MAINTAINABILITY PROGRAM REQUIREMENTS FOR SPACE SYSTEMS

National Aeronautics and Space Administration

PREFACE

Effective Date: March 10, 1987

This document, "Maintainability Program Requirements for Space Systems," is established to provide common general requirements for all NASA programs to:

- Design maintainability into all systems where maintenance is a factor in system operation and mission success.
- Ensure that maintainability characteristics are developed through the systems engineering process.

These requirements are not new. Design for ease of maintenance and minimization of repair time have always been fundamental requirements of the systems engineering process. However, new or reusable orbital manned and in-flight maintainable unmanned space systems demand special emphasis on maintainability, and this document has been prepared to meet that need.

Maintainability requirements on many NASA programs differ in phasing and task emphasis from requirements promulgated by other Government agencies. This difference is due to the research and development nature of NASA programs where:

- Quantities produced are generally small. Therefore, the depth of logistics support typical of many programs is generally not warranted.
- The cost of excessive maintenance is very high due to the logistics problems associated with the space environment.
- The ability to provide timely maintenance often involves safety considerations for manned space flight applications.

This document represents a basic set of requirements that will achieve a design for maintenance. These requirements are directed primarily at manned and unmanned orbital space systems. To be effective, maintainability requirements should be tailored to meet specific NASA program and project needs and constraints. NASA activities shall invoke the requirements of this document consistent with program planning in procurements or on in-house development efforts.

General questions on the intent of the maintainability requirements specified herein should be referred to the National Aeronautics and Space Administration Headquarters, Director, Reliability, Maintainability and Quality Assurance Division, Office of the Associate Administrator for Safety, Reliability, Maintainability and Quality Assurance, Washington, D.C. 20546. Questions concerning the application of these requirements to specific programs or projects should be referred to the cognizant NASA center.

Copies of this document are available from the Superintendent of Documents, U.S. Goverment Printing Office, Washington, D.C. 20402.

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ORGANIZATION OF THE RM&QA MANUAL

OVERALL COVERAGE

The Reliability, Maintainability, and Quality Assurance Manual - referred to as the "RM&QA Manual" - is the overall generic title which identifies all NASA RM&QA management publications published under the basic RM&QA subject classification code. The publications are grouped by major subject breakdown and further divided into specific categories identified as Parts. These Parts (not a complete RM&QA Manual) are published as individual RM&QA publications.

The following list shows the grouping of RM&QA publications:

Title	Number
Volume 1 - General Provisions	
Reliability Program Requirements for Aeronautical and Space System Contractors	NHB 5300.4 (1A-1) (January 1987)
Quality Program Provisions for Aeronautical and Space System Contractors	NHB 5300.4 (1B) (April 1969)
Inspection System Provisions for Aeronautical and Space System Materials, Parts, Components and Services	NHB 5300.4 (1C) (July 1971)
Volume 2 - Government Agency Provisions	
Quality Assurance Provisions for Delegated Government Agencies	NHB 5300.4 (2B-1) (June 1985)
Management of Government Quality Assurance Functions for Supplier Operations	NHB 5330.7 (April 1966)
Volume 3 - Standards	
Requirements for Soldered Electrical Connections	NHB 5300.4 (3A-1) (December 1976)
Qualified Products Lists Requirements for Microcircuits	NHB 5300.4 (3F) (June 1972)
Requirements for Interconnecting Cables, Harnesses, and Wiring	NHB 5300.4 (3G) (April 1985)

Requirements for Crimping and Wire Wrap	NHB 5300.4 (3H) (May 1984)
Requirements for Printed Wiring Boards	NHB 5300. 4(3I) (May 1984)
Requirements for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies	NHB 5300.4 (3J) (April 1985)
Design Requirements for Rigid Printed Wiring Boards and Assemblies	NHB 5300.4 (3K) (January 1986)

DOCUMENT REFERENCING

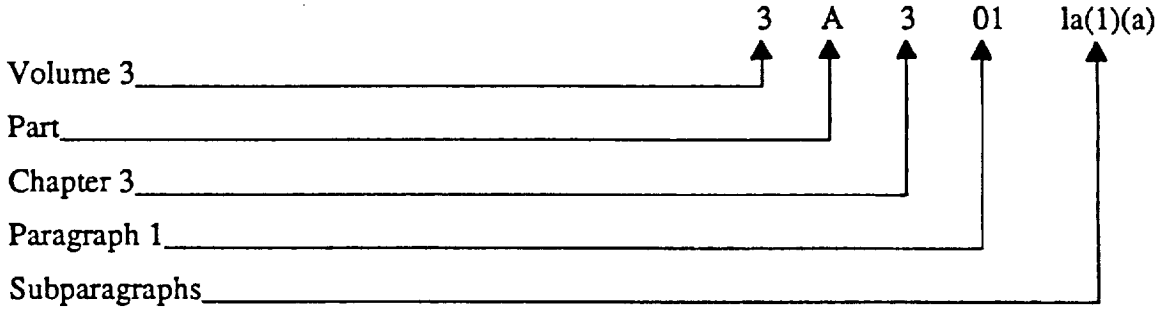
Each RM&QA Manual Part is assigned its own identification number within the basic classification code. The numeric-alpha suffix within a parenthesis identifies the grouping of the publication, that is, the volume and part, such as NHB 5300.4(3A). This number indicates that this is the first "Standards" (Volume 3) publication to be issued.

When a part is revised, the suffix identification will be changed to indicate the revision number, such as NHB 5300.4 (3A-1).

In referencing or requesting any RM&QA publication, the complete specific NHB number must be used.

PARAGRAPH REFERENCING

1. Within the RM&QA Manual. The following shows the paragraph numbering system applicable to all RM&QA publications.



This system provides for referencing any RM&QA publication requirement (paragraph) in any other RM&QA publication without the need for identifying the NHB number, title, the volume number, or parts. However, when referencing a complete part within another RM&QA publication, the specific NHB number must be used.

2. In Other NASA Documents. When it is necessary to reference an RM&QA publication requirements (paragraph) in any other NASA document, the specific NHB number and paragraph number must be used together as follows: "NHB 5300.4 (3A-1), paragraph 3A301-1a(1)(a), " or "paragraph 3A301-2b of NHB 5300.4(3A-1)."

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CHAPTER 1: INTRODUCTION

1E100 SCOPE

This document prescribes the maintainability program requirements for use on NASA in-house projects and for NASA contracts. These requirements are applicable to manned and unmanned space programs where on-orbit maintenance is planned and will be invoked to the extent necessary by the NASA procuring activity in the statement of work and/or contract. This document can be tailored to meet specific program needs.

1E101 APPROACH

1. This document contains maintainability program requirements for program phases A, B, C, and D as defined in Appendix C. In general, phase A/B tasks will analyze and definitize the design requirements for maintainability. In general, phase C/D tasks will include engineering (Chapter 3) and analytical (Chapter 4) tasks that result in a system design that will achieve desired maintainability characteristics.

2. Definition of the maintainability requirements in phase B shall result in a set of maintainability requirements to be implemented in phase C/D. These requirements shall be based upon a well defined maintenance concept (see par. 1E301) and include quantitative maintainability requirements (see par. 1E401). Quantitative maintainability requirements shall specify items, such as, time to restore, equipment or system availability, diagnostics time, built-in test false alarm rates, built-in test fault isolation requirements, extravehicular reach envelope criteria, and Orbital Replaceable Unit (ORU) and spares volume/weight requirements. Both the maintenance concept and quantitative maintainability requirements shall be used as design criteria for systems engineering to achieve design attributes necessary for ease of maintenance, minimization of repair time, and logistics support planning. Prior experience and lessons learned relative to design features for maintenance in space shall be incorporated to the maximum extent possible.

1E102 RELATION TO OTHER CONTRACT REQUIREMENTS

1. Nothing in this document shall be construed as a requirement for duplication of effort. Organizational responsibility for overlapping and interfacing functions such as reliability and safety shall be clearly identified in the Maintainability Program Plan and cross referenced in other pertinent technical program documents.

2. The program requirements set forth herein are intended to be used in conjunction with the following related NASA publications: "Quality Program Provisions for Aeronautical and Space System Contractors," NHB 5300.4(1B); "Reliability Program Requirements for Aeronautical and Space System Contractors," NHB 5300.4(1A-1); "Basic Safety Manual," NHB 1700.1(V1); and "Safety Policy and Requirements for Payloads Using the Space Transportation System(STS)," NHB 1700.7.

3. Provisions stated herein should not be interpreted to preclude compliance with those which are invoked elsewhere in the contract.

4. If conflict exists between provisions of this document and those stated in the contract, the contractual statement of precedence shall govern.

1E103 ACTIONS AND PREROGATIVES OF THE GOVERNMENT

1. GENERAL. All work, data, and documentation developed for the contract effort by the contractor and suppliers are subject to examination, evaluation, and inspection at any practical time and place by the NASA procuring activity or its designated representatives. The contractor and suppliers at all tiers shall cooperate fully with such representatives, providing access to the contractor's and supplier's facilities to permit performance of their designated function.

2. SEPARATE MAINTAINABILITY EVALUATIONS FOR NASA. NASA reserves the right to contract separately with evaluation contractors to function as designated NASA representatives. Such contractors usually will:

   a. Provide technical advice to the NASA procuring activity.

   b. Determine effectiveness of the system, subsystem, and suppliers programs in the areas of maintainability.

   c. Assess, evaluate, and recommend improvements to maintainability efforts within NASA.

3. INPUTS TO DATA EXCHANGE PROGRAMS. NASA reserves the right to utilize portions of the data generated under the contract as inputs to various Government data exchange programs (e.g., Government/Industry Data Exchange Program (GIDEP)). Requirements for specific contractor efforts will be specified in the contract.

1E104 RELATIONSHIP BETWEEN MAINTAINABILITY REQUIREMENTS/ ACTIVITIES AND PROGRAM PHASES

Appendix A provides the relationship between the maintainability requirements/activities of this document and the acquisition program phases. The general applicability of each requirement/activity is shown in the appendix. The specific applicability of each requirement/activity shall be determined by the NASA procuring activity and defined in the contract.

1E105 MAINTAINABILITY PROGRAM DATA REQUIREMENTS

1. Appendix B identifies the documentation required by this document. In tailoring requirements, the NASA procuring activity may permit the contents of several of these documents to be combined into a single report, while others may not be required.

2. In some cases the contract will specify that certain documents be submitted to NASA for approval, review, or information as follows:

   a. APPROVAL. Documents in this category require written NASA approval prior to use. Receipt by NASA shall occur within the time specified in the contract. Requirements for resubmissions shall be as specified in letter(s) of disapproval.

b. REVIEW. Documents in this category require receipt by NASA prior to use and within the time period specified in the contract. They are subject to evaluation by NASA or its designated Government representatives to determine effectiveness in meeting contract objectives. When Government evaluations reveal inadequacies, the contractor will be requested in writing to correct and resubmit the document within a specified time period.

c. INFORMATION. Documents in this category require receipt by NASA within the time specified in the contract for the purpose of determining current program status, progress, and future planning requirements.

3. All contractor and supplier generated documents utilized to meet requirements of the contract, whether they are specifically cited for submittal or not, shall be readily available to the NASA procuring activity or its designated representatives upon request. To facilitate Government and contractor evaluation of the maintainability program, the contractor's data control system should be maintained in such a manner as to permit rapid identification, location, and retrieval of documentation pertinent to the maintainability program.

1E106 GLOSSARY OF TERMS

For definitions of selected terms used in this document, see Appendix C.

CHAPTER 2: MAINTAINABILITY PROGRAM MANAGEMENT

1E200 ORGANIZATION

The contractor shall identify and implement an organization for the planning and management of the contractually required maintainability program. The individual designated as head of the maintainability organization shall have the necessary authority and resources to execute the overall maintainability program, and shall report to a level having full responsibility for the program. Although the accomplishment of many of the maintainability program tasks may not be the line function of the maintainability organization, that organization shall monitor and ensure that all maintainability program tasks are accomplished effectively. They shall also ensure that all pertinent maintainability data are provided to support each formal project milestone review.

1E201 MAINTAINABILITY PROGRAM PLAN

1. The contractor shall provide, maintain, and implement a Maintainability Program Plan appropriate for each program phase, which describes how compliance with the specified contractually required maintainability effort will be ensured. This Plan shall serve as the master planning and control document for the maintainability program.
2. The Plan shall cover the applicable requirements of this document and shall include:
   a. The duties of each organizational element involved in the accomplishment of the maintainability tasks cited in the product specification and/or contract statement of work.
   b. Identification of the organizations that will have the lead and assist roles in the execution of each task, and the organizations that have review or approval authority over the documents generated as part of the maintainability program.
   c. Identification of the interfaces between other project organizations, such as, software, reliability, safety, maintenance, and logistics.
   d. Identification of each maintainability task to be performed, together with narrative descriptions, schedules, and supporting documentation that describe in detail the plan for execution and management of each task. Where existing methods or procedures are planned to be used, they shall be referenced. All documents referenced shall be available upon request.
   e. A description of the nature and extent that the maintainability function participates in informal and formal design reviews, and the authority of maintainability personnel in the approval cycle for drawing release.

1E202 MAINTAINABILITY PROGRAM CONTROL

1. GENERAL. The contractor shall devise a system for effective management and control of the maintainability program to assure compliance with contractual requirements. Insofar as practical, this system will utilize the reporting system prescribed for the overall

contract effort, with supplemental provisions as agreed to with the NASA procuring activity. This system shall periodically monitor and report the status of each maintainability task against the plan, schedule, and budget.

2. MAINTAINABILITY PROGRAM SURVEYS. The contractor shall conduct periodic surveys of the maintainability program and those of suppliers required to utilize one. These surveys shall be conducted either independently or as a part of broader surveys of assurance areas. They shall be conducted at a level of detail to assure that the design and configuration will meet system maintainability requirements, with special emphasis on ease of maintenance. Where requirements are not being met, an assessment shall be made of the potential impact on maintenance cost, maintenance planning, and overall system availability. Any design or configuration characteristic that has the potential for adversely impacting maintenance costs, maintenance planning, or system availability shall be formally reported to the NASA procuring activity.

3. PROGRAM REVIEWS. The contractor shall address maintainability at normally scheduled program reviews.

4. CONFIGURATION MANAGEMENT. The contractor's maintainability organization shall assure that an interface is identified and maintained with configuration management to ensure that characteristics are maintained for every manned and unmanned space vehicle. Additionally, maintainability shall be represented on the Configuration Control Board and have signature approval.

1E203 REPORTS

1. GENERAL. The contractor shall periodically report on the progress of the maintainability program in scheduled written reports and in minutes of program reviews. This formal reporting will be augmented by day-to-day informal reporting on pertinent matters as they arise. Schedules for maintainability progress reports shall be identified in the Maintainability Program Plan.

2. WRITTEN PROGRESS REPORTS. Periodic written reports shall include:

   a. Technical progress of each maintainability program task, including significant accomplishments and milestones reached during the reporting period.

   b. Maintainability related problem areas and proposed corrective actions.

   c. Decisions and actions during the reporting period having an impact on maintainability, including a description of the anticipated effect on maintenance planning, maintenance cost, ability to achieve the prescribed availability, and impact on life cycle costs.

   d. Revised schedules, as appropriate, with a discussion of the impact of delays on product design and configuration.

3. MAINTAINABILITY PROGRAM CONTROL REPORTS. The contractor shall submit maintainability program control data as a separately identified part of the periodic financial and management report required by the contract. The report shall include data comparing resources planned vs. resources expended for the reporting period, as well as revised projections for succeeding milestone intervals. The report shall include the identification of resources expended to accomplish maintainability tasks by organizations other than maintainability.

1E204 MAINTAINABILITY TRAINING

The contractor shall use trained and qualified personnel to implement the maintainability program. Necessary additional training and indoctrination in technologies and techniques peculiar to the program, as well as training directed toward fostering technical excellence, shall be provided to appropriate personnel. The Maintainability Program Plan shall identify these training requirements and describe training courses and activities, as well as types and numbers of personnel to be trained under each. Efforts shall be made to assemble "lessons learned" from other programs, and to make such information available to project personnel.

1E205 SUBCONTRACTOR AND SUPPLIER CONTROL

1. The contractor shall ensure that the maintainability of system elements obtained from subcontractors and suppliers meets the maintainability requirements of the overall system. This applies to items obtained from any subcontractor or supplier whether in the first or any subsequent tier or whether the item is obtained by an intracompany order from any element of the contractor's parent organization. The contractor shall provide requirements, guidance, and controls to ensure the adequacy of subcontractor or supplier maintainability program implementation. The level of maintainability requirements imposed on subcontractors and suppliers shall be appropriately tailored and identified to be consistent with those imposed on the prime contractor.
2. Where off-the-shelf hardware is anticipated, the contractor in the selection process shall examine historical data, such as, other contractor and program requirements and experience as well as reliability history, including failure mode and effects analyses (FMEA), maintainability, problem reporting and corrective action, materials specifications and applications, test data (certification and acceptance testing), and design data. The results of this examination shall be documented and additional maintainability controls, as appropriate, shall be applied.
3. For subcontractors and suppliers who are not required to maintain a formal maintainability program, the contractor shall assure that the hardware purchased from these suppliers and subcontractors possesses characteristics consistent with overall system objectives.

1E206 MAINTAINABILITY OF GOVERNMENT-FURNISHED PROPERTY (GFP)

Where the overall system includes components or subsystems furnished by NASA, the contractor shall be responsible for obtaining via the NASA procuring activity, maintainability data on these items for use in performing required maintainability tasks for the system. Where examination of these data or testing by the contractor indicate inconsistency of the maintainability of Government-Furnished Property with the requirements of the overall system, the NASA procuring activity shall be formally and promptly notified for appropriate action.

CHAPTER 3: MAINTAINABILITY ENGINEERING

1E300 GENERAL

Maintainability engineering includes a process for establishing design requirements and a number of engineering tasks that are a part of the systems engineering process. These tasks focus primarily on the form, fit, and function of the design that will allow for practical and economical maintenance within established program and mission constraints. The tasks prescribed in this chapter are basic requirements. These requirements shall be implemented in conjunction with the maintainability analyses requirements prescribed by Chapter 4.

1E301 MAINTENANCE CONCEPT

1. A system maintenance concept will be developed by the cognizant NASA organization or a contractor designated by NASA and provided as an end item design requirement to the contractor. Inputs to the maintenance concept shall include: a mission profile, system reliability and availability requirements, overall size and weight constraints, and crew considerations. The concept shall be the basis for establishing maintainability design requirements that will be applied to the system, subsystem(s), or equipment being developed.
2. As a minimum, the system maintenance concept shall include a discussion of:
   a. System Operational Availability (Ao).
   b. Repair vs. replacement policy. Replacement is the normal mode. If any on-orbit repair actions are contemplated, they shall be clearly identified in the concept.
   c. Level of replacement.
   d. Skill level requirements.
   e. Sparing concept (i.e., on-board vs. deliverable).
   f. Standardization policy and practice.
   g. Diagnostic principles and concepts.
   h. Responsibilities for payload maintenance.
   i. Crew time allocated for both preventive and corrective maintenance actions.

   Additional items shall be included in the maintenance concept as operational or mission requirements dictate.

1E302 MAINTENANCE PLAN

1. The contractor shall prepare a maintenance plan to support the maintenance concept adopted to satisfy operational requirements. The initial plan shall include the early identification of logistic items requiring long range acquisition planning and implementation by the contractor and the NASA procuring activity.

2. The plan shall identify tradeoffs and decisions concerning, for example, repair by replacement, repair by remote activated or automatic command bypass or switchout of faulty item, repair in orbiter cargo bay or manned platform or spacecraft, and ground return of failed system or ORU for repair and subsequent relaunch for space mission application. Tradeoffs and decisions shall be supported by: volume/weight constraints, repair/replacement items carried on-board spacecraft, and repair/replacement items supplied by orbiter missions. Feasibility of the maintenance plan shall be supported by design analysis results including estimates of preventive and corrective maintenance requirements and associated schedules for accomplishment, proportion of failures which will be localized by automatic, semi-automatic and manual means, and preventive and corrective maintenance task times.

3. The plan shall use inputs from maintainability engineering efforts to identify personnel training and technical data requirements for each level of maintenance. As a minimum, the following shall be identified and described in the plan: a. training programs, facilities, and equipment necessary for training personnel; b. all technical data (i.e., publications, engineering drawings, maintenance standards, etc.) necessary to enable personnel to operate and maintain the equipment; and c. special aids (i.e., photographs, video tapes, etc.) depicting tool usage, failure isolation, repair/replacement procedures, and other maintenance actions for training and operational maintenance.

1E303 MAINTAINABILITY DESIGN CRITERIA

1. The contractor shall develop and implement specific design criteria to facilitate maintenance or repair actions in predicted environments. In establishing maintainability design criteria, the contractor, with the assistance of the procuring activity, shall use data obtained from previous maintenance activities during Intravehicular Activity (IVA) or Extravehicular Activity (EVA) maintenance activities (particularly the difficulties encountered during maintenance). Design criteria shall include design for modularity, optimum accessibility, accurate fault diagnostics, standardization, commonality, and crew handling compatibility.

2. The following examples of maintainability design criteria shall be included:

   a. Each ORU shall include both coarse and fine installation alignment guides as necessary to assure ease of ORU installation and removal.

   b. Reach envelopes, crew load/forces, and general work constraints for EVA and IVA maintenance tasks shall be defined.

   c. General accessibility criteria for each ORU shall include minimum sweep clearances between interface tools and hardware structures, and connector clearance constraints. Replacement of an ORU shall be accomplished without removal of other ORU's.

   d. Accessibility criteria for planned maintenance activity shall include clearance envelopes for those activities where access to an opening for an ORU maintenance activity is required.

   e. System thermal design criteria shall provide for ORU replacement or maintenance in a manner which will preclude degradation or damage to any other ORU, subsystem, or component.

f. Requirements shall be defined for handling provisions for ORU's so as to simplify handling and minimize the likelihood of mishandling equipment.

g. Tooling and hardware items shall be designed for commonality, standardization, and interchangeability to ensure the minimum number of items.

h. ORU fasteners shall be selected to minimize accessibility time consistent with good design practice.

i. The ORU surface structure shall be designed such that no safety hazard is created during the removal, replacement, test, or checkout of any ORU during an EVA or IVA maintenance activity. Design criteria shall include minimum radii requirements, surface finish requirements, and special requirements for protective mechanisms where indicated. Additionally, the design shall include caution/warnings for mission or safety critical ORU's.

j. Software design criteria shall allow replacement of software segments on-line without disrupting mission or safety critical functions, or introduce hazardous conditions during on or off-line software modification, software replacement, or verification. Software shall be designed to easily facilitate modifications, verifications, and expansions.

1E304 ENGINEERING DESIGN ANALYSES

As part of the systems engineering process, analytical tasks shall be conducted to facilitate a design which complies with maintainability requirements. These analytical tasks shall not be duplicative of any engineering analysis that is conducted as a routine procedure in the contractor's system engineering process. As a minimum, these analyses shall include:

1. Analyses to determine the optimum ORU configurations - considering performance, mission or safety criticality, reliability, cost, fault diagnostics capability, projected fault diagnostics, and unit replacement times. A system functional block diagram identifying the components that comprise each ORU and the functional interface between each ORU shall be developed and documented, as part of this task. The block diagram shall be used for the maintainability models and prediction tasks prescribed by Chapter 4.

2. A thermal analysis shall be conducted to ensure that the design complies with the design criteria (see par. 1E303-2e). The results of the thermal analysis shall determine if there is a need for a heat source or heat sink to maintain thermal specifications, including thermal balance, during ORU changeout or repair. The thermal analysis shall also (for manned EVA maintenance activities) identify any thermal surfaces that exceed the EVA gloved-hand temperature limits.

3. An analysis to: a. identify the safety hazards induced as a result of maintenance activities; and b. determine safety procedures, precautions, and protection devices to safeguard crew personnel during maintenance including safe haven provisions.

4. An analysis which identifies reaction time constraints where repair or replacement must be performed by the crew within specified time intervals.

5. An analysis of diagnostic alternatives to most effectively detect and isolate failures to the ORU level and accurately verify system restoration. The analysis shall: a. identify the system, subsystem, or equipment parameters that will be monitored; b. identify the

proportion of faults that can be detected; and c. determine the projected false alarm rate and estimated impact on crew maintenance time and the ability to meet the objectives contained in the maintenance concept.

6. A volume/weight analysis to determine the quantity and types of spare ORU's necessary to sustain satisfactory operational availability. The volume/weight analysis shall assure that the volume and weight of the recommended ORU spares are consistent with available or planned pallet types, payload volume and weight limits, and planned or available on-board stowage area. The results and recommendations of the Spares Requirements Analysis (see par. 1E408) shall be used.
7. A worst case tolerance analysis to verify that the form, fit, and function of each ORU will not be compromised from worst case tolerance build-up.
8. An analysis to determine areas in need of preventive maintenance action. These areas include both ORU's with known life characteristics, as well as components (such as bearings and seals) that may require periodic maintenance.
9. An analysis to determine the maximum number of maintenance actions that each ORU can be subjected to without degradation in performance.
10. An analysis of software to verify that inherent maintainability characteristics and ease of maintenance are incorporated in the design.

1E305 TOOL REQUIREMENTS

The system design shall minimize the need for maintenance tools. When tools are required, the contractor shall design on-orbit replaceable units to use tools and equipment previously designed and qualified for the intended use in the EVA or IVA environment to the greatest degree practical. Use of tools shall be standardized to minimize the number of special tools required. Any special tools designed shall be of light weight but durable construction.

1E306 ORU PLACEMENT

Consideration shall be given to priority placement of ORU's for optimum accessibility. In general, ORU's that have been designated for periodic replacement, or ORU's that contain catastrophic or critical failure modes shall be located where removal and replacement can be most readily accomplished. A failure mode and effects analysis shall be used to aid in prioritizing the location of ORU's (see NHB 5300.4(1A-1), par. 1A304).

1E307 SOFTWARE MAINTAINABILITY

1. A Software Maintainability Plan shall be developed in accordance with the guidelines specified in paragraph 1E201, Maintainability Program Plan, and integrated with associated documentation to reduce duplication of effort. Software maintainability shall give specific attention to the software structuring and documentation characteristics, and other software design characteristics, in the development of maintainable software.
2. The contractor shall implement software maintainability early in the software

development phase, identifying software maintainability parameters in accordance with the specific software development and assurance requirements of the contract, to achieve ease of software maintenance. The software maintainability parameters shall be documented in the Software Maintainability Plan. All software which the specified requirements address shall be defined.

1E308 PROBLEM REPORTING AND CORRECTIVE ACTION

The contractor shall have a controlled system for identification, reporting, analysis, correction, and recurrence prevention of maintainability problems and nonconformances. Where the Problem/Failure Reporting System of NHB 5300.4(1A-1) or an approved equivalent system is invoked by contract, the contractor shall assure that the system contains provisions for reporting maintainability problems and nonconformances to program management. Maintainability problems and nonconformances encountered during all phases of testing, problem and failure investigation, and handling shall be reported. The selected system shall collect maintainability task time data for each maintenance action, including but not limited to: fault detection, isolation, access, diagnostics, removal, ORU acquisition, replacement, checkout, and realignment.

CHAPTER 4: MAINTAINABILITY ANALYSES

1E400 GENERAL

The tasks in this chapter are oriented towards a system design that will achieve the availability and time-to-restore requirements specified by the maintenance concept (see par. 1E301) and the quantitative maintainability requirements (see par. 1E401). These tasks may be tailored by the NASA procuring activity to achieve optimum effectiveness. The exact nature of the tailoring of these requirements depends upon both the particular program and the program phase.

1E401 QUANTITATIVE MAINTAINABILITY REQUIREMENTS

1. Quantitative system maintainability requirements will be identified based on mission scenarios. The quantitative maintainability requirements shall be established by the NASA procuring activity. These requirements will appear in the appropriate sections of the system or end item specifications. Quantitative maintainability requirements may be structured as functions of time, staff hours, or in terms of fault detection and isolation. The requirements will be related and traceable to the overall system performance requirements and the maintenance concept. The maintainability characteristics of design alternatives shall be evaluated against these quantitative requirements.
2. As a minimum, the following quantitative maintainability requirements shall be defined:
   a. Inherent Availability (Ai).
   b. Mean time to restore for mission critical items.
   c. Maximum allowable time to restore for safety critical items.
   d. Proportion of faults and percentage of time detected or failure modes to be detected and/or isolated by automatic or built-in test equipment.
   e. Maximum false alarm rate for automatic or built-in test equipment.
   f. Allowable crew time for maintenance activities.

1E402 MAINTAINABILITY MODELS

Maintainability models shall be developed and used to assist: 1. the allocation and prediction process; and 2. the ORU definition process in achieving a performance, cost, reliability, and maintainability balance in the system design. Maintainability models may be developed manually or through computer techniques. Maintainability models shall be based on the systems engineering models, and shall be developed for alternative system concepts (or configurations) and design changes that are a normal part of the systems engineering process. These models shall be documented and used continually throughout the design process. These maintainability models shall be used to augment systems engineering tradeoff studies.

1E403 MAINTAINABILITY ALLOCATION

1. Quantitative maintainability requirements (see par. 1E401) shall be allocated to the ORU level unless otherwise required to comply with the maintenance concept. These maintainability allocations shall be used as the baseline against which design alternatives are evaluated.

2. Contractors shall, to the degree appropriate for the subsystem, assembly, or component being procured, invoke allocated quantitative maintainability requirements on subcontracted hardware.

1E404 MAINTAINABILITY PREDICTION

1. The contractor shall prepare maintainability predictions using the most effective methods available, and employ them as a design tool to assess and compare design alternatives with specified maintainability requirements. Maintainability predictions shall emphasize estimation of the time-to-restore at the ORU level considering: a. diagnostics time to detect and fault isolate to the defective ORU; b. time required to remove and replace the defective ORU; and c. time required to complete system checkout and restore to operational status. Maintainability models (see par. 1E402) shall be used as the basis for the maintainability predictions and to assess compatibility with the maintenance human resource requirements.

2. The accuracy of the maintainability predictions depends upon the accuracy and validity of the data used. These data shall be classified into the following categories:

CATEGORY	DEFINITION
A	Data that have been directly obtained from previous on-orbit repair or maintenance missions on hardware of similar function and configuration.
B	Data that have been directly obtained from repair or maintenance tasks on hardware of similar function and configuration in a simulated EVA or IVA environment. Data obtained in previous maintainability validation/verification tests is an example of Category B data.
C	Data obtained from task repair times for "elemental" activities to build up to the ORU level (i.e., Predetermined Time Standards), or other data that cannot be classified as Category A or Category B.

Category A and B data shall be used in preference to Category C where available. The maintainability predictions shall identify the data category that was used.

3. Maintainability estimates for ORU configurations identified as safety critical shall be so designated. These data shall be referred to the Safety Program for appropriate analysis and risk assessment.

4. Maintainability estimates for ORU configurations identified as mission critical shall be so designated. These data shall be used as inputs to assess overall program risk.

1E405 FAILURE MODE AND EFFECTS ANALYSIS (FMEA) - MAINTAINABILITY INFORMATION

The contractor shall develop Maintainability Information in conjunction with the FMEA task effort described in NHB 5300.4(1A-1). The FMEA shall be expanded at the ORU level to include: 1. failure prediction; 2. failure detection means; and 3. identification of maintenance actions to correct failures. The Maintainability Information shall be used to provide criteria for maintenance planning, preparation of logistics support analysis, test planning, inspection and checkout requirements, and to identify maintainability design deficiencies requiring redesign. Whenever the FMEA is updated, the Maintainability Information shall be updated as changes occur. ORUs which contain critical items shall be identified in the critical items list (CIL) developed in accordance with NHB 5300.4(1A-1).

1E406 PREVENTIVE MAINTENANCE ANALYSIS

The contractor shall conduct an analysis to determine an optimum preventive maintenance schedule that will minimize the amount of manpower required to sustain the required mission capability and will also minimize down time. The results of this analysis shall be used as inputs to the Engineering Design Analysis Reports (see par. 1E304-8).

1E407 EMERGENCY MAINTENANCE ANALYSIS

The sole or integrating contractor shall prepare analyses of the time-to-restore for any emergency restoration or repair procedures designed for sustaining mission capability in the absence of necessary spare parts. These analyses shall consider emergency actions to reconfigure components, cannibalize parts, or other work around in an emergency state. For manned platforms where a "safe haven" concept is used, time estimates to accomplish "safe haven" procedures shall be determined. These analyses and estimates will be inputs to mission contingency planning.

1E408 SPARES REQUIREMENTS ANALYSIS

Consistent with the maintenance concept (see par. 1E301), the contractor shall determine the quantities of spares required for each ORU and the total quantities required to sustain the required operational availability (see par. 1E304-6).

CHAPTER 5: MAINTAINABILITY ASSESSMENT, DEMONSTRATION, AND DATA COLLECTION

1E500 GENERAL

Maintainability Assessment, Demonstration, and Data Collection includes test and analytical procedures to verify that space systems, subsystems, or related equipment possess the specified maintainability characteristics.

1E501 MAINTAINABILITY ASSESSMENT

The contractor shall conduct periodic maintainability assessments to: 1. assess the quantitative maintainability characteristics of the design; and 2. evaluate the maintenance support factors that will assure an adequate design support interface. Maintainability assessment shall be conducted by the maintainability assurance function with support from other program functions including systems engineering, reliability, safety, and logistics. Informal maintainability assessments should be conducted throughout the design process. Formal maintainability assessments shall be conducted in preparation for all major design reviews. A summary of findings of the formal maintainability assessment shall be presented at all major design reviews. As appropriate for the particular program phase, formal maintainability assessments shall include, but not be limited to, an evaluation of:

1. Overall conformance to specified maintainability requirements.
2. Status of open maintainability problem areas requiring corrective actions.
3. Equipment compatibility with interface and tolerance requirements.
4. Hardware as-built vs. adequacy and accuracy of the built-to documented configuration.
5. Adequacy and accuracy of Built-in Test Equipment (BITE) to fault isolate failures to a restorable/replaceable unit.
6. Acceptability with respect to human factors of parts and materials selection and application.
7. Adequacy of specified maintainability assurance tasks, including maintainability demonstration test planning.
8. Compatibility of the maintenance concept with the current design configuration and current reliability and maintainability estimates.
9. Availability of spares and provisioning requirements.
10. Degree and adequacy of commonality of subsystems and equipment for utilization to accommodate emergency maintenance actions and contingency planning.
11. Status and adequacy of maintenance manuals, handbooks, and instructions.
12. Status and adequacy of training plans and training equipment requirements.
13. Any maintainability issue that is identified through maintainability assessment and demonstrations, or the maintainability engineering tasks defined in Chapter 3 of this document.

14. Given the default values for administrative and logistic actions, the status of the program's operational availability shall be provided by the sole or integrating contractor.

1E502 MAINTAINABILITY DEMONSTRATION

1. OBJECTIVES. The contractor shall conduct Maintainability Demonstration tests as part of design verification to verify that all preventive and corrective maintenance activities can be successfully executed within the scope of the maintenance concept. As a minimum, the demonstration shall verify the ability to:

   a. Successfully detect, diagnose, and isolate a faulty ORU.

   b. Successfully remove and replace each ORU.

   c. Successfully demonstrate mission essential repairs that are not intended to be accomplished by replacement of an ORU.

   d. Successfully verify that the system is fully functional after maintenance actions have been completed.

   e. Verify that no safety hazard is directly or indirectly introduced as a result of maintenance activities.

2. DEMONSTRATION ENVIRONMENT. Maintainability Demonstration shall be conducted in an environment that closely simulates the conditions in which the maintenance crew will be required to perform maintenance actions. Mockup hardware that contains the same ORU and system configuration, and similar human factor constraints, may be used in the Maintainability Demonstration. For maintenance actions where a near "zero g" environment will be a factor, facilities such as a neutral buoyancy laboratory shall be used as practical. Those maintenance activities that are planned to be demonstrated in a near "zero g" environment shall be identified in the Maintainability Demonstration Plan.

3. TEST PERSONNEL

   a. Personnel involved with executing the maintenance tasks prescribed by the Maintainability Demonstration shall have received the same indoctrination training that will be given to the crew personnel required to perform on-orbit maintenance actions.

   b. To the maximum degree practical, crew members responsible for on-orbit maintenance of the system shall perform the maintenance actions during the Maintainability Demonstration test. Personnel, such as engineers or technicians who have detailed knowledge of the system hardware or software characteristics, shall not participate directly in the Maintainability Demonstration test.

1E503 MAINTAINABILITY DEMONSTRATION DOCUMENTATION

The contractor shall provide the following documentation in support of the Maintainability Demonstration.

1. MAINTAINABILITY DEMONSTRATION PLAN. The contractor shall develop a

Maintainability Demonstration Plan as a separate document or as a part of system test procedures. This plan shall be reviewed and approved by the NASA procuring activity. As a minimum, the Maintainability Demonstration Plan shall include:

a. Test objectives.

b. Rationale and techniques for integrating the Maintainability Demonstration with other system/equipment testing.

c. Identification of procedures and tools to be used and descriptions of the equipment/ORU's to be tested (including criticality) and identification of any software programs.

d. Identification of the equipment/ORU's that will not be tested with supporting rationale for not testing and also include the associated equipment/ORU's mission and safety criticality.

e. Identification of both preventive and corrective maintenance actions that will be tested on the equipment or software (identified in item c above).

f. Identification of both NASA and contractor facilities that will be used during the demonstration test.

g. Test schedule and reference to the appropriate test planning documents should be included in the test planning documentation. (Note: These documents should be consistent with NASA or contractor procedures information, such as, test scenarios, established rules for corrective maintenance events, and anticipated test results.)

2. MAINTAINABILITY DEMONSTRATION REPORT. The contractor shall prepare a report that documents the results of the Maintainability Demonstration. This report may be a part of an overall system test report. The report shall be used in assessing mission risk associated with the inherent ability to complete both preventive and corrective maintenance actions. The report shall, as a minimum, provide the following information:

a. ORU(s) involved in the maintenance action(s).

b. Maintenance actions performed.

c. System and subsystem failures that required the maintenance actions.

d. The personnel including the degree of training, if different than specified in the plan, involved in performing the maintenance actions.

e. Recommended number of crew members required to execute the maintenance actions.

f. Observed time to detect, diagnose, and isolate the failure or fault to the ORU level (as applicable).

g. Observed time to remove and replace the defective ORU and to successfully complete a system checkout.

h. Mean Time to Repair/Replace (MTTR) estimate.

i. Special tools and support equipment used to perform the maintenance actions.

j. Summary of the difficulties encountered in performing the maintenance actions.

k. Recommended corrective action(s).

l. Support documentation required.

m. A summary of the failure modes (using FMEA as a baseline) that were not verified as restorable during the maintenance demonstration.

n. Identification of any ORU or other flight equipment for which the on-orbit ability to remove/replace was not verified during the Maintainability Demonstration as a result of any deviation from the approved demonstration plan. For each item identified, the consequences of a failure to safety or mission success shall be summarized.

o. Identification and adequacy of crew translation paths.

p. Adequacy of handrails, footholds, and other crew aids.

1E504 MAINTAINABILITY INPUTS TO READINESS REVIEWS

The maintainability organization shall ensure that all pertinent maintainability data necessary to support each project milestone or readiness review is provided in complete form and in a timely manner as determined by the NASA procuring activity. This shall include all pertinent data on subcontractor and supplier furnished articles that are a part of the specific hardware assembly to which the readiness review pertains.

1E505 MAINTAINABILITY EVALUATION REVIEWS

To support each project milestone or readiness review, the contractor shall review the maintainability evaluation effort. This review shall be conducted as a part of the contractor's overall maintainability review activity. In these reviews of maintainability evaluation effort, pertinent tests results will be examined to determine the need for revisions to the Maintainability Demonstration Plan and/or to confirm that completed portions of the maintainability evaluation effort have adequately accomplished their required purpose. After each review, the contractor will provide the NASA procuring activity a written report of results of the review, including actions to be taken, responsibility therefor, and revisions to the Maintainability Demonstration Plan. Results of these maintainability reviews will also be considered and acted upon in contractor-NASA maintainability program management meetings.

1E506 MAINTAINABILITY DATA COLLECTION

1. GENERAL REQUIREMENTS. Accuracy of the data on which maintainability predictions/estimates and quantitative spares estimates are based is paramount in executing a cost effective maintainability program and ultimately developing a space system that minimizes operational support cost. Similarly, the use of design rules, based on on-orbit maintenance experience, is important in achieving a design with good maintenance characteristics. Therefore, the contractor shall implement a data collection and analysis program to obtain the best possible data for these purposes. These data shall be based upon actual test or flight experience to the maximum degree possible.

2. SPECIFIC REQUIREMENTS. Data shall be developed and maintained in support of the maintainability program in the following areas: a. design engineering guidelines that will accomplish design for maintenance in spaceflight applications; and b. quantitative maintainability data. Design engineering guideline data shall, as a minimum, include design and packaging constraints applicable to both preventive and corrective maintenance activities in both EVA and IVA maintenance actions. Quantitative data shall, as a minimum, include time-to-restore, diagnostics time, and mean time between failures. Data developed under these requirements shall be based on in-flight experience or test data (provided that the conditions under which test data was obtained is similar to the appropriate EVA or IVA environment).

1E507 MAINTAINABILITY ACCEPTANCE

As a condition of hardware and software acceptance, the contractor shall have verified through the appropriate demonstrations or analyses that the maintainability requirements have been met. All verifications of maintainability requirements shall be completed and available as an input to the flight readiness review process.

APPENDIX A: RELATIONSHIP BETWEEN MAINTAINABILITY REQUIREMENTS/ACTIVITIES AND PROGRAM PHASES

PAR. NO.	REQUIREMENTS/ACTIVITIES	PROGRAM PHASES A B C D
1E201	Maintainability Program Plan	X X X X
1E202	Maintainability Program Control	X X X
1E203	Reports	X X X X
1E204	Maintainability Training	X X
1E205	Subcontractor and Supplier Control	X X X
1E206	Maintainability of Government-Furnished Property (GFP)	X X
1E301	Maintenance Concept	X X X
1E302	Maintenance Plan	X X X
1E303	Maintainability Design Criteria	X X
1E304	Engineering Design Analyses	X X
1E305	Tool Requirements	X X X
1E306	ORU Placement	X X X

APPENDIX A: RELATIONSHIP BETWEEN MAINTAINABILITY REQUIREMENTS/ACTIVITIES AND PROGRAM PHASES(CONT.)

PAR. NO.	REQUIREMENTS/ACTIVITIES	PROGRAM PHASES A B C D
1E307	Software Maintainability	X X X X
1E308	Problem Reporting and Corrective Action	X X X
1E401	Quantitative Maintainability Requirements	X X
1E402	Maintainability Models	X X X
1E403	Maintainability Allocations	X X X
1E404	Maintainability Predictions	X X X
1E405	FMEA - Maintainability Information	X X
1E406	Preventive Maintenance Analysis	X X
1E407	Emergency Maintenance Analysis	X X
1E408	Spares Requirements Analysis	X X
1E501	Maintainability Assessment	X X X
1E502	Maintainability Demonstration	X X
1E503	Maintainability Demonstration Documentation	X X

APPENDIX A: RELATIONSHIP BETWEEN MAINTAINABILITY REQUIREMENTS/ACTIVITIES AND PROGRAM PHASES(CONT.)

PAR. NO.	REQUIREMENTS/ACTIVITIES	PROGRAM PHASES A B C D
1E504	Maintainability Inputs To Readiness Reviews	X X
1E505	Maintainability Evaluation Reviews	X X
1E506	Maintainability Data Collection	X X X
1E507	Maintainability Acceptance	X X

APPENDIX B: RECOMMENDED LIST OF CONTRACTOR - GENERATED MAINTAINABILITY DOCUMENTS

A listing of potential contractor-generated documents resulting from maintainability efforts identified in this document is provided on pages B-2 through B-4. Each item (i.e., plan, report, etc.), with reference to the maintainability activity paragraph, recommended date of submittal, and the suggested NASA action, is presented on these pages.

The NASA procuring activity using this document in support of an acquisition must determine what documentation is required for the program (see par. 1E105). As a part of the systems engineering process an assessment must be made to ensure there is no duplication of contractor-generated documentation. The tailoring of documentation requirements is encouraged from both a practical and economical standpoint. Some documents may be required for delivery to the NASA procuring activity for the management and surveillance of a program, while some areas of maintainability effort can best be assessed through reviews in the contractor's facility, thus eliminating the need for documentation submittals. In some cases, documentation needs may be combined into a single report (see par. 1E105).

The NASA procuring activity has the flexibility to add, modify, or eliminate documentation requirements listed on pages B-2 through B-4.

APPENDIX B: RECOMMENDED LIST OF CONTRACTOR - GENERATED MAINTAINABILITY DOCUMENTS(CONT.)

ITEM	PAR. REF.	DUE DATE	NASA ACTION*
Maintainability Program Plan (include one copy of each procedure referenced in the plan)	1E201	a. With proposal. b. Negotiated changes before contract execution. c. Update to include negotiated changes 30 days after contract award.	I A A
Maintainability Program Survey Reports	1E202	15 days after each survey.	I
Maintainability Progress Reports	1E203	Monthly	I
Maintainability Program Control Reports	1E203	Monthly	I
Maintenance Plan	1E302	30 days before Preliminary Design Review (PDR),then updated as required.	A
Maintainability Design Criteria Report	1E303	30 days after contract award, then updated as required.	R
Engineering Design Analyses Reports	1E304	30 days before each ORU Critical Design Review (CDR).	R
Software Maintainability Plan (include one copy of each procedure referenced in the plan)	1E307	a. With proposal. b. Negotiated changes before contract execution. c. Update to include negotiated changes 30 days after contract award.	I A A

*NASA Action

A - Approval
R - Review
I - Information

See Par. 1E105

APPENDIX B: RECOMMENDED LIST OF CONTRACTOR - GENERATED MAINTAINABILITY DOCUMENTS(CONT.)

ITEM	PAR. REF.	DUE DATE	NASA ACTION*
Problem/Failure, Analysis, and Corrective Action Reports	1E308	a. Orally, 24 hours after each occurrence. b. Initial written report within 5 working days. c. Failure analysis and proposed corrective action orally as generated. d. Closure report including failure analysis on completion of required action.	I I I A
Verification of Corrective Actions	1E203 1E308	With periodic progress reports.	R
Problem/Failure Status Summaries	1E203 1E308 1E504	a. With periodic progress reports. b. Prior to each Readiness Review.	R R
Maintainability Models, Allocations, and Predictions	1E402 1E403 1E404	Before PDR then updated for CDR.	R
Failure Mode and Effects Analysis-Maintainability Information	1E405	a. Before PDR and CDR. b. Update consistent with design changes.	R R
Maintainability Assessment Design Review Package	1E501	a. Before PDR. b. Before CDR.	R R

APPENDIX B: RECOMMENDED LIST OF CONTRACTOR - GENERATED MAINTAINABILITY DOCUMENTS(CONT.)

ITEM	PAR. REF.	DUE DATE	NASA ACTION*
Design Review Reports	1E203 1E501	30 days after each review.	R
Maintainability Demonstration Plan	1E503	a. Initial submittal 30 days prior to PDR. b. Updates as revised, final plan 30 days before each test.	A A
Maintainability Demonstration Reports	1E503	30 days after each test.	R
Maintainability Evaluation Reports	1E505	30 days after each review.	I
Maintainability Data Base Reports	1E203 1E506	a. Periodic reporting with progress reports. b. Final report 60 days after mission completion.	I R

APPENDIX C: GLOSSARY OF TERMS

Accessibility - The feature of design layout and installation which permits quick and easy admission (for performance of visual and manipulative maintenance) to the area in which a failure has been traced.

Acquisition Phases

a. Phase A. Preliminary Analysis includes the identification and exploration of alternative solutions or concepts to satisfy a specific and verified need.

b. Phase B. Definition includes a period of time when selected design concepts are detailed through extensive study and analysis, initial hardware is developed, and test and evaluation conducted (if appropriate).

c. Phase C. Design includes a period of time during which a system and all its associated subsystems necessary for its support are designed, fabricated, tested, and evaluated.

d. Phase D. Development/Operation is the period of time from fabrication to system delivery and acceptance, and from acceptance to operational deployment.

Adjustment and Calibration Time - The time for recalibration when adjustments are necessary, either to compensate for performance degradation or to compensate for differences between the operating characteristics of the replacement item and those of the original item.

Assessments - A survey or audit process, using predetermined checklists, that evaluates procedures and technical documents and the adequacy of their implementation.

Automatic Test Equipment (ATE) - Equipment that is designed to conduct analysis of functional or static parameters to evaluate the degree of performance degradation and that may be designed to perform fault isolation of unit malfunctions. The decision making, control, or evaluation functions are conducted with a minimum reliance upon human intervention.

Availability - A measure of the degree to which an item is in the operable and commitable state at the start of the mission, when the mission is called for at an unknown (random) point in time. Availability is the probability of a system readiness over a long interval of time.

Built-In Test - A test approach using BITE or self-test hardware or software to test all or part of the unit under test.

Built-In Test Equipment (BITE) - Any device which is part of an equipment or system and used for the express purpose of testing that equipment or system. BITE is an identifiable unit of the equipment or system.

Catastrophic Failure - A failure which may cause loss of life or loss of space system.

Component - A combination of parts, devices, and structures, usually self-contained, which

performs a distinctive function in the operation of the overall equipment. A "black box" (e.g., transmitter, encoder, cryogenic pump).

Corrective Action - Action taken to preclude occurrence of an identified hazard or to prevent recurrence of a problem.

Corrective Maintenance - That maintenance, other than scheduled maintenance, performed to restore an item to a satisfactory condition by providing correction of a malfunction which has caused degradation of the item below the specified performance.

Corrective Maintenance Action - Action required to repair a failure is comprised of all those individual maintenance tasks involved in the maintenance procedure (e.g., fault localization, isolation, restoration, checkout).

Critical Item - A single failure point and/or an item in a life or mission essential operation application.

Design for Testability (DFT) - A design process or characteristic thereof, such that deliberate effort is expended to assure that a product may be thoroughly tested with minimum effort, and that high confidence may be ascribed to test results.

Extravehicular Activities (EVA) - Activities conducted external to the space system.

Failure - The inability of a system, subsystem, component, or part to perform its required function within specified limits, under specified conditions for a specified duration.

Failure Isolation - An operator/machine task to isolate the cause of a malfunction or failure.

Failure Mode - A particular way in which failure occurs, independent of the reason for failure; the condition or state which is the end result of a particular failure mechanism.

False Alarm - An indicated fault where no fault exists. (Does not include good items in an ambiguity group.)

Fault - A condition that causes a functional unit to fail to perform its required function.

Fault Detection - A process which discovers or is designed to discover the existence of faults; the act of discovering existence of a fault. One or more tests performed to determine if any malfunctions or faults are present in a unit.

Fault Isolation - Where a fault is known to exist, a process which identifies or is designed to identify the location of that fault replaceable unit.

Inherent Availability (Ai) - The probability that a system, ORU, or component when used under stated conditions, without consideration for any preventive or corrective maintenance in an ideal support environment will operate satisfactorily at any given time. Generally derived from analysis and potentially present in design.

Intravehicular Activities (IVA) - Activities conducted internal to the space system.

Logistic Support Analysis (LSA) - A systematic process for defining logistic support requirements.

Maintainability - A measure of the ease and rapidity with which a system or equipment can be restored to operational status following a failure. It is a characteristic of equipment and installation, personnel availability in the required skill levels, adequacy of maintenance procedures and test equipment, and the physical environment under which maintenance is performed.

Maintainability Analysis - The formal procedure for evaluating system and equipment design, using prediction techniques, failure modes and effects analysis procedures, and design data to evolve a comprehensive quantitative description of maintainability design status, problem areas, and corrective action requirements.

Maintainability Assurance - Implementation of required maintainability controls during design and fabrication of an equipment to assure that maintainability requirements are achieved in the design. Maintainability assurance effort consists of design liaison, design review, and fabrication liaison.

Maintainability Data - Data (other than administrative data) resulting from the performance of maintainability tasks in direct support of an equipment or system acquisition program.

Maintainability Demonstration Tests - Tests to measure conformance to specified quantitative maintainability requirements.

Maintainability Engineering - The engineering discipline which formulates an acceptable combination of design features, repair policies, and maintenance resources to achieve a specified level of maintainability, as an operational requirement, at optimum life cycle costs.

Maintainability Evaluation - Review and evaluation of basic designs and hardware items to determine the degree of application of maintainability principles to the equipment.

Maintenance - The act of diagnosing and physically repairing, or preventing, equipment failures.

Maintenance Concept - A description of the planned general scheme for maintenance and support of an item in the operational environment. The maintenance concept provides the practical basis for design, layout, and packaging of the system and its test equipment and establishes the scope of maintenance responsibility for each level (echelon) of maintenance and the personnel resources (maintenance manning and skill levels) required to maintain the system.

Mean Time Between Maintenance (MTBM) - The mean of the distribution of time intervals between maintenance actions (either preventive, corrective, or both).

Mean Time To Restore/Repair (MTTR) - The statistical mean of the distribution of times-to-repair. The accumulation of active repair times during a given period of time divided by the total number of malfunctions during the same time interval.

Mission Critical - An item or function, the failure of which may result in the inability to retain operational capability for safe mission continuation if a corrective maintenance action is not successfully completed.

Mission Profile - A sequential and chronological description of the mission of an item; a description of system environmental and use duty cycles throughout the mission period.

Operational Availability (Ao) - The probability that a system, ORU, or component when used under stated conditions and in an actual support environment, shall operate satisfactorily at any given time.

Orbital Replaceable Unit (ORU) - The lowest level of component or subsystem hardware that can be removed and replaced on location under orbital conditions.

Part - One or two pieces joined together which are not normally subject to disassembly without destruction of design use.

Preventive Maintenance - That maintenance performed to maintain a system or equipment in satisfactory operational condition by providing scheduled inspection, detection, and correction of incipient malfunctions before they occur or develop into major malfunctions.

Safe Haven - A contingency concept providing for the safety of crew members in the event of an emergency situation.

Safety Critical - An item or function, the failure of which may result in loss of life and/or vehicle, if a corrective maintenance action is not successfully completed in a finite period of time.

Staff hours - The requirement for human resource time expressed in total clockhours, frequently expressed as manhours or maintenance manhours.

System - One of the principal functioning entities comprising the project hardware, software, and related operational services within a project or flight mission. Ordinarily, a system is the first major subdivision of project work. Similarly, a subsystem is a major functioning entity within a system.

Testability - A design characteristic which allows the status (operable, inoperable, or degraded) of a system or any of its subsystems to be confidently determined in a timely fashion. Testability attempts to quantify those attributes of system designs which facilitate detection and isolation of faults that affect system performance. Testability has been defined as "the characteristic of a design which allows the status of a system or any of its subsystems to be confidently determined in a timely fashion."