefore, the demanding cycle rates were excluded from the overall AIPS requirements (e.g., 200 Hz for commercial transport aircraft propulsion management). This is consistent with general hierarchical philosophies that delegate demanding bandwidth or response time requirements to lower levels.

APPLICATION SUMMARIES (PERFORMANCE REQUIREMENTS)

	Allowable Failure Probability per mission	Mission Duration	Mean-Time-To Repair		Thru-put (MIPS)	Online Memory (bytes)	Mass Memory (bytes)	Peak I/O Rate (bits/sec)	Maximum Cycle Rate (HZ)	Minimum Transport Lag (ms)
			Onboard	Ground						
Commercial Transport Aircraft	10^{-9}	10 hrs	N/A	6 Mos	5.5	2M (12M)	15M	750K	100 (200)	5
Tactical Military Aircraft	10^{-7}	4 hrs	N/A	300 hrs	6.0 (18)	1M	100M	1M	50	10
Manned Space Platforms	10^{-2}	20 yrs	24 hrs	90 days	15.0	20M	400M	15M (1000M)	50	10
Unmanned Space Platforms	10^{-2}	5 yrs	N/A	90 days	2.0	750K	750K	150K	100	5
Manned Space Vehicles	10^{-7}	10 days	2 hrs	2 wks	1.5	3M	3M	1.0M	25	20
Unmanned Space Vehicles	10^{-6}	1 wk	N/A	60 days	0.5	300K	300K	1.5M	10	10
Unmanned Deep-Space Probes	10^{-2}	5 yrs	N/A	N/A	0.5	300K	1M (100M)	1.5M	20	10

Parentheses denote an excluded capability ("Long Pole")

FIGURE 3

APPLICATION SUMMARIES (DESIGN OBJECTIVES)

Application	Adaptability	Affordability	Integrability	Manageability	Realizability	Testability
Commercial Transport Aircraft	6	1	5	3	2	4
	3	2	4	5	6	1
Tactical Military Aircraft	4	3	6	5	2	1
Manned Space Platform	1	4	5	6	2	3
	3	2	6	5	1	4
	3	4	5	1	6	2
	3	1	6	2	5	4
Unmanned Space Platform	4	1	2	3	6	5
	5	4	6	3	1	2
Manned Space Vehicle	4	1	6	5	2	3
Unmanned Space Vehicle	2	4	5	6	3	1
Unmanned Deep-Space Probes	4	2	5	6	1	3

Notes: Ratings range from most desirable (1) to least necessary (6).
The multiple responses for three applications are indicated.

FIGURE 4

4.0 PROJECTED GROWTH REQUIREMENTS

The Application Survey Questionnaire responses reflected, for the most part, the projected growth in requirements to the intended 1990's operational time frame. These include varying performance margins for: traditional, relatively stable functions; historically less stable functions (e.g., displays and controls, systems checkout, redundancy management); and potentially demanding new functions (TV text and graphics, structural control).

If past experience is repeated, these present extrapolations will fall short in certain areas. Also, additional growth must be anticipated for yet undefined new functions.

Therefore, in order to avoid the traditional need to provide the enormous excess initial capacity implied, AIPS architectural features will be provided that accomodate:

- Addition of major AIPS elements (e.g., processors, memory, input/output devices).
- Insertion of higher performance technology.
- Modification for greater system reliability and/or depth of fault tolerance.
- Cumulative verification and validation to avoid total system retest subsequent to modification.

PRECEDING PAGE BLANK NOT FILMED

PAGE 12 INTENTIONALLY BLANK

5.0 COMMON SYSTEM REQUIREMENTS

The ranges of requirements itemized in Figure 5 characterize the spectrum of needs that exist across the several applications surveyed ("Appendix C. Application Summaries") and summarized in Figure 3. Specific design requirements, i.e., points within these ranges, will depend on the application being addressed. The "AIPS System Requirements" which are listed in Section 6.0 represent a typical first step towards this increased specificity, in this case for the AIPS proof-of-concept demonstration.

Figure 5 is in essence a summary of what the filled in "performance matrices" revealed, which, together with the AIPS System Requirements, provide a high level AIPS system functional characterization.

PRECEDING PAGE BLANK NOT FILMED

INTENTIONALLY BLANK

COMMON SYSTEM REQUIREMENTS

CRITERION	REQUIREMENT
ENVIRONMENT	MUST CONFORM TO APPLICABLE SPECIFICATIONS - ARINC, SAE, FAA, NASA, AND MIL-STDS.
PHYSICAL DISPERSION	ARCHITECTURE MUST BE COMPATIBLE WITH PHYSICAL DISPERSION.
RELIABILITY AND MAINTENANCE	ALLOWABLE FAILURE PROBABILITIES PER MISSION RANGE FROM 10^{-9} FOR A 10-HR MISSION WITH NO REPAIR TO 10^{-2} FOR A 20-YR MISSION WITH REPAIR. WITHIN A MISSION (APPLICATION), A RANGE OF RELIABILITY REQUIREMENTS MUST BE ACHIEVABLE.
THROUGHPUT	TOTALS FOR APPLICATIONS RANGE FROM 500 KIPS TO 15 MIPS.
MEMORY	TOTAL ONLINE MEMORY RANGES FROM 300K TO 20M BYTES. TOTAL MASS MEMORY RANGES FROM 300K TO 400M BYTES.
INPUT/OUTPUT RATE	PEAK TOTALS RANGE FROM 150K TO 15M BITS/SEC.
TIMING	CYCLE RATES FROM ON-DEMAND TO 100 HZ, TRANSPORT LAG TO 5 MS, STABLE CYCLE RATES.

FIGURE 5

6.0 AIPS SYSTEM REQUIREMENTS

This section contains the requirements imposed on the AIPS by the needs of the applications surveyed. Since the AIPS is a generalized architecture which may evolve into several realizations, these requirements are meant to place design constraints on the architecture which permit the implementation of a variety of systems with the characteristics defined in these requirements. As a goal, AIPS should provide the common thread of an architecture that exists in all application realizations. For each realization, however, these general, system-level requirements will be augmented by additional application-specific requirements.

The AIPS program will, during the development process, maintain the ability to trace each design decision back to its requirement(s).

The AIPS system-level requirements are presented on the following pages. These requirements serve two purposes: they bound what is expected of the AIPS architecture; and they define what is required for the proof-of-concept demonstrations. Budget, schedule, available technology, and AIPS demonstration goals constrain the latter most directly.

1. ENVIRONMENT AND IMPLEMENTATION

a. The AIPS must be able to be implemented with components conforming to the appropriate environmental specifications (e.g., radiation hardening, temperature, vibration/acceleration limits), and power, weight, and volume characteristics for each specific application. (i.e., the AIPS architecture should be as insensitive to alternate realizations as is practical).

2. PHYSICAL DISPERSION

a. The AIPS elements shall be capable of physical dispersion for reason of environmental protection, damage protection, or proximity to sensors and effectors.

3. FUNCTION DISTRIBUTION

a. The AIPS architecture shall support the distribution of application functions among the processing elements.

b. The AIPS for the proof-of-concept demonstrations shall contain a sufficient number of processing elements to satisfy this requirement.

4. RELIABILITY AND MAINTENANCE

a. The AIPS architecture must permit the achievement of reliability levels commensurate with a range of applications and their respective maintenance strategies (e.g., allowable AIPS failure probabilities per mission range from 10^{-9} for a 10-hr mission with no repair to 10^{-2} for a 20-year mission with repair).

b. For each application, the AIPS must incorporate a range of reliability requirements to support functions of varying criticality.

c. These reliability requirements encompass detection and recovery from both internally and externally induced hardware and software failures.

d. The AIPS shall provide the capability to remain fully operational after any single failure.

e. The AIPS shall provide the capability for automatic fault detection, identification, and recovery.

f. The AIPS fault detection, identification, and recovery techniques shall include the capability to mask data errors.

g. The AIPS shall contain system fault detection, identification, and recovery techniques that are transparent to the applications software.

h. The AIPS shall provide for the ability to perform online repair.

18 INTENTIONALLY BLANK
PRECEDING PAGE BLANK NOT FILMED

5. THROUGHPUT

a. The AIPS architecture shall be capable of throughput expansion to 100 MIPS (million instructions per second). Total throughput refers to the combined processing capabilities which are available to support application functions.

b. The AIPS for the proof-of-concept demonstrations shall have a minimum total throughput of 3 MIPS.

c. These numbers do not include any processor redundancy requirements.

6. MEMORY

a. The AIPS architecture shall be capable of memory expansion to 500 million bytes. This memory can be divided into two general types: 1) online memory for the storage of currently executing or soon-to-be-executed programs, and 2) mass memory for the storage of programs and data for which immediate access is not required. The partition between these two types is application-specific.

b. The AIPS architecture shall not require the use of mass memory.

c. The AIPS for the proof-of-concept demonstrations shall have a minimum of 1 million bytes of online memory and a minimum of 10 million bytes of mass memory.

d. These numbers do not include any memory redundancy requirements.

7. INPUT/OUTPUT

a. The AIPS architecture shall be capable of expansion of total external input/output to 100M bits/second.

b. The AIPS for the proof-of-concept demonstrations shall be capable of performing a minimum total external I/O rate of 3M bits per second.

c. These numbers do not include any I/O redundancy requirement or communication protocol overhead.

d. The AIPS for the proof-of-concept demonstrations shall utilize common external I/O interfacing elements.

8. TIMING

a. The AIPS shall provide system-wide knowledge of real time with a clock accuracy and quantization commensurate with application-specific requirements.

b. The AIPS for the proof-of-concept demonstrations shall include the capability to provide a minimum transport lag of 5ms and a maximum cycle rate of 100 Hz.

9. SPECIAL CHARACTERISTICS -

a. The AIPS shall be capable of interfacing with and utilizing special processing equipment such as signal processors, and very high data rate intercommunication such as digital video transmissions.

b. The AIPS for the proof-of-concept demonstrations shall not include these special elements.

10. ADAPTABILITY

a. The AIPS architecture shall minimize sensitivity to changes in functional requirements, performance goals, and levels of desired reliability and/or fault tolerance.

b. It shall be possible to physically or functionally add to the AIPS without affecting other functions with which the added function has no communication.

c. The AIPS shall be amenable to the insertion of higher performance technology elements.

11. PROGRAMMING LANGUAGES

a. The AIPS architecture shall not preclude the simultaneous use of multiple high order languages.

b. For the proof-of-concept demonstrations, the AIPS software shall be programmed using a single high order language.

c. AIPS breadboard or prototype systems will demonstrate multiple high order language compatibility.

12. PROCESSING ELEMENTS

a. The AIPS architecture shall not preclude the simultaneous use of multiple instruction set architectures (ISA's).

b. For the proof-of-concept demonstrations, all AIPS processing elements shall use a single processor ISA.

c. AIPS breadboard or prototype systems will demonstrate multiple ISA compatability.

13. POWER

a. The AIPS shall include power conditioning, distribution, and control techniques that provide reliable, fault tolerant service to its elements.

14. METHODOLOGY

a. The AIPS shall support the utilization of methodologies and tools that enhance analysis, design, design evaluation, verification, and validation of performance, reliability, and cost characteristics.

15. VERIFICATION AND VALIDATION

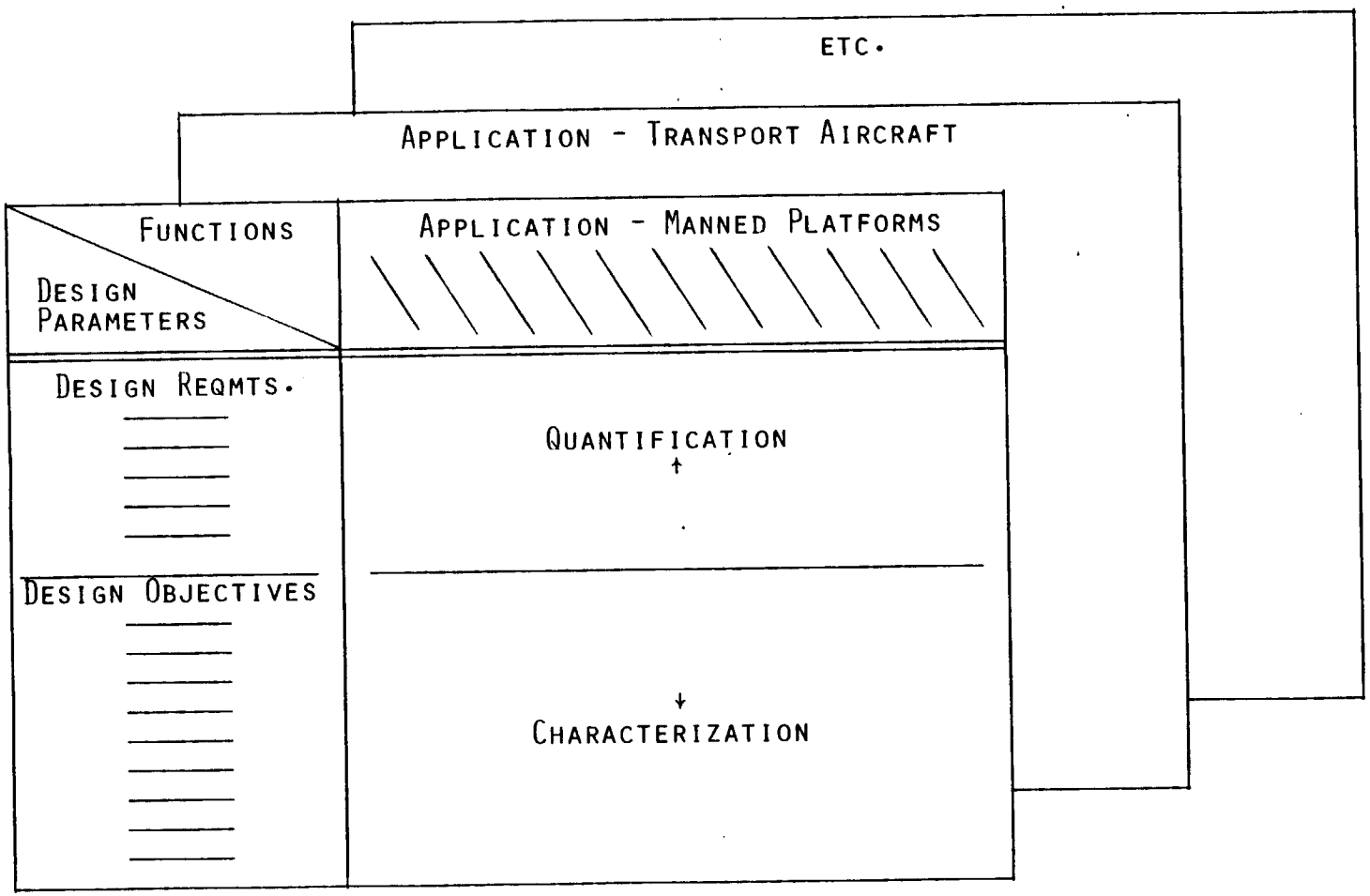
a. The AIPS shall utilize verification and validation techniques that do not require total system simulations, (i.e., the AIPS verification and validation will be performed using logical proofs, math models, selected subsystem or element simulation, and internal and external hardware and software aids such as BIT, HOL "enforcement" features, and test points for both stand-alone and integrated testing. Examples of the latter include the ability to stop the AIPS clock(s); to step processor instructions; to log faults, machine states and reconfiguration history; to record data other than normal I/O.)

b. Cumulative verification techniques shall be employed to minimize the required reverification after changes to functions where inter-function communication exists.

APPENDIX A. PERFORMANCE MATRICES

This appendix contains key viewgraphs from the presentation to the AIPS Working Group at LaRC on April 14, 1983.

REQUIREMENTS DOCUMENTATION
("PERFORMANCE MATRICES")



APPLICATIONS*	SURVEY SUBJECTS
• TRANSPORT AIRCRAFT	LARC/DRYDEN
• MILITARY AIRCRAFT	DRYDEN/AF
• MANNED PLATFORMS (SPACE STATION)	JSC/MSFC
• UNMANNED PLATFORMS	GSFC/MSFC/(AF)
• MANNED VEHICLES (SHUTTLE UPGRADE, OTV)	JSC
• UNMANNED VEHICLES (OTV, TMS)	MSFC/JSC
• UNMANNED DEEP-SPACE PROBES	JPL

* SURVEY MAY SUGGEST CONSOLIDATION POSSIBILITIES.

FUNCTIONAL REQUIREMENTS (TRANSPORT & MILITARY AIRCRAFT)

- BASIC FLIGHT CONTROL (AUTOPILOT AND FLIGHT DIRECTOR)
- CATEGORY III AUTOLAND
- FLIGHT-CRITICAL FLIGHT CONTROL (STATICALLY UNSTABLE A/C)
- FLUTTER CONTROL/LOAD ALLEVIATION
- FLIGHT MANAGEMENT (PERFORMANCE OPTIMIZATION/4D NAV)
- PROPULSION CONTROL
- SYSTEMS MONITORING AND CONTROL (HYDRAULIC, ELECTRIC, FUEL, ETC.)
- AIR DATA
- COMMUNICATIONS, NAVIGATION, IDENTIFICATION, WX RADAR
- THREAT AND COLLISION AVOIDANCE SYSTEM
- MODE-S DATA LINK
- INERTIAL/GPS/MLS NAVIGATION
- COCKPIT DISPLAYS (ATTITUDE, STATUS, CHECKLISTS)
- AURAL AND VISUAL CAUTIONS AND WARNINGS
- ENVIRONMENTAL CONTROL/PASSENGER SERVICES
- FLIGHT-DATA RECORDING
- TERRAIN FOLLOWING/AVOIDANCE*
- JTIDS
- TARGET ACQUISITION/TRACKING SYSTEMS (RADAR, IR, ETC.)*
- MILITARY NAV SYSTEMS (TACAN, SAR, LANTIRN, ETC.)*
- MOVING MAP DISPLAYS*
- WEAPONS MANAGEMENT*

*MILITARY ONLY

FUNCTIONAL REQUIREMENTS (MANNED & UNMANNED PLATFORMS & VEHICLES)

- NAVIGATION (ONBOARD)
- NAVIGATION (AIDED)
- GUIDANCE (BOOST, RE-BOOST; BRAKING, ENTRY)
- ATTITUDE CONTROL (INCL. RCS)
- STRUCTURAL CONTROL (E.G., VIBRATION SUPPRESSION)
- ENVIRONMENTAL CONTROL; LIFE SUPPORT*
- POWER GENERATION
- POWER DISTRIBUTION AND CONTROL
- FLUIDS MANAGEMENT (E.G., PROPELLANTS)
- PROPULSION STAGE MANAGEMENT (INCL. ENGINE CONTROL)
- ACTIVE THERMAL CONTROL
- TRAFFIC CONTROL (INCL. TRACKING)
- COMMUNICATIONS
- COMMAND/DATA ACQUISITION AND PROCESSING
- TV TEXT AND GRAPHICS*
- AUDIO*
- INTEGRATED DISPLAYS AND CONTROL*
- OPERATIONS PLANNING AND SCHEDULING
- DATA MANAGEMENT (INCL. DISTRIBUTION, BULK MEMORY)
- FACILITIES MANAGEMENT (INCL. LOGISTICS, INSTRUMENTATION)
- MEDICAL SUPPORT*
- PAYLOAD OPERATIONS (INCL. REMOTE MANIPULATOR)
- EXPERIMENT SUPPORT
- CHECKOUT

*MANNED ONLY

FUNCTIONAL REQUIREMENTS (UNMANNED DEEP-SPACE PROBES)

- NAVIGATION (ONBOARD)
- NAVIGATION (AIDED)
- GUIDANCE (MIDCOURSE AND TERMINAL)
- ATTITUDE CONTROL (INCL. RCS)
- ENVIRONMENTAL CONTROL
- POWER GENERATION
- POWER DISTRIBUTION AND CONTROL
- FLUIDS MANAGEMENT (E.G., PROPELLANTS)
- PROPULSION STAGE MANAGEMENT (INCL. ENGINE CONTROL)
- ACTIVE THERMAL CONTROL
- COMMUNICATIONS AND TRACKING
- COMMAND/DATA ACQUISITION AND PROCESSING
- TV AND OTHER REMOTE SENSOR SUPPORT
- OPERATIONS PLANNING AND SCHEDULING
- DATA MANAGEMENT (INCL. DISTRIBUTION, BULK MEMORY)
- SUBSYSTEMS MANAGEMENT
- EXPERIMENT/INSTRUMENTATION SUPPORT

DESIGN REQUIREMENTS (QUANTIFIABLE, OBJECTIVE)

- PROCESSING
  - COMPUTATION THRUPUT AND TYPE (LOGICAL, ARITHMETIC PRECISION AND DYNAMIC RANGE, TEXT, OTHER)
  - MEMORY SIZE (INSTRUCTION/DATA, MAIN/BULK)
  - INPUT/OUTPUT (INTERFUNCTION TRAFFIC DENSITY, PEAK/AVERAGE BIT RATE, # OF PARAMETERS AND SIZE)
  - TIMING CHARACTERISTICS (CYCLE RATE(S), JITTER, TRANSPORT LAG, RESPONSE TIME)
  - SPECIAL CHARACTERISTICS (SIGNAL PROCESSING, OTHER)

- RELIABILITY
  - OVERALL MISSION (DURATION, SUCCESS PROBABILITY, OPERATIONAL STRATEGY)
  - FUNCTION CRITICALITY (LIFE, VEHICLE, MISSION, ECONOMY; IMPORTANCE RELATIVE TO OTHERS)
  - DESIRED FUNCTION SUCCESS PROBABILITY (OVER MISSION DURATION AND/OR FAILURE RATE PER HOUR)
  - CRITICAL MINIMUM FUNCTION SUCCESS PROBABILITY (DITTO)
  - TOLERANCE TO ERRONEOUS INPUT/OUTPUT (# OF CONSECUTIVE ITERATIONS)
  - ONBOARD MAINTENANCE (AVAILABILITY, MTTR)
  - GROUND MAINTENANCE (SCHEDULED INTERVAL, ACCEPTABLE UNSCHEDULED PROBABILITY)

DESIGN REQUIREMENTS (QUANTIFIABLE, OBJECTIVE)

- ENVIRONMENT
  - LIGHTNING
  - VIBRATION/ACOUSTICS
  - RADIATION
  - TEMPERATURE
  - EMI
  - PRESSURE
  - HUMIDITY
  - EMP
  - ACCELERATION/SHOCK

DESIGN OBJECTIVES (NON-QUANTIFIABLE, SUBJECTIVE)

- ADAPTABILITY (FLEXIBILITY)
  BETWEEN APPLICATIONS, FOR TECHNOLOGY UPGRADE, FOR CAPABILITY GROWTH, FOR FUNCTIONAL CHANGE, FOR OPERATIONAL EVOLUTION

- TESTABILITY (ASSESSABILITY, VALIDATIBILITY, CERTIFIABILITY)
  BUILT-IN TESTS, MODULARITY, TOOLS, METHODOLOGIES

- MANAGEABILITY
  PARTITIONED TO EASE CONTRACTUAL INTERFACES, SELECTIVE UPGRADING, SECOND SOURCING; STANDARDS; VISIBLE DESIGN PROCESS

- AFFORDABILITY (REPAIRABILITY, MAINTAINABILITY)
  UTILIZE STANDARDS, TOOLS, METHODOLOGIES DURING DEVELOPMENT, OPERATION, MAINTENANCE

- INTEGRABILITY
  FAVORING OR CAPABLE OF INTEGRATED OPERATION

- PHYSICAL REALIZABILITY
  POWER, MASS, VOLUME

APPENDIX B. EXAMPLE QUESTIONNAIRE

This appendix contains an example of the application questionnaires that were sent to the NASA Centers surveyed. The example questionnaire is abbreviated only in that it does not repeat each of the Navigation function questions for each of the other listed functions.

PRECEDING PAGE BLANK NOT FILMED

32

DEEP SPACE PROBE REQUIREMENTS QUESTIONNAIRE

April 28th, 1983

The Charles Stark Draper Laboratory, Inc.
555 Technology Square
Cambridge, Massachusetts 02139

PRECEDING PAGE BLANK NOT FILMED

CONTENTS

1.0 APPLICATION SPECIFIC REQUIREMENTS 1
1.1 Environment 1
1.2 General 2
1.2.1 Physical Dispersion 2
1.2.2 Overall Mission Reliability 3
1.2.3 Maintenance 4
1.3 Design Objectives 5

2.0 FUNCTION SPECIFIC REQUIREMENTS 6
2.1 Deep Space Probe - Navigation 7
2.1.1 Throughput 7
2.1.2 Memory 8
2.1.3 Timing Characteristics 9
2.1.4 Input/Output 10
2.1.5 Special Characteristics 11
2.1.6 Function Criticality 12
2.1.7 Success Probability 13
2.2 Deep Space Probe - Guidance 14
2.2.1 Throughput 14
2.2.2 Memory 15
2.2.3 Timing Characteristics 16
2.2.4 Input/Output 17
2.2.5 Special Characteristics 18
2.2.6 Function Criticality 19
2.2.7 Success Probability 20
2.3 Deep Space Probe - Flight Control 21
2.3.1 Throughput 21
2.3.2 Memory 22
2.3.3 Timing Characteristics 23
2.3.4 Input/Output 24
2.3.5 Special Characteristics 25
2.3.6 Function Criticality 26
2.3.7 Success Probability 27
2.4 Deep Space Probe - Environmental Control 28
2.4.1 Throughput 28
2.4.2 Memory 29
2.4.3 Timing Characteristics 30
2.4.4 Input/Output 31
2.4.5 Special Characteristics 32
2.4.6 Function Criticality 33
2.4.7 Success Probability 34
2.5 Deep Space Probe - Power Generation 35
2.5.1 Throughput 35
2.5.2 Memory 36
2.5.3 Timing Characteristics 37
2.5.4 Input/Output 38
2.5.5 Special Characteristics 39
2.5.6 Function Criticality 40
2.5.7 Success Probability 41
2.6 Deep Space Probe - Power Distribution and Control 42
2.6.1 Throughput 42

2.6.2 Memory 43
2.6.3 Timing Characteristics 44
2.6.4 Input/Output 45
2.6.5 Special Characteristics 46
2.6.6 Function Criticality 47
2.6.7 Success Probability 48
2.7 Deep Space Probe - Propulsion Management 49
2.7.1 Throughput 49
2.7.2 Memory 50
2.7.3 Timing Characteristics 51
2.7.4 Input/Output 52
2.7.5 Special Characteristics 53
2.7.6 Function Criticality 54
2.7.7 Success Probability 55
2.8 Deep Space Probe - Active Thermal Control 56
2.8.1 Throughput 56
2.8.2 Memory 57
2.8.3 Timing Characteristics 58
2.8.4 Input/Output 59
2.8.5 Special Characteristics 60
2.8.6 Function Criticality 61
2.8.7 Success Probability 62
2.9 Deep Space Probe - Communications 63
2.9.1 Throughput 63
2.9.2 Memory 64
2.9.3 Timing Characteristics 65
2.9.4 Input/Output 66
2.9.5 Special Characteristics 67
2.9.6 Function Criticality 68
2.9.7 Success Probability 69
2.10 Deep Space Probe - Systems Management 70
2.10.1 Throughput 70
2.10.2 Memory 71
2.10.3 Timing Characteristics 72
2.10.4 Input/Output 73
2.10.5 Special Characteristics 74
2.10.6 Function Criticality 75
2.10.7 Success Probability 76
2.11 Deep Space Probe - Mission Scheduling 77
2.11.1 Throughput 77
2.11.2 Memory 78
2.11.3 Timing Characteristics 79
2.11.4 Input/Output 80
2.11.5 Special Characteristics 81
2.11.6 Function Criticality 82
2.11.7 Success Probability 83
2.12 Deep Space Probe - Systems Checkout 84
2.12.1 Throughput 84
2.12.2 Memory 85
2.12.3 Timing Characteristics 86
2.12.4 Input/Output 87
2.12.5 Special Characteristics 88
2.12.6 Function Criticality 89
2.12.7 Success Probability 90
2.13 Deep Space Probe - Experiment Support 91

2.13.1 Throughput 91
2.13.2 Memory 92
2.13.3 Timing Characteristics 93
2.13.4 Input/Output 94
2.13.5 Special Characteristics 95
2.13.6 Function Criticality 96
2.13.7 Success Probability 97

1.0 APPLICATION SPECIFIC REQUIREMENTS

1.1 ENVIRONMENT

Which of the following environmental criteria apply to your application? If possible, indicate the appropriate environmental specifications.

ANSWER BELOW

Environment	Applicable Specification(s)
Temperature	
Pressure	
Humidity	
Vibration	
Shock	
Acceleration	
Acoustics	
EMI	
Lightning	
EMP	
Radiation	
Other	

1.2 GENERAL

1.2.1 PHYSICAL DISPERSION

Some applications require that the components of the data processing system be physically dispersed. Please indicate if this requirement exists for the Deep Space Probe.

ANSWER BELOW

Must the processing system for the Deep Space Probe be physically dispersed?

YES _____ NO _____

Indicate the reason(s) for the requirement:

Proximity to sensors and actuators ____

Environmental protection ____

Physical damage redundancy ____

Other (explain) ____

1.2.2 OVERALL MISSION RELIABILITY

State the maximum mission duration (hours, days etc.) for the Deep Space Probe. State the required overall mission reliability apportioned to the Information Processing System for the Deep Space Probe.

Please state the requirement in the form of a mission success probability.

ANSWER BELOW

1.2.3 MAINTENANCE

State the onboard maintenance constraints and strategy as applicable to the Deep Space Probe.

Will onboard maintenance be allowed? If yes, what is the Mean-Time-To-Removal & Replacement? That is, how frequently would repair personnel examine system status and take corrective actions such as remove and replace a faulty module (once-an-hour, once-a-day etc.)? If such a constraint does not exist and it is the designer's choice to impose a desired MTTR, state so.

What is the onboard availability requirement for the Information Processing System as a whole for the Deep Space Probe? That is, can any system down time be tolerated? If so, state what fraction of mission time or for what length of time can the system be unavailable?

ANSWER BELOW

State the ground maintenance requirements for the Deep Space Probe.

Is the ground maintenance strategy to provide on-demand maintenance (after every mission/flight/sortie etc.)? Or is it to have a scheduled maintenance interval (every T flight-hours etc.)?

In case of a scheduled maintenance interval, what is the maximum acceptable probability of requiring unscheduled maintenance?

What is the system availability requirement or dispatch reliability apportioned to the Information Processing System?

ANSWER BELOW

1.3 DESIGN OBJECTIVES

Please indicate the order of importance of the following design objectives, i.e., if you were forced to, what objectives would you compromise last. Try to adhere to the following rules:

1. First in importance = 1,..., sixth in importance = 6

2. Do not rank any equally

Add other design objectives if appropriate.

ANSWER BELOW

____ Adaptability (Flexibility)
Between applications, for technology upgrade, for capability growth, for functional change, for operational evolution

____ Affordability (Repairability, Maintainability)
Utilize standards, tools, methodologies during development, operation, maintenance

____ Integrability
Favoring or capable of integrated operation

____ Manageability
Partitioned to ease contractual interfaces, selective upgrading, second sourcing; standards; visible design process

____ Physical Realizability
Power, mass, volume

____ Testability (Verifiability, Certifiability)
Built-in tests, modularity, tools, methodologies

2.0 FUNCTION SPECIFIC REQUIREMENTS

The following is a list of functions. Please feel free to modify the list as appropriate for the Deep Space Probe.

Navigation

Guidance

Flight control

Environmental control

Power generation

Power distribution and control

Propulsion management

Active thermal control

Communications (tracking, command, data)

Systems management (instrumentation, data recording)

Mission scheduling

Systems checkout

Experiment support (TV, sensors)

2.1 DEEP SPACE PROBE - NAVIGATION

2.1.1 THROUGHPUT

Estimate the required highest-load throughput for this function. Use whatever units or measure you have the most confidence in. For example, if the function is thought to require 25% of a VAX 11/780, say that.

Some possible ways of expressing throughput are:

Number of instructions or operations per second (KIPS or KOPS)

Percentage of a particular computer's time

Multiple of what is required in some known application (also indicate the computer model used in the application)

Please do not include any operating system overhead in the estimated throughput.

ANSWER BELOW

Throughput _____

2.1.2 MEMORY

Estimate the memory requirements for Navigation. Indicate the size of the unit of memory (eg, byte).

If possible, indicate the separate requirements for code and data.

Also indicate what amount or percentage of the total memory required must be main execution memory and what amount or percentage can be bulk storage.

ANSWER BELOW

Unit size: 8-bit byte ___ 16-bits ___

32-bits ___

other _____

Memory required: code _____

data _____

total _____

Can this function be characterized as permitting the storage of a significant percentage of its code or data in or on some type of mass storage medium? If yes, please elaborate.

2.1.3 TIMING CHARACTERISTICS

This section requests information about the timing requirements of Navigation.

The cycle rate or samples per second should be quoted in hertz. If this function is an on-demand, non-cyclic one, indicate that fact.

The maximum allowable transport lag can be stated in terms of time or as a percentage of the cycle period.

The maximum response time can be stated in terms of either time or as a multiple of the cycle period.

Please indicate whether or not this function is especially sensitive to variations of its cycle rate.

ANSWER BELOW

Cycle rate (Hz) _____

Transport lag _____

Response time _____

Is this function particularly sensitive to cycle rate variations?

Yes ____ No ____

2.1.4 INPUT/OUTPUT

Estimate the average input and output requirements for Navigation assuming that it is not co-resident with any other application function. Indicate the quantity in units of either data-elements per second or bits per second. If data-elements are used, also indicate the bit length of the average element. In either case, also indicate if any communication protocol overhead is included.

Estimate the peak I/O requirements. Use data per second, bits per second or a multiple of the average requirement.

Also indicate the other functions that the Navigation function has high data communications with.

ANSWER BELOW

Units: data per second ___ bits per data ___

bits per second ___

Average I/O rate _____

Peak I/O rate _____

Is communication overhead included? Yes___

No ___

If yes, indicate what percent _____

Other functions _____

_____

_____

2.1.5 SPECIAL CHARACTERISTICS

This section requests information concerning any special processing requirements of the Deep Space Probe Navigation function.

Some examples of a special characteristic are:

Signal processing

Security requirements

Describe any such special requirement below.

ANSWER BELOW

2.1.6 FUNCTION CRITICALITY

Describe the criticality of the Navigation function.

The function might be critical in one or more of the following ways:

Life safety

Vehicle integrity

Mission success

Economy

ANSWER BELOW

Would the loss of this function result in

Loss of life ____

Loss of vehicle ____

Mission abort ____

Economic penalty ____

2.1.7 SUCCESS PROBABILITY

State the required probability of success of the Navigation function over the length of the mission.

ANSWER BELOW

Required Probability of Success _____

APPENDIX C. APPLICATION SUMMARIES

This appendix contains the following application survey response summaries:

Commercial Transport Aircraft - LaRC, CSDL

Tactical Military Aircraft - ARC/DFRF

Manned Space Platforms - NASA/HQ, MSFC, JSC, CSDL

Unmanned Space Platforms - GSFC, CSDL

Manned Space Vehicles - CSDL

Unmanned Space Vehicles - MSFC

Unmanned Deep-Space Probes - JPL

Where functions or design parameters were not addressed by a respondent, the associated row or column on the summary was deleted.

PRECEDING PAGE BLANK NOT FILMED

PRECEDING PAGE BLANK NOT FILMED

COMMERCIAL TRANSPORT AIRCRAFT (LaRC response)
COMPUTER REQUIREMENTS SURVEY

1.0 Application-Specific Requirements

1.1 Environment

Environment	Applicable Specification(s)
Temperature	__DO-160_____
Pressure	__DO-160, ARINC 414_____
Humidity	__DO-160_____
Vibration	__DO-160, DO-108_____
Shock	__DO-160, MIL-S-901_____
Acceleration	__DO-160_____
Acoustics	_____
EMI	__DO-160, DO-108, MS-461A____
Lightning	__SAE AE4L 81-2, FAA ADVISORY CIRCULAR 20-53, MIL STD 1757A
EMP	_____
Radiation	_____
Other	
Cooling	__ARINC 404_____
Power	__MS-704, MS-1332 B_____
Maintainability	__MS-470_____
Environmental	__MS-810_____
Construction	__MS-454_____

1.2 General

1.2.1 Physical Dispersion

Yes __X_____ No_____

Comments

__Proximity to sensors and actuators_____

__Physical damage redundancy_____

_____

_____

1.2.2 Overall Mission Reliablilty

__10 hours maximum mission time_____

__$P_F = 10^{-9}$ Flight Crucial Controls_____

__Maintain Twice Yearly_____

_____

1.2.3 Maintenance

Onboard

__Yes, On Board Maintenance will be_____

__allowed_____

Ground

__Scheduled Maintenance every 6 months.__

__Dispatch only with complement required to achieve 10^{-9} P_F.

__10^{-9} P_F will be probable application to allow dispatch

__with 1 system out._____

1.3 Design Objectives

Adaptability	__6_____
Affordability	__1_____
Integrability	__5_____
Manageability	__3_____
Realizability	__2_____
Testability	__4_____

COMMERCIAL TRANSPORT AIRCRAFT REQUIREMENTS MATRIX (LaRC response)

FUNCTION	THROUGHPUT (KOPS)	MEMORY (16 bit - K)	UTILIZE MASS MEMORY	INPUT/OUTPUT 16 bit words/s average/peak	Cycle rate/ Transport lag/ Response time	SAMPLE RATE VAR. SENSITIVE	MISSION SUCCESS (# of 9's)	Function Criticality	Notes
Navigation	- 350	- 32	- 256K	- 2048/2048	- 128Hz/10ms/ 2 cycles	- yes	- 9	- Life/Veh./ Mission/Ec.	- 1-3
Guidance	- 250	- 32	- 256K	- functional I/O only	- 20Hz/50ms/ 50ms	- yes	- 9 for 1 min. A/L	- Life/Veh./ Mission/Ec.	- 4
Flight Control	- 500	- 32	- no	- 200/220	- 20Hz/50ms/ 50ms	- yes	- 9	- Life/Veh./ Mission	- -
Structure Control	- 100	- .6	-	- 700/700	- 100Hz/10ms/ 10ms	- yes	- economic	- Economic	- 5,6
Environmental Control	- 10	- 1	-	- 24/24	- 1/na/na	- no	- economic	- Mission/Ec.	7,8
Power Generation	- insignificant computing requirements			-	-	-	- 9 for 'All Electric'	- Life/Veh.	- -
Power Dist. & Control	- 10	- 5	-	- 200	- 20Hz/-/100ms	- no	- 9 for 'All Electric'	- Economic	-
Fluids Management	- 20	- 4	-	- 20	- 2Hz/1sec/-	- no	- economic	- Mission/Ec.	- 8
Propulsion Management	- 1.5-2 MIPS	- 50	-	- 25K/25K bps	- 25&200Hz/ 1 cycle/-	- yes	- <9	- Mission/Ec.	- 10,11
Traffic Control	- 200	- 32	-	- 100K/100K bps	- .25/100ms/-	- no	- economic	- Mission/Ec.	- 8,12,13
Communications	- included within the Navigation function				-	-	-	-	-
Command and Data Acquisition	- have not had activities in this area to use as a basis for judgment							- Economic	- 8,14
TV Text and Graphics	- 1 VAX + 2 AMD 2903	- 3000(32-bit)	-	- 30K/100K bps	- 50Hz/na/40ms	- yes	- economic	- Mission/Ec.	- 8,9,15
Displays and Controls	- 300	- 32	-	- 250K/250K bps	- 50Hz/na/ .1 sec	- no	- 9	- Life/Veh./ Mission/Ec.	- 16
Systems Management	- 300	- 500	-	- 300/300	- 10 Hz/-/-	- no	- economic	- Mission/Ec.	- 8
Operations Planning	- 200	- 10	- included in Guid.	- 0/20K bps	- 1Hz/1sec/-	- no	- economic	- Mission/Ec.	- 8,17
Systems Checkout	- 100	- 16	-	- 10/100 Hz	- 10Hz/-/-	- no	- economic	- Mission/Ec.	- 8
Performance Management	- 300	- 128	- 1M bytes	- 3600/3600	- input 100Hz out 1Hz/-/-	- no	- economic	- Economic	- 8,18
Passenger Entertainment Sys.	- have not had occasion to work actively in this area							-	- -

Suggested additional function - Voice Control

COMMERCIAL TRANSPORT AIRCRAFT REQUIREMENTS MATRIX (LaRC response)

No.	Notes
1	Throughput includes allowance for double-precision slowness when computing NAV variables.
2	I/O assumes a strapdown inertial navigator, the IMU sets the navigation function mission success criteria.
3	GPS security code for emergency (hijack) situations.
4	Autoland is flight crucial near ground
5	Assume that structure control will be used only to satisfy overspeed requirements and not within normal a/c flight envelope.
6	Failure imposes economic penalty-- dispatch failure or airspeed constraints
7	Other functions: oxygen control
8	The required probability of success in avoiding mission abort or economic penalty is highly dependent on the details of the air transport system and the prevailing economic conditions. Therefore, no numerical value is assigned.
9	CSDL estimates 1 VAX + 2 AMD 2903 to have throughput of 1 MIP
10	- Electronic engine control. - Assume extensive analytical redundancy which requires much processing.
11	Probability of failure for loss of propulsion = 10^{-9}. The individual probabilities of failure for the propulsion control computers can be much higher since they are dual computers with a high diagnostic level on each engine and there are two to four engines on each airplane. By taking engines and controllers together, there are many success paths for the system.
12	Throughput estimates based on CDTI driven by ATCRBS Mode-S.
13	.25 Hz cycle rate is ATCRBS sweep rate.
14	Special Characteristic: Security for company information.
15	Output is CRT picture, input is basic sensor data.
16	Control of flight-crucial system would set the requirement on failure probability.
17	Sorting bulk data requires high computation rate.
18	The bubble memory is used in lieu of a tape recorder.
19	Much data processing/selection performed by processor.

PRECEDING PAGE BLANK NOT FILMED

PAGE 58 INTENTIONALLY BLANK

COMMERCIAL TRANSPORT AIRCRAFT (CSDL estimate)
COMPUTER REQUIREMENTS SURVEY

1.0 Application-Specific Requirements

1.1 Environment

Environment	Applicable Specification(s)
Temperature	RTCA DO-160
Pressure	"
Humidity	"
Vibration	"
Shock	"
Acceleration	"
Acoustics	"
EMI	"
Lightning	Modified Shuttle Specification
EMP	NA
Radiation	NA
Other	

1.2 General

1.2.1 Physical Dispersion

Yes X No

Comments
Proximity to sensors & effectors

Physical damage redundancy

1.2.2 Overall Mission Reliability

AIPS Loss of life/vehicle - E-9

AIPS Mission Failure - E-7

Dispatch Failure - E-2

Mission Duration - 10 hours

1.2.3 Maintenance

Onboard
Automated in-flight logging

Ground
Preflight checks / Post Flight Repair

Periodic Inspections (300 hrs)

Post Flight inspection of in-flight log

1.3 Design Objectives

Adaptability	3
Affordability	2
Integrability	4
Manageability	5
Realizability	6
Testability	1

COMMERCIAL TRANSPORT AIRCRAFT REQUIREMENTS MATRIX (CSDL estimate)
(System software not included)

FUNCTION	THROUGHPUT KIPS	MEMORY-16 BIT Main	UTILIZE MASS MEMORY	INPUT/OUTPUT 16 bit w/s	Loop Freq. Min. Hz	Loop Freq. Max. Hz	SAMPLE RATE VAR. SENSITIVE	MISSION SUCCESS (# of 9's)	FUNCTION CRITICALITY
Navigation	- 300	- 85K	- 128K	- 2000/ 200	- 1	100	- yes	- 9	- life/vehicle
Guidance	- 60	- 20K	- no	- 850/ 225	- 1	20	- no	- 9	- life/vehicle
Flight Control	- 80	- 15K	- no	- 650/ 225	- 10	25	- yes	- 9	- life/vehicle
Structure Control	- 120	- 5K	- no	- 1200/ 600	- 50	100	- yes	- 2	- economic
Environmental Control	- 2	- 3K	- no	- 20/ 4	- 1	1	- no	- 7	- mission
Power Gen., Dist. & Control	- 80	- 5K	- no	- 400/ 200	- 1	10	- no	- 7	- mission
Fluid Management (Fuel)	- 1	- 2K	- no	- 20/ 25	- 1	1	- no	- 7	- mission
Propulsion Management	- 20	- 8K	- no	- 1800/ 30	- 1	10	- no	- 7	- mission
Traffic Control	- 50	- 15K	- no	- 3000/ 100	- 1	10	- no	- 2	- economic
Communications	- 1	- 1K	- no	- 1/ 1	- .1	.1	- no	- 2	- economic
Displays and Controls	- 150	- 35K	- no	- 2000/ 3000	- 1	25	- no	- 9	- life/vehicle
Systems Management	- 5	- 35K	- no	- 200/ 110	- .1	1	- no	- 2	- economic
Operations Planning	- 1	- 1K	- no	- 1/ 1	- .1	.1	- no	- 2	- economic
Systems Checkout	- 5	- 6K	- no	- 200/ 60	- 1	1	- no	- 2	- economic
Performance Management	- 200	- 20K	- no	- 250/ 20	- 1	10	- no	- 2	- economic
Passenger Entertainment Sys.	- 1	- 1K	- no	- 1/ 1	- .1	.1	- no	- 2	- economic
Hydraulics System (added)	- 4	- 5K	- no	- 100/ 50	- 1	1	- no	- 9	- economic

TACTICAL MILITARY AIRCRAFT (ARC/DFRF response)
COMPUTER REQUIREMENTS SURVEY

1.0 Application-Specific Requirements

1.1 Environment

Environment	Applicable Specification(s)
Temperature	mil spec
Pressure	"
Humidity	"
Vibration	"
Shock	"
Acceleration	"
Acoustics	"
EMI	"
Lightning	"
EMP	"
Radiation	"
Other	

1.2 General

1.2.1 Physical Dispersion

Yes X No

Comments
Proximity to sensors and actuators
Simple physical packaging constraint
due to the aircraft structure.

Also due to some extent to EMI
considerations -- radar, threat warning

1.2.2 Overall Mission Reliablilty

Fighter/Interceptor: Varies 1.0 to 4.0 hrs
depending on mission. Mission success prob:
1 abort in 100K hrs. (note some later
specs allow 1 in 1000 hrs.)**

MTTR approx. = 300 hrs.

1.2.3 Maintenance

Onboard

Mission specific. Periodic and sortie
maint. required. Some less-critical
subsystems have a lesser requirement.

Ground

Same as onboard.

1.3 Design Objectives

Adaptability	4
Affordability	3*
Integrability	6
Manageability	5
Realizability	2
Testability	1

* Note: Affordability, if redefined in terms of life cycle cost, would subsume realizability and testability.

** Note: Know of no tactical fighter meeting either 1000 or 100,000 hours.

TACTICAL MILITARY AIRCRAFT REQUIREMENTS MATRIX (ARC/DFRF response)
(System software not included)

FUNCTION	THROUGHPUT (MOPS)	MEMORY (32 bits, K)	UTILIZE MASS MEMORY	INPUT/OUTPUT K words/sec	TIMING (rate/xport) Hz/ms	SAMPLE RATE VAR. SENSITIVE	MISSION SUCCESS (# of 9's)	FUNCTION CRITICALITY
Navigation	- 1	- 64	- Yes, for Moving Map >>100 megabits	- 1 (16 bit words)	- 50/	-	- 5	- life/veh./ mission
Guidance	- 1	- 64	-	- 1.25 (10 bit words)	- 25/<10	- Yes	- 5	- life/veh./ mission
Flight & Struct. Control*	- 1	- 64	- No	- 10 (10 bit words)	- 50/<10	- Yes	- 7	- life/veh./ mission
Propulsion Management	- Approx. = to Flight Control			-	-	-	-	-
Displays and Controls	- 1 (.5 for HUD)	- 64	- Yes, for Moving Map	-	- 50/<10	- Yes (HUD)	- 5	- life/veh./ mission
Systems Management								
Mission Setup	- < 5% of func.	- included in func.	-	-	- same as func.	-	-	-
FDIR	- 10% of func.	- "	-	-	- "	-	-	-
Weapon Systems Management	- 10-20 Total	- 4 MEG Total	-	- large	- 50/100	- Yes	- 5	- life/mission
Sensors/Imaging/Proc	- 18	-	-	- large	- 50/100	-	- 5	- life/mission
Closed Loop Control	- 1 - 2	-	-	- large	- 50/100	-	- 5	- life/mission
Displays/weapon rlse	- 1 - 2	-	-	- large	- 50/100	-	- 5	- life/mission

Suggested additional function - automated flight-fire control.

* Special characteristic: Best if floating point.

MANNED SPACE PLATFORM (NASA HQ response)
COMPUTER REQUIREMENTS SURVEY

1.0 Application-Specific Requirements

1.1 Environment

Environment	Applicable Specification(s)
Temperature	
Pressure	
Humidity	
Vibration	
Shock	
Acceleration	
Acoustics	
EMI	
Lightning	
EMP	
Radiation	
Other	

1.2 General

1.2.1 Physical Dispersion

Yes X No

Comments
Proximity to sensors and actuators
Distances to sensors and actuators
Distances to instruments, processing
equipment, laboratories, and users

1.2.2 Overall Mission Reliability
Mission duration -- 20 years with
repair, maintenance and evolution.
P(success)==>0.95 Because we can
fix it.

1.2.3 Maintenance

Onboard
Onboard MTTR · 1 Hr, Outboard MTTR · 2days
Coorbital platform MTTR · 2-4 weeks
Auto monitor system & bypass dependant
on store & forward capacity · 1 hr.

Ground
System will be partitioned into criticality
levels, so availability will be a function of level.

1.3 Design Objectives

Adaptability	3
Affordability	2
Integrability	6
Manageability	5
Realizability	1
Testability	4

MANNED SPACE PLATFORM REQUIREMENTS MATRIX (NASA HQ response)
(System software not included)

FUNCTION	THROUGHPUT (KIPS)	MEMORY (32 bits, K)	UTILIZE MASS MEMORY	INPUT-OUTPUT (bits/second)	TIMING (rate/xport /response)	SAMPLE RATE VAR. SENSITIVE	MISSION SUCCESS PROB.	FUNCTION CRITICALITY
Navigation and Guidance	-1/2 VAX 11/780	- 2000	- Yes	- 10K	- 1hz/2s/1s See Note 1	- Yes	- .95	- vehicle/mission/ economy
Attitude Control	- VAX 11/780	- 1000	- No	-	-10KHz/rt/ms	- Yes	- .99	- vehicle/mission/ economy
Structure Control	-1/4 VAX init.	- 350	- Probably	-	-	-	-	-
Environmental Control	- 1 to 2	- 200	- Yes	- 80	-.01Hz/1 min/ 1 min	- No	- .9999	- life/mission/ economy
Power Generation and Storage	- 2 to 4	- 350	- No	- 1600	-.01Hz/min/s	- No	- .9	- mission/economy
Communications	- Z80 class	- 30 (8 bits)	- No	- 300M	- 10Hz/.1s/.1s	- No	- .9	- mission/economy
Command and Data Acq.	- Z80	-	-	-	-	-	-	-
TV Text and Graphics	- 30% of VAX	- 100 (16 bits)	- Yes (Note 2)	- 24M	- 5MHz/min/min	- No	- .8	- economy
Displays and Controls	-1/2 VAX	- 700	- Yes	- 4000	- 100Hz/ms/ms	- Yes	- .99	- mission/economy
Systems Management	- 5 Z80's	- 600	- Yes	- 800	- 10Hz/s/s	- No	- .7	- economy
Operations Planning	- VAX	- 7000	- Yes	- 800	- .1Hz/min/min	- No	- .8	- mission/economy
Systems Checkout	-1/4 VAX	- 600	-	- 8000	- 100Hz/ms/ms	- No	- .8	- economy
Payload Support	-1/10 VAX	- 110	-	- 300M	- 1KHz/ms/s	- Yes	- .95	- economy
Experiment Support	-Z80/exp to VAX if SAR	- 0 to 5000	-	- 10 to 300M	- rates are .001 to 5MHz	-	- .95	- life/vehicle/ mission/economy

Note 1: Doppler -- 1 KHz; Data = 1Hz
Note 2: Diagnostic diagrams and documents, test procedures, all in data base.
Note: The following are extracted from 'special characteristics' question in questionnaire.
Nav & Guid: Correlation of location of manned station, location of platforms, attitude knowledge, and resultant user equipment pointing knowledge and control vectors.
Att.Contrl: Distributed sensors and effectors on a large flexible body will require a math-model-like controller.
Env.Contrl: Critical layer will require multiple redundancy, control, warning, and fault-tolerant or self-test-and-repair computer.
Power Gen.: Circuit breaker control of sets of experiments or processing Equipment.
Communicat: Multi-stream interleaving(message level) and virtual channel control.
Systems CO: In-flight integration and checkout of added modules, equipment, laboratories, S/W, other spacecraft.
Payload : Multi-Instrument & Process processing labs with a variety of bits, bytes, lengths, codes, encription and rates.
Experiment: Every imaginable kind and type of algorith must be anticipated.

MANNED SPACE PLATFORM (MSFC response)
COMPUTER REQUIREMENTS SURVEY

1.0 Application-Specific Requirements

1.1 Environment

Environment	Applicable Specification(s)
Temperature	x
Pressure	x
Humidity	x
Vibration	x
Shock	x
Acceleration	x
Acoustics	x
EMI	x
Lightning	
EMP	
Radiation	x
Other	

1.2 General

1.2.1 Physical Dispersion

Yes X No

Comments
Proximity to sensors and actuators
Distributed processing is necessary for growth
Physical damage redundancy

1.2.2 Overall Mission Reliability

Mission duration -- years.

Reliability for CDMS* -- 0.99

(*Computer Data Management System)

1.2.3 Maintenance

Onboard
Required. Redundancy allows hrs to days for replacement. Complete set of spare not available at station. Total CDMS cannot be down at ALL.

Ground
Scheduled and unscheduled Maintenance.
50% acceptable probability of requiring unscheduled maintenance.

1.3 Design Objectives

Adaptability	1
Affordability	4
Integrability	5
Manageability	6
Realizability	2
Testability	3

MANNED SPACE PLATFORM REQUIREMENTS MATRIX (MSFC response)
(System software not included)

FUNCTION	THROUGHPUT (KIPS)	MEMORY (16 bits, K)	UTILIZE MASS MEMORY (16 bit)	INPUT/OUTPUT (bps-average)	LOOP RATE (Hz)	FUNCTION CRITICALITY
Navigation	- 100	- 120	- 880K	- 75K	-	- Mission/Economic
Guidance and Flight Control	- 150	- 130	- 500K	- 75K(peak)	-	- Mission/Economic
Structure Control	-	- 130	-	-	-	- Mission/Economic
Environmental Control	-	- 32	-	- .5K	-	- Life/Vehicle/Mission/Economic
Power Generation (see note 1)	- 47	- 32K/chanx6	-	- .1K	- .05 & .5	- Life/Vehicle/Mission/Economic
Power Distribution & Control	- 80	-	-	- .1K	- 1, .5 & .01	- Life/Vehicle/Mission/Economic
Fluids Management	- page missing	- 3.5	-	-	-	- Mission/Economic
Propulsion Management	-	- 42	-	-	-	- Vehicle/Mission/Economic
Active Thermal Control	- 100	- 8	- Nó	- 2K	-	- Life/Vehicle/Mission/Economic
Communications	-	- 128	- up to 5M	-	-	- Mission/Economic
Command and Data Acquisition	-	- 35	-	-	-	- Life-?/Vehicle-?/Mission/Economic
TV Text and Graphics	-	- 47	-	-	-	- Economic
Displays and Controls(Note 2)	-	- 30K bytes	- 1M bytes	-	-	- Life-?/Vehicle-?/Mission/Economic
Systems Management	- 300	- 500	- 75M	-	-	- Life/Vehicle/Mission/Economic
Operations Planning	-	- 500	- 18.5M	-	-	- Economic
Systems Checkout	-	- 30	-	-	-	- Economic-?
Medical Support	-	- 32	- Several Million	-	-	- Life-?
Payload Support	-	- 256	-	-	-	- Mission

Suggested additional functions - Docking/Berthing, Redundancy Management

Note 1 - Estimates are per channel. Depending on EPS implementation, six processors each with the indicated memory requirements may be needed.

MANNED SPACE PLATFORM (JSC response)
COMPUTER REQUIREMENTS SURVEY

1.0 Application-Specific Requirements

1.1 Environment

Environment	Applicable Specification(s)
Temperature	
Pressure	
Humidity	
Vibration	
Shock	
Acceleration	
Acoustics	
EMI	
Lightning	
EMP	
Radiation	
Other	

1.2 General

1.2.1 Physical Dispersion

Yes X No

Comments
Proximity to sensors and actuators
Environmental protection
Physical damage redundancy
Modularity

1.2.2 Overall Mission Reliability

Vehicle life = 20 yrs; ave crew stay = 3 mo.
Aips elements should be capable of
75K to 100K hour design life(MTBF)

1.2.3 Maintenance

Onboard
Allowed. MTTR approx 8 hrs.
No down-time for life-crit. func. (cap can be reduced)

Ground
Equipment can be returned to grd via
shuttle for repair, then recycled on
90 day centers.

1.3 Design Objectives

Adaptability	3
Affordability	4
Integrability	5
Manageability	1
Realizability	6
Testability	2

MANNED SPACE PLATFORM REQUIREMENTS MATRIX (JSC response)
(System software not included)

FUNCTION	THROUGHPUT (MIPS)	MEMORY (code/data) (K bytes)	UTILIZE MASS MEMORY (K bytes)	INPUT-OUTPUT PEAK (K bits/sec)	TIMING (rate/xport) (Hz/ms)	SAMPLE RATE VAR. SENSITIVE	MISSION SUCCESS (# OF 9'S)	FUNCTION CRITICALITY
Navigation	- 5	- 20/30	- 250	- 2	minutes/ minutes	- No	- many	- mission
Guidance	-	-	-	-	-	- No	- 2	- economic
Flight Control	- 5	- 25/100	- No	- 600	- 50/20	- Yes	- High	- vehicle
Structure Control	- 50	- 250/900	- No	- 16K	- 100/5	- Yes	- High	- vehicle
Environmental Control	- .05	- 25/100	- No	- 160	- 10/250	- No	- 2	- life
Power Generation	- .05	- 50/200	- No	- 120	- 10/25	- No	- 2	- mission
Power Distribution & Control	- .05	- 100/150	- 1K	- 200	- 25/5	- No	- 2	- mission
Fluids Management	- .025	- 25/100	- 512	- 200	- 25/10	- No	- 2	- mission
Propulsion Management	- .025	- 25/100	- 512	- 200	- 25/10	- No	- 2	- vehicle
Active Thermal Control	- .025	- 25/100	- 256	- 200	- 25/25	- No	- 2	- mission
Communications	- .05	- 100/300	- 2K	- 600	- 25/25	- No	- 3	- mission
Command & Data Acquisition	- 5-10	- 2500/3750	- 256K	- 8K	-	-	- 2	- vehicle
TV Text and Graphics*	- 5	- 150/400	- No	- video	- 100/10	-	- 2	- mission
Displays and Controls	- .5	- 512/2K	- 50K	- 4K	- 50/75	- Yes	- 2	- life
Systems Management	- .1	- 512/5K	- 50K	- 200	- 25/100	- No	- 2	- mission
Operations Planning	- .05	- 200/800	- 5K	- 8K**	- 25/150	- No	- 2	- economic
Systems Checkout	- .25	- 200/800	- 25K	- 2K	- 25/150	- No	- 2	- mission
Medical Support	- .025	- 125/250	- 5K	- 80	- 25/50	- No	- 2	- economic
Payload Support	- .05	- 250/500	- 15K	- 1.6K	- 25/25	- No	- 2	- economic
Experiment Support*	- 50	-	- 10^9	-	-	-	- 1	- economic

* Special processors and buses

**initialization excluded

MANNED SPACE PLATFORM (CSDL estimate)
COMPUTER REQUIREMENTS SURVEY

1.0 Application-Specific Requirements

1.1 Environment

Environment	Applicable Specification(s)
Temperature	same as shuttle
Pressure	"
Humidity	shuttle launch and entry
Vibration	"
Shock	"
Acceleration	"
Acoustics	"
EMI	"
Lightning	"
EMP	maybe for mil version
Radiation	long term exposure
Other	
METEOROIDS	see Shuttle Payloads
	Accommodations for all spec's
	JSC-07700 Volume XIV sec 4

1.2 General

1.2.1 Physical Dispersion

Yes X No

Comments
Proximity to sensors and actuators
Environmental protection
Physical damage redundancy

1.2.2 Overall Mission Reliability
Vehicle life = 20 yrs; ave crew stay = 3 mo.
Prob. of veh loss in 20 yrs = .1
ave crew size = 6; Prob of 1 crew-person
loss in 20 yrs = .02; avionic portion of
above is 10% of which DMS is .1

1.2.3 Maintenance

Onboard
Allowed. MTTR approx 1 day.
No down-time for life-crit. func. (cap can be reduced)
Veh-crit func: down-time < 1 hr
Mission-crit func: down-time < 1 day

Ground
Equipment can be returned to grd via
shuttle for repair, then recycled.

1.3 Design Objectives

Adaptability	3
Affordability	1
Integrability	6
Manageability	2
Realizability	5
Testability	4

MANNED SPACE PLATFORM REQUIREMENTS MATRIX (CSDL estimate)
(System software not included)

FUNCTION	THROUGHPUT (KIPS)	MEMORY (fast/total) (32 bits, K)	UTILIZE MASS MEMORY	INPUT-OUTPUT (Note 1) (16 bit wds)	TIMING (rate/xport)	SAMPLE RATE VAR. SENSITIVE	MISSION SUCESS (# OF 9's)	FUNCTION CRITICALITY
Navigation	- 30	- 40/40	- Yes	- 2700/M	- 6.25hz/80ms	- No	- 3	- mission
Guidance	- 160	- 40/40	- Yes	- 1900/M	- 6.25/80	- No	- 3	- mission
Flight Control	- 240	- 40/40	- Yes	- 12000/M	- 12.5/40	- Yes	- 3	- vehicle
Structure Control	- 500	- 25/25	- No	- 5000/S	- 50/10	- Yes	- 3	- vehicle
Environmental Control	- 25	- 25/25	- No	- 1200/S	- 1/500	- No	- 3	- life
Power Generation	- 50	- 25/25	- No	- 1300/S	- 2/250	- No	- 3	- life
Power Distribution & Control	- 80	- 30/40	- No	- 5000/S	- 2/250	- No	- 3	- life
Fluids Management	- 25	- 25/25	- No	- 2800/S	- 6.25/80	- No	- 3	- mission
Propulsion Management	- 40	- 20/20	- No	- 9000/S	- 12.5/40	- No	- 3	- vehicle
Active Thermal Control	- 40	- 20/20	- No	- 1100/S	- 1/500	- No	- 3	- life
Communications	- 160	- 40/40	- No	- 2000/M	- 12.5/40	- No	- 3	- mission
TV Text and Graphics	- 40	- 35/35	- No	- 2100/S	- 6.25/80	- No	- 3	- mission
Displays and Controls	- 200	- 25/225	- Yes	- 2300/L	- 12.5/40	- No	- 3	- life
Systems Management	- 200	- 35/80	- Yes	- 32000/L	- 25/na	- No	- 3	- life
Operations Planning	- 40	- 20/30	- Yes	- 1000/S	- demand	- No	- 3	- mission
Systems Checkout	- same as(func)	- 20/250	- Yes	- s.a.(func)	- s.a.(func)	- Yes	- 3	- mission
Medical Support	- 40	- 25/25	- Yes	- 2000/S	- 6.25/na	- No	- 3	- mission
Payload Support	- 320	- 30/65	- Yes	- 3200/M	- 12.5/40	- Yes	- 3	- mission
Experiment Support	- 40	- 20/20	- Yes	- 1000/M	- 2/na	- No	- 3	- mission

Note 1: Entries signify Total/Interfunction traffic (S=small, M=medium, L=large)

UNMANNED SPACE PLATFORM (GSFC response)
COMPUTER REQUIREMENTS SURVEY

1.0 Application-Specific Requirements

1.1 Environment

Environment	Applicable Specification(s)
Temperature	_____
Pressure	_____
Humidity	_____
Vibration	_____
Shock	_____
Acceleration	_____
Acoustics	_____
EMI	_____
Lightning	_____
EMP	_____
Radiation	_____

Other

_Application is Landsat type, sun-synchronous

_orbit, 705 Km, within range of shuttle for

_retrieval/repair._____

_____ _____

1.2 General

1.2.1 Physical Dispersion

Yes _____ No_____

Comments

_____

_____

_____

_____

1.2.2 Overall Mission Reliability

_Mission length: 2 to 5 years._____

_Currently achieving .9 for 2 years._____

_DMS should be .99, especially for cmd link.

_Design should avoid failures which would disrupt repairability (e.g. no tumbling)

1.2.3 Maintenance

Onboard

_Shuttle on-orbit repair allowable._____

_____

_____

_____

Ground

_Yes, after shuttle retrieval._____

_____

1.3 Design Objectives

Adaptability _4_____

Affordability _1_____

Integrability _2_____

Manageability _3_____

Realizability _6_____

Testability _5_____

UNMANNED SPACE PLATFORM REQUIREMENTS MATRIX (GSFC response)
(System software not included)

FUNCTION	THROUGHPUT	MEMORY (16 bits, K)	INPUT/OUTPUT (Kbps)	TIMING (rate/ lag / response time)	SAMPLE RATE VAR. SENSITIVE	MISSION SUCCESS PROB.	FUNCTION CRITICALITY (Life/Vehicle/ Mission/Economic)
Navigation (high accuracy)	- 25-30 ms	- 8	-average - 2 peak - 4	- 2-4 Hz / 50% / 150%	- Yes	-s/w .99-	For autonomous rendezvous: L/V/M/E
Navigation (low accuracy)	- 15 ms	- 5	-average -2 peak - 4	- .25-1 Hz / 50% / 150%	- Yes	-s/w .99-	For earth pointing applications: M/E
Navigation (GPS)	- 10-15 ms	- 2	-average - 2 peak - 4	- 1-4 Hz / 50% / 150%	- Yes	-s/w .99-	___
Guidance	- 50-70 ms	- 11	-average - 12 peak - 16	- 5-20 Hz / 25% / 125%	- Yes	-s/w .98-	rendezvous: L/V/M/E/ orbital pos: V/M/E
Attitude Control	- 80-160 ms	- 16	-average - 6.4 peak - 10	- 1-5 Hz / 20% /120%	- Yes	-s/w .97-	V/M/E
Fluids Management	-	-	-	- 10&on demand/ .1 s/ .5 s	- No	-.9999	- M/E
Propulsion Management	- 1 KIP	-	-	-	-	-.9999	- M/E

Note 1: Navigation is assumed to be the platform ephemeris calculation. For precision earth-pointing platforms or those with high guidance accuracy requirements a sophisticated interpolation model is required. The throughput calculation times assume a 1 microsecond CPU with 3-4 cycles per average instruction (e.g. NSSC-I).
Note 2: Navigation has special characteristics influenced by security, TDRS, PCM and DOD.
Note 3: Attitude Control thoughput depends on requirements & plant structure.
Note 4: Historically mass memory has not been utilized, although it would be desirable for program backup on future applications.

UNMANNED SPACE PLATFORM (CSDL estimate)
COMPUTER REQUIREMENTS SURVEY

1.0 Application-Specific Requirements

1.1 Environment

Environment	Applicable Specification(s)
Temperature	yes
Pressure	
Humidity	yes prelaunch
Vibration	" launch
Shock	" launch
Acceleration	" launch
Acoustics	" launch
EMI	" launch
Lightning	
EMP	
Radiation	yes
Other	

1.2 General

1.2.1 Physical Dispersion

Yes _____ No X

Comments

1.2.2 Overall Mission Reliability

P(s) = 0.95 for 7 to 10 years

1.2.3 Maintenance

Onboard
None

Availability of system ·0.99

Ground
None

1.3 Design Objectives

Adaptability	5
Affordability	4
Integrability	6
Manageability	3
Realizability	1
Testability	2

UNMANNED SPACE PLATFORM REQUIREMENTS MATRIX (CSDL estimate)
(System software not included)

FUNCTION	THROUGHPUT (KIPS)	MEMORY (32 bits, K)	UTILIZE MASS MEMORY	INPUT/OUTPUT (bits/sec.)	TIMING (rate/xport)	SAMPLE RATE VAR. SENSITIVE	MISSION SUCCESS PROB.	FUNCTION CRITICALITY	SPECIAL CHARACTERISTICS
Navigation	- <10	- 9	-	- I aperiodic 0 500	- 2/na	- No	- .6	- mission	- Absolute time ref./Restart
Attitude Control	- 250	- 8	-	- 10000	- 30/5	- Yes	- .95	- vehicle	- Tight cyclic/ Restart
Structure Control	- 1250	- 42	-	- 50000	- 25/10	- Yes	- .9	- mission	- Major cyclic
Fluids Management	- see attitude control								
Propulsion Management (incl. orbit adjust)	- 25	- 24	-	- 500	- 2/100	- No	- .90	- mission	- none
Communications	- 100	- 16	-	- 50000	- 100/5	- No	- .95	- mission	- Recovery from transients
Systems Management	- 50	- 60	-	- 10000	- 1/na	-	- .8	- economic	- Long term memory
Experiment Support	- mission dependent -- range of 100 - 1000 mflops								

MANNED SPACE VEHICLE (CSDL estimate)
COMPUTER REQUIREMENTS SURVEY

1.0 Application-Specific Requirements

1.1 Environment

Environment	Applicable Specification(s)
Temperature	same as shuttle
Pressure	"
Humidity	"
Vibration	"
Shock	"
Acceleration	"
Acoustics	"
EMI	"
Lightning	"
EMP	"
Radiation	"
Other	
METEOROIDS	see Shuttle Payloads
	Accommodations for all specs
	JSC-07700 Volume XIV sec. 4

1.2 General

1.2.1 Physical Dispersion

Yes X No

Comments
Proximity to sensors and actuators
Environmental protection
Physical damage redundancy

1.2.2 Overall Mission Reliability

Mission duration = 10 days
Prob. of veh loss = E-6
Orbiter = E-7; avionics = E-8
AIPS = E-9

1.2.3 Maintenance

Onboard
Allowed on-orbit for some boxes. Present shuttle carries 1 spare GPC with entry load. MTTR approx. 2 hrs. Can swap CRT/DEU from mission-spec. loc. to flt crew sta. No down-time for sys. as a whole allowed.

Ground
Ground maintenence on demand after each flt. Flt freq. = 1 month.

1.3 Design Objectives

Adaptability	4
Affordability	1
Integrability	6
Manageability	5
Realizability	2
Testability	3

MANNED SPACE VEHICLE REQUIREMENTS MATRIX (CSDL estimate)
(System software not included)

FUNCTION	THROUGHPUT (KIPS)	MEMORY (32 bits, K)	UTILIZE MASS MEMORY	INPUT/OUTPUT (16 bit wds)	TIMING (rate/xport)	SAMPLE RATE VAR. SENSITIVE	MISSION SUCCESS# (# of 9's)	FUNCTION CRITICALITY
Navigation	- 60	- 60	-	- 2400	- 6.25hz/80ms	- No	- 7	- life
Guidance	- 80	- 45	-	- 2000	- 6.25/80	- No	- 7	- life
Flight Control	- 200	- 65	-	- 12000	- 25/20	- Yes	- 7	- life
Environmental Control	- 20	- 15	-	- 1200	- 1/500	- Yes	- 7	- life
Life Support	- 20	- 15	-	- 1200	- 1/500	- No	- 7	- life
Power Generation	- 40	- 15	-	- 1300	- 2/250	- No	- 7	- life
Power Distribution & Control	- 40	- 25	-	- 2500	- 2/250	- No	- 7	- life
Fluids Management	- 20	- 15	-	- 1200	- 1/500	- No	- 7	- life
Propulsion Management	- 60	- 30	-	- 1800	- 12.5/40	- No	- 7	- life
Communications	- 80	- 20	-	- 1600	- 6.25/80	- No	- 5	- mission
TV Text and Graphics	- 20	- 12	-	- 1700	- 6.25/80	- No	- 5	- mission
Displays and Controls	- 160	- 190	-	- 2400	- 12.5/40	- No	- 7	- life
Systems Management	- 160	- 60	-	- 24000	- 25/na	- No	- 7	- life
Operations Planning	- 20	- 30	-	- 1000	- demand	- No	- 3	- economy
Systems Checkout	- same as(func)	- 80	-	- s.a.(func)	- s.a.(func)	- No	- 5	- mission
Medical Support	- 40	- 25	-	- 2000	- 6.25/na	- No	- 5	- mission
Payload Support	- 200	- 45	-	- 2200	- 12.5/40	- Yes	- 5	- mission
Experiment Support	- 40	- 20	-	- 1000	- 2/na	- No	- 5	- mission

UNMANNED SPACE VEHICLE (MSFC response)
COMPUTER REQUIREMENTS SURVEY

1.0 Application-Specific Requirements

1.1 Environment

Environment	Applicable Specification(s)
Temperature	X
Pressure	X
Humidity	X
Vibration	X
Shock	X
Acceleration	X
Acoustics	X
EMI	X
Lightning	X
EMP	
Radiation	X
Other	

1.2 General

1.2.1 Physical Dispersion

Yes X & No X

Comments

Proximity to sensors and actuators (RIU's)

Engine interface unit located in engine area. Basic core data management hardware can be centrally located.

1.2.2 Overall Mission Reliability

No idea.

1.2.3 Maintenance

Onboard

For ground-based system - repair and refurbishment will occur after each flight. Turn-around probably 1 to 2 months.

For space-based system - more frequent flights; less maintenance. Turn-around time probably (10-15) days. Self test would determine frequency of repair.

Ground

1. Scheduled maintenance.

2. Unscheduled maintenance probability - 70% on early vehicles and 30% on later vehicles of the same make.

3. No idea.

1.3 Design Objectives

	space based/groundbased
Adaptability	2/2
Affordability	4/1
Integrability	5/4
Manageability	6/5
Realizability	3/3
Testability	1/6

UNMANNED SPACE VEHICLE REQUIREMENTS MATRIX (MSFC response)

FUNCTION	THROUGHPUT (KOPS)	MEMORY (16 bit - K)	UTILIZE MASS MEMORY	TIMING (cycle rate)	SAMPLE RATE VAR. SENSITIVE	MISSION SUCCESS	FUNCTION CRITICALITY
Navigation	- 100	- 14	- no	-	- yes	- .99	- Vehicle/Mission/ Economy
Guidance (Note 1)	- 30	- 5	-	-	- yes	- .99	- Vehicle/Mission/ Economy
Flight Control	- 30	- 3	-	- 10	- yes	- .99	- Vehicle/Mission/ Economy
Env. (Thermal) Control	- 1	- .5	- no	-	- no	- .99	- Vehicle/Mission/ Economy
Power Generation	- 10	- 2	- no	-	- no	- .99	- Vehicle/Mission/ Economy
Power Distribution & Control	- included in power generation-			-	-	-	-
Fluids Management	- 10	- 2	- no	-	- no	- .99	- Vehicle/Mission/ Economy
Propulsion Management	- 20 (when firing)	- 3	- no	-	- yes	- .99	- Vehicle/Mission/ Economy
Communications	- 100	- 20	- no	-	- yes	- .99	- Vehicle/Mission/ Economy
Systems Management	- 50	- 10	-	-	- yes	- .99	- Mission
Systems Checkout	- 30	- 64	- yes	-	- no	- .99	- Mission
Payload Support	- 10	- 5	- no	-	- yes	- .99	- Economy(?)

Suggested Additional Functions - Aerobrake, Docking/berthing, TV System, Redundancy Management
Note 1: Special characteristic - Radar interface for rendezvous and docking.

UNMANNED DEEP-SPACE PROBE (JPL response)
COMPUTER REQUIREMENTS SURVEY

1.0 Application-Specific Requirements

1.1 Environment

Environment	Applicable Specification(s)
Temperature	
Pressure	Hard Vacuum
Humidity	N.A.
Vibration	
Shock	
Acceleration	
Acoustics	
EMI	N.A.
Lightning	N.A.
EMP	N.A.
Radiation	15K Rad Total Dose
Other	

1.2 General

1.2.1 Physical Dispersion

Yes X No

Comments

Proximity to sensors and actuators

1.2.2 Overall Mission Reliability

- Two levels of mission performance have been identified:
  1. Enhanced Mission - Total design performance, all functions operating.
  2. Basic Mission - Key functions operating. Loss of up to half of the non-critical engineering telemetry and up to one science instrument telemetry stream.
- Probability of success for 5-year mission: .95 enhanced, .99 basic (no repairs).
- Other reliability requirements for short-term safe operation through separation from Space Station or Shuttle will exist.

1.2.3 Maintenance

Onboard

No onboard maintenance. Ground telemetry/command contact only once a week during non-critical mission phases.

Ground

No reuseability. Dispatch reliability is critical to meet launch opportunities.
.01 probability of launch scrub/hold due to data system acceptable.

1.3 Design Objectives

Adaptability	4
Affordability	2
Integrability	5
Manageability	6
Realizability	1
Testability	3

UNMANNED DEEP-SPACE PROBE REQUIREMENTS MATRIX (JPL response)
(System software not included)

FUNCTION	THROUGHPUT (KIPS)	MEMORY	UTILIZE MASS MEMORY	INPUT/OUTPUT (KBPS) peak	TIMING	SAMPLE RATE VAR. SENSITIVE	MISSION SUCCESS PROB.	FUNCTION CRITICALITY	NOTES
Flight Control (GLL AACS)	-140K Whetstone-IPS using HAL/S (5% exec ovhd)	64K, 16 bit	-1 Megabit-for entire application (Att.Con., Comm.,etc)	low to moderate	- rate: 1 Hz response: 11 ms	- yes	- .995	- mission/ economic	- 1
Communications and Systems Management (GLL CDS)	-3/4 of 6 RCA 1802's with clock = 1.6Mhz	- 176K, 8 bit	-900 Mega--bit tape recorder for exp. recording	3 channels: 134/400/805 overhead: 0/10/0 %	- rate: 15 Hz lag:.3 to 10 ms response: 15 Hz	- yes	- capa-bility half = .995 full = .96	- life/veh.: during launch & shuttle op. mission: through-out mission	- 2,3, 4

Note 1: If target-body tracking is required for future missions, image processing will be added to these requirements.
Note 2: Machine cycle 4.96 microsec, most instructions take two cycles, some three. In addition, hardware DMA sequencers use channel programs to move data.
Note 3: Must recover from short power loss
Note 4: Timing must be synchronized with radio hardware