

*NDS 11
711-33
1711736
P.72*

RELIABILITY PROGRAM REQUIREMENTS FOR AERONAUTICAL AND SPACE SYSTEM CONTRACTORS

(NHB-5300.4(1A-1)) RELIABILITY
PROGRAM REQUIREMENTS FOR
AERONAUTICAL AND SPACE SYSTEM
CONTRACTORS (NASA) 72 p

N93-72441

Unclass

29/38 0171736

January 1987



National Aeronautics and
Space Administration

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

Volume 1 - General Provisions

Title	Number
Reliability Program Requirements for Aeronautical and Space System Contractors	NHB 5300.4 (1A-1) (January 1987)
Maintainability Program Requirements for Space Systems	NHB 5300.4 (1E) (Soon to be released.)
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 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

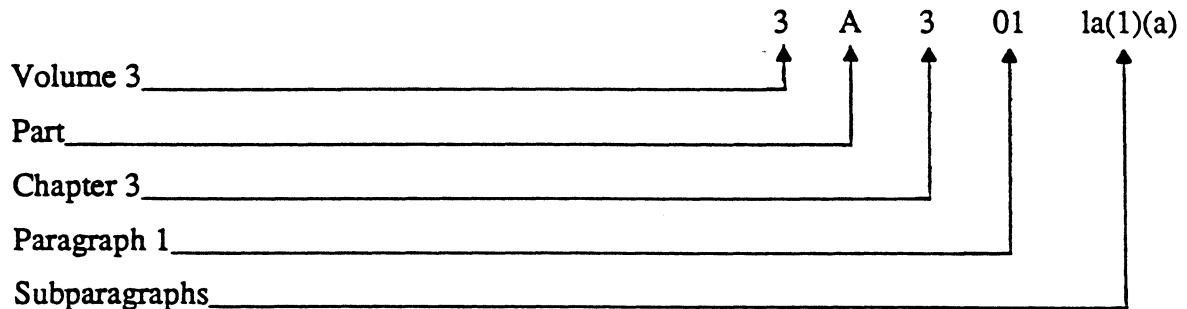
Each RM&QA Manual Part is assigned its own identification number within the basic classification code. The numeric-alpha suffix within a parenthesis identifies the grouping of the publication, that is, the volume and part, such as NHB 5300.4(3A): This number indicates that this is the first "Standards"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

Table of Contents

CHAPTER 1: INTRODUCTION

1A100 SCOPE	1-1
1A101 APPROACH	1-1
1A102 RELATION TO OTHER CONTRACT REQUIREMENTS	1-1
1A103 ACTIONS AND PREROGATIVES OF THE GOVERNMENT	1-2
1A104 RELIABILITY PROGRAM DOCUMENTS	1-2
1A105 GLOSSARY OF TERMS	1-3
1A106 REQUIREMENT FOR SUPPLEMENTAL DETAILS TO BE SPECIFIED	1-3

CHAPTER 2: RELIABILITY PROGRAM MANAGEMENT

1A200 ORGANIZATION	2-1
1A201 RELIABILITY PROGRAM PLAN	2-1
1A202 RELIABILITY PROGRAM CONTROL	2-2
1A203 RELIABILITY PROGRESS REPORTING	2-3
1A204 RELIABILITY TRAINING	2-3
1A205 SUPPLIER CONTROL	2-4
1A206 USE OF PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE	2-4
1A207 RELIABILITY OF GOVERNMENT-FURNISHED PROPERTY (GFP)	2-5

CHAPTER 3: RELIABILITY ENGINEERING

1A300 GENERAL	3-1
1A301 DESIGN SPECIFICATIONS	3-1
1A302 STANDARDIZATION OF DESIGN PRACTICES	3-2
1A303 RELIABILITY PREDICTION	3-2
1A304 FAILURE MODE AND EFFECTS ANALYSES (FMEA's)	3-3
1A305 PARTS STRESS ANALYSES	3-4
1A306 WORST-CASE ANALYSES	3-5
1A307 TREND ANALYSES	3-5
1A308 SPECIAL ANALYSES	3-5
1A309 SOFTWARE ASSURANCE	3-5
1A310 MAINTAINABILITY/SERVICEABILITY AND HUMAN INDUCED FAILURE	3-6
1A311 ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PARTS	3-6
1A312 MATERIALS AND PROCESSES	3-6
1A313 REVIEW OF ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PACKAGING	3-7
1A314 DESIGN REVIEW PROGRAM	3-7
1A315 PROBLEM/FAILURE REPORTING AND CORRECTION	3-8

CHAPTER 4: TESTING AND RELIABILITY EVALUATION

1A400 GENERAL	4-1
1A401 RELIABILITY EVALUATION PLAN	4-1
1A402 TESTING	4-2
1A403 RELIABILITY ASSESSMENT	4-4
1A404 RELIABILITY INPUTS TO READINESS REVIEWS	4-4

1A405 RELIABILITY EVALUATION PROGRAM REVIEWS	4-4
--	-----

APPENDICES

APPENDIX A: INTERFACING AREAS OF RELIABILITY PROGRAMS WITH OTHER ASSURANCE PROGRAMS FOR NASA CONTRACTS	A-1
APPENDIX B: LIST OF CONTRACTOR-GENERATED RELIABILITY DOCUMENTS REQUIRED BY THIS PUBLICATION	B-1
APPENDIX C: GLOSSARY OF TERMS	C-1
APPENDIX D: REQUIREMENT DETAILS TO BE SPECIFIED IN THE RFP OR CONTRACT..	D-1

CHAPTER 1: INTRODUCTION

1A100 SCOPE

This publication prescribes general reliability program requirements for NASA contracts involving the design, development, fabrication, test, and/or use of aeronautical and space systems including critical ground support equipment.

1A101 APPROACH

The reliability program requirements herein require:

1. Thorough planning and effective management of the reliability effort.
2. Definition of the major reliability tasks and their place as an integral part of the design and development process.
3. Planning and evaluating the reliability of the system and its elements (including effects of software interfaces) through a program of analysis, review, and test.
4. Timely status indication by formal documentation and other reporting to facilitate control of the reliability program.

1A102 RELATION TO OTHER CONTRACT REQUIREMENTS

1. Nothing in this publication shall be construed as a requirement for duplication of effort. Organizational responsibility for overlapping and interfacing functions such as quality assurance, safety, maintainability, and test shall be clearly delineated in the Reliability Program Plan and cross-referenced in other pertinent technical program documents. To assist the contractor in compliance with this requirement, a cross-reference listing of principal reliability program requirements interfacing with those of the quality program is provided in Appendix A.
2. The program requirements set forth herein are consistent with those of NASA publications "Quality Program Provisions for Aeronautical and Space System Contractors," NHB 5300.4(1B); "Basic Safety Manual," NHB 1700.1(V1-A); 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 the provisions of this document and those stated in the contract, the contractual statement of precedence shall govern.
5. If inconsistencies become evident between the provisions of this document and those stated in the approved reliability program plan (see par. 1A201), this document shall take precedence except where specific deviations have been identified and approved prior to contract award.

1A103 ACTIONS AND PREROGATIVES OF THE GOVERNMENT

1. GENERAL. All work, data, and documentation generated for the contract effort by the contractor and suppliers are subject to examination, evaluation, and inspection at any practicable time and place by the procuring NASA installation or its designated representatives. The contractor and suppliers at all tiers shall cooperate fully with such representatives, providing to them access to the contractor's and supplier's facilities to permit performance of their designated function. Subcontracts shall include provisions to accommodate such representatives.
2. SEPARATE RELIABILITY EVALUATIONS FOR NASA. NASA reserves the right to contract separately with reliability evaluation contractors to function in the capacity of designated NASA representatives. Evaluation contractors usually will:
 - a. Provide technical advice to the procuring NASA installation;
 - b. Determine effectiveness of system and subsystem contractors' and suppliers' reliability programs, particularly with regard to potential sources of unreliability; and
 - c. Assess, evaluate, and recommend improvements in the reliability of the system hardware and software.
3. INPUTS TO DATA EXCHANGE PROGRAMS. NASA reserves the right to utilize portions of the reliability program data generated under the contract (particularly data on parts, devices, and materials), as inputs to various Government data exchange programs. Requirements for specific contractor efforts will be specified in the contract.

1A104 RELIABILITY PROGRAM DOCUMENTS

1. Appendix B, "List of Contractor-Generated Reliability Documents Required By This Publication," lists reliability program documents called for in this publication. These documents are required to convey technical information, to support or obtain technical discipline and decisions, to provide visibility for evaluating reliability status of hardware and software, and to provide visibility for assessing the reliability program. These documents are required to be generated and available to the procuring NASA installation and its designated representative unless expressly waived by the contract. In addition, the contract will specify that certain of these 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 evaluation reveals inadequacies, the contractor will be requested to correct the documents.
 - 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.

2. 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 and shall be submitted to the procuring NASA installation and its designated representatives upon request (see also par. 1A205-2). To facilitate Government and contractor evaluation of the reliability program, the contractor's filing system should be maintained in such a manner as to permit rapid identification, location, and retrieval of documentation pertinent to the reliability program.

1A105 GLOSSARY OF TERMS

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

1A106 REQUIREMENT FOR SUPPLEMENTAL DETAILS TO BE SPECIFIED

Appendix D provides guidelines for contractual specification of supplemental details to the general requirements stated in this publication. The contractor shall determine the need to specify details similarly when imposing the requirements of this publication on suppliers.

CHAPTER 2: RELIABILITY PROGRAM MANAGEMENT

1A200 ORGANIZATION

The contractor shall have one clearly identified organizational element which will be responsible for the planning and management of the contract reliability program and for ensuring its effective execution. The individual designated as the head of this reliability management organization shall have the necessary authority and resources to discharge this responsibility. The individual shall have direct, unimpeded access to higher management and shall report regularly to higher management on the status and adequacy of the program. Although the accomplishment of many of the reliability program tasks may not be the line function of the reliability management organization, that organization shall monitor and ensure that all reliability program tasks are accomplished effectively.

1A201 RELIABILITY PROGRAM PLAN

1. GENERAL. The contractor shall provide, maintain, and implement a Reliability Program Plan which describes how the contractor will ensure compliance with specified reliability program requirements for the contract effort. The Plan shall be submitted and updated as required by Appendix B. This Plan, together with the reliability program control reporting system (see pars. 1A202-1 and 1A203-3), shall serve as the master planning and control document for the reliability program.

2. CONTENTS. The Plan shall include:

- a. Charts and narrative statements which describe the organizational responsibilities and functions associated with the conduct of the reliability program and each task therein. This shall include for each task in the reliability program detailed statements of:
 - (1) Duties of each organizational element (e.g., engineering, reliability, safety, fabrication, test, quality assurance) involved in its accomplishments or use of its outputs.
 - (2) Delineation of interfaces in responsibilities and functions where more than one organizational element is involved.
 - (3) The relationship of the reliability management organization to each of the other organizational elements performing reliability program tasks and reliability management's authority to control and monitor these tasks.

A summary (matrix or other brief form) shall be included which indicates for each reliability program requirement, the principal organization responsible for implementation and the specific organization responsible for generating the necessary documents. In addition, the summary shall indicate each contractor organization which has approval or review authority relative to documents generated.

- b. Narrative descriptions, time or milestone schedules, and supporting documents which describe in detail the contractor's plan for execution and management of each task in the reliability program. Directives, methods, and procedures shall be documented by

the contractor to implement each task, and these documents shall be referenced in the Reliability Program Plan, be available, and be submitted on request.

- c. A listing of contractor documents (methods, procedures, etc.) requiring origination or modification to meet requirements of this document. This shall include a schedule for completion of these documents or changes and a description of them.
 - d. Identification of items to be obtained by subcontract where the criticality and nature of the item is considered to warrant application of a formal reliability program (see also pars. 1A205-1 and -2). The Plan shall contain or reference a detailed description of the reliability program requirements to be included in the subcontract for each such item.
 - e. A listing of items provided by suppliers not required to use a reliability program. For each item listed, identify the document(s) specifying the applicable reliability and quality controls; also indicate the contractor organization responsible and actions planned for ensuring that these controls are accomplished. This listing shall be updated as prescribed in Appendix B to reflect additional hardware items or controlling documents.
3. SEPARATE FACILITY PLANS. The reliability program effort at each remote facility shall be governed by a self-contained separate part of the overall Reliability Program Plan or by a separate plan written for each remote facility. The facility plans for the reliability program effort may be combined with the separate plans for quality program effort at the corresponding remote facility.

1A202 RELIABILITY PROGRAM CONTROL

1. GENERAL. The contractor shall devise a system for effective management control and survey of the reliability program. Insofar as practical, this system will utilize the reporting system prescribed for the overall contract effort, with supplemental provisions as agreed on with the procuring NASA installation. This system shall provide and periodically update a time or milestone phased listing for each reliability task of planned, expended, and projected man-hours, materials, facilities, services, and support with associated costs and responsible organizational element (see also par. 1A203-3).
2. RELIABILITY PROGRAM SURVEYS
 - a. The contractor shall conduct periodic surveys of the reliability program and those of suppliers required to utilize one (see par. 1A201-2d). These shall be conducted either independently or as a part of broader surveys of assurance areas. They shall evaluate progress and effectiveness and shall determine the need for adjustments or changes in the reliability programs.
 - b. The surveys shall cover the reliability program and interfacing project areas. Surveys shall be conducted at appropriate intervals as scheduled in the Reliability Program Plan. Provisions shall be made for participation of NASA personnel in selected portions of this contractor survey activity at the discretion of the procuring NASA installation.

- c. Reports of survey results and reports of verification of corrective action completions shall be documented by the contractor and submitted in accordance with Appendix B. Although the schedule of surveys in the Reliability Program Plan shall show the general frequency of surveys within stated milestone intervals, the precise scheduling of surveys shall be random insofar as practicable.

1A203 RELIABILITY PROGRESS REPORTING

1. GENERAL. The contractor shall report periodically on the progress of the reliability program. This reporting shall include pertinent information on the reliability programs of the suppliers identified in accordance with par. 1A201-2d. Reliability progress reporting shall comprise formal, scheduled written reports and/or a schedule of documented joint contractor-NASA reliability program management meetings. This formal reporting will be augmented by day-to-day informal reporting of pertinent matters as they arise. Schedules for reliability progress reports and management meetings shall be as specified in the Reliability Program Plan. Formal reliability progress reports may be submitted as a separate part of overall periodic progress reports for the contract.
2. WRITTEN PROGRESS REPORTS. Periodic written progress reports shall include the following:
 - a. Technical progress of each reliability program task including significant accomplishments and milestones reached during the reporting period.
 - b. Reliability problem areas and proposed corrective actions.
 - c. Decisions and actions during the reporting period having impact on the reliability effort and description of their anticipated effect on hardware reliability.
 - d. Revised schedules for contract work and significant events in the succeeding reporting period.
 - e. Anticipated reliability program slippage and their effects.
3. RELIABILITY PROGRAM CONTROL REPORTS. The contractor shall submit reliability program control data as a separately identified part of the periodic financial and management reports required by the contract. This shall include data for each task comparing resources planned vs. resources expended for the reporting period, as well as revised projections for succeeding milestone intervals, (see also par. 1A202-1). This data shall also identify resources expended to accomplish reliability program tasks (e.g., failure mode and effects analyses (FMEA's)) by organizations other than the reliability organization.

1A204 RELIABILITY TRAINING

The contractor shall use trained and competent personnel to implement the reliability 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 Reliability 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.

1A205 SUPPLIER CONTROL

1. GENERAL. The contractor shall be responsible for ensuring that system elements obtained from suppliers will meet the reliability and reliability assurance requirements of the overall system. This applies to items obtained from any 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 guidance and controls to assure the adequacy of reliability program controls used by suppliers. All subcontracts, regardless of tier, shall include provisions for review and evaluation of the supplier's reliability effort by NASA or its representatives as prescribed in par. 1A103.
2. RELIABILITY PROGRAM REQUIREMENTS FOR SUPPLIERS REQUIRED TO UTILIZE RELIABILITY PROGRAMS. Appropriate provisions of this publication shall be imposed by the contractor on subcontracts considered to require a reliability program, as prescribed in par. 1A201-2d. Appropriate provisions for such subcontracts shall at least include all provisions of this publication which:
 - a. Specifically require the contractor to impose that requirement on these suppliers, or
 - b. Require the contractor to receive or to provide to NASA supplier data or documentation (see Appendix D).

All such subcontracts shall also contain provisions for access of the contractor's personnel to the supplier's facilities as necessary to monitor and evaluate the supplier's reliability program and related activities.

3. MINIMUM RELIABILITY CONTROLS FOR ITEMS NOT REQUIRING RELIABILITY PROGRAMS. The reliability of all items obtained from suppliers who are not required to maintain a formal reliability program shall be controlled by quality assurance requirements required by the contract and by selected appropriate reliability task requirements.

1A206 USE OF PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE

Where the contractor proposes to use previously designed, fabricated, or flown hardware in the mission system, the contractor shall demonstrate that the proposed hardware will comply with the assurance requirements of this procurement as well as the performance requirements. Where the contractor considers such hardware to have demonstrated compliance with the assurance requirements of this procurement, the contractor shall submit substantiating documentation. The documents shall:

1. Compare each performance, design, interface, qualification, and test requirement for this project (as delineated in other documents related to this procurement) with the corresponding previous requirement. For any that do not comply, either describe what modification will be made to achieve compliance or provide a rationale and supporting information stating why the deviation is considered acceptable.

2. Compare each assurance requirement for this project (as delineated in the reliability, parts, quality, maintainability, and system safety assurance documents for this procurement) with the corresponding previous requirement. For any that do not comply, describe what will be done to achieve compliance or provide a rationale and supporting information stating why the deviation is considered acceptable. In addition, state how any modifications proposed as a result of par. 1A206-1 will be shown to comply with the assurance requirements of this document.
3. Compare the manufacturing information for the hardware proposed for this project with that for the previous hardware. As a minimum, this comparison shall include the name and location of the manufacturer, the date of manufacture, any design changes, any changes to parts or materials, any modification to packaging techniques, and any change to fabrication or assembly processes.
4. Describe all test and flight experience with the proposed hardware including, in particular, a description of all failures or anomalies, their cause, and corrective action taken.

Such documentation shall be submitted with the proposal and be updated in accordance with Appendix B. For previously flown hardware found to be necessary later during contract effort, the documentation shall be submitted as part of the Class I change justification.

1A207 RELIABILITY 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 procuring NASA installation, adequate reliability data on these items for use in performing required reliability tasks for the system. Where examination of these data or testing by the contractor indicate inconsistency of the reliability of Government-Furnished Property with the reliability requirements of the overall system, the procuring NASA installation shall be formally and promptly notified for appropriate action.

CHAPTER 3: RELIABILITY ENGINEERING

1A300 GENERAL

Reliability engineering consists of a number of interrelated technical assurance tasks that should be conducted as an integral part of project activity. These tasks include selected measures in design definition and review, reliability analysis, interfaces with other assurance activities and control of general design practices, and problem correction and prevention. This Chapter describes the reliability engineering task requirements.

1A301 DESIGN SPECIFICATIONS

1. The contractor shall generate a design specification for each item of hardware at the system, subsystem, and component level. Each design specification shall state the physical and functional requirements seen by the envelope of the item being specified; and this statement of requirements shall be the best estimate available at the stage of project life at which the specification is generated or revised. These specifications shall describe requirements for the item in question, as well as its interfaces with other items (including GFP) and shall include:
 - a. Functional (performance) and environmental requirements;
 - b. Test requirements, including qualification stress levels requirements and test quantities;
 - c. Safety margins, derating factors, apportioned reliability goal, and unacceptable failure effects (from a criticality standpoint);
 - d. Physical parameters and constraints;
 - e. Fault tolerance criteria; and
 - f. Testability/diagnostic requirements.

Design specifications will initially be generated early in the functional design process and will be iteratively updated to reflect refinements and changes during the evolution of the design. These documents will provide a consistent recorded basis for guiding the design of the system and its elements throughout the design evolution process.

2. The contractor's reliability organization, in conjunction with other contractor organizations, shall review for concurrence all design specifications or shall ensure that they are independently reviewed prior to their release. This review shall ensure that the set of specifications covers all items of hardware and software at the appropriate levels, that each is complete in its contents, and that each is functionally and physically consistent with interfacing design specifications, and that the resultant documentation changes from updating comply with the project configuration management requirements. These reviews shall also be conducted whenever individual specifications change; they shall be documented individually as they occur and shall be summarized at milestones (or periodically) on an overall basis. The documentation of individual design specification reviews shall be used as inputs at design reviews of components and subsystems, and the

overall summaries shall be used as inputs at subsystems and system level design reviews and in program status reporting.

3. Design specifications and their revisions shall be subject to NASA action as specified in the contract.

1A302 STANDARDIZATION OF DESIGN PRACTICES

1. The contractor shall maintain a continuous effort to standardize and control design practices and fabrication processes. The contractor's existing design and process standards and specifications shall be used insofar as practicable, modifying them as necessary to meet the reliability, quality, and other requirements of the contract. To the extent prescribed in the contract, NASA design or processing standards shall be incorporated in the contractor's design standards system and the contractor shall impose a similar requirement on appropriate suppliers. The contractor's reliability or other assurance organization shall be responsible for reviewing design and process standards to be used for the contract effort to ascertain their adequacy in meeting assurance requirements of the contract.
2. The contractor shall review for adequacy the standards and design practices applicable to the contract effort of all suppliers required to utilize a reliability program (see par. 1A201-2d). All standards and practices (including process specifications) shall be subject to action by NASA (e.g., approval or review, and control of changes) as specified in the contract.

1A303 RELIABILITY PREDICTION

1. DEVELOPMENT OF RELIABILITY PREDICTIONS. Starting in the conceptual design stage, the contractor shall develop reliability prediction models and predictions for the system. These models and predictions shall reflect applicable experience from previous space or aeronautical programs and shall be revised as required by design evolution and as additional pertinent data become available. Predictions shall be performed in close coordination with failure mode and effects analyses (FMEA's) on the same system elements. The scale of effort and degree of precision in each prediction shall be appropriate to the phase of project life in which the prediction is made and to the intended use of the results. Individual predictions shall be made and the results reported to users within the contractor's organization in time for the uses and decisions which each prediction is to support. Final predictions, if required, shall utilize data from the electrical, mechanical, and thermal analyses prepared in accordance with pars. 1A305 and 1A313. Predictions are variously useful as a basis for:
 - a. Comparing predicted reliability against apportioned reliability goals within the system and planning a design capable of meeting mission reliability goals.
 - b. Timely identification of potential reliability problem areas and guiding design tradeoffs and redundancy decisions.
 - c. Mission planning, test program planning, and reliability evaluation program planning.

- d. Probability-of-occurrence determinations in cases where failure mode, effects, and criticality analyses (FMECA's) are used.
 - e. Guiding reliability vs. maintainability/serviceability tradeoffs.
 - f. Preliminary estimation of mean-time-between-failures (when used with FMEA) to support maintainability analysis and logistics planning.
2. COMMON DATA BASE. The contractor shall use a common data base for analyses and studies on reliability, maintainability, and system safety for the contract effort. In the Reliability Program Plan, the contractor shall identify initial data sources for this data base and the plans and procedures for updating and using it. The contractor shall submit data base information in accordance with Appendix B.
 3. FUNCTIONAL AND EQUIPMENT BLOCK DIAGRAMS. In support of the reliability prediction and FMEA efforts, the contractor shall utilize functional and/or equipment block diagrams of the system. Each block shall indicate the current predicted reliability and apportioned reliability goal and other pertinent data for the system element represented. These diagrams shall be updated with the analyses they support as prescribed in Appendix B.

1A304 FAILURE MODE AND EFFECTS ANALYSES (FMEA's)

1. As an integral part of the early design phase, the contractor shall develop analyses to determine possible modes of failure and their effects on mission objectives and crew safety. The primary objective of these analyses shall be to identify critical and catastrophic failure modes to enable removal from the system of susceptibility to such failures or their effects. Catastrophic failures are defined as those that result in loss of life or mission or serious injury to personnel. Critical failures are defined as those that significantly degrade the achievement of mission success. The analysis shall be performed for all mission hardware.
2. The failure mode and effects analyses shall be conducted at the system-to-subsystem, subsystem-to-component, and the system-to-instrument interfaces as well as interfaces with ground test equipment. Potential critical and catastrophic failures at the component level or instrument-to-system interfaces shall be analyzed to the extent necessary to identify single items that could cause the failures. Analysis of redundant equipment shall address particularly any single failures that adversely affect the redundant capability of cross strapped, alternate path, or other redundant designs. The analysis shall also be directed to identify any single failure that could prevent the successful removal of power from a payload instrument. All single failure points and potential critical and catastrophic failures that cannot be eliminated from the system shall be itemized on a Critical Items List (CIL) for appropriate attention in corrective and risk management activities. Existence of redundancy shall not preclude listing of a critical item on the CIL. Justification for the retention of the risk residual in each item on the list shall be included. This list shall be subject to NASA action as required in Appendix B.
3. FMEA results shall be communicated in a timely manner for prompt action by design organizations and project management. They shall be a major consideration in design and management reviews and shall provide criteria and data for other types of analysis, design improvement, testing, and safe operations. Some important applications include:

- a. Determining need for redundancy, fail-safe design features, and/or further derating.
- b. Supporting systems safety analyses and hazard analyses.
- c. Supporting establishment of safety requirements in testing and operations.
- d. Assuring that the test program is responsive to known and suspected potential failure modes.
- e. Supporting studies to establish tradeoffs of reliability vs. serviceability/maintainability.
- f. Establishing data recording requirements and needed frequency of monitoring in testing, checkout, and mission use.
- g. Supporting mission operations activities such as designing fault isolation sequences and alternate-mode-of-operation planning.
- h. Supporting establishment of quality assurance requirements in determining mandatory inspection points for critical items during manufacturing and at hardware acceptance.

FMEA's and other analyses interfacing with them should be coordinated closely to provide consistency and to minimize duplication. The analysis technique selected and the data output of the FMEA should be planned to provide maximum practicable usefulness to interfacing analysis activities. FMEA's and their revisions should be prepared and distributed within the contractor's organization in time for the decisions and uses they are intended to support.

- 4. The FMEA's shall be updated periodically at specified milestones and additionally as required by changes in the design or other pertinent data or events. The FMEA's, together with the Critical Items List and updates, shall be submitted to the procuring NASA installation in accordance with Appendix B.

1A305 PARTS STRESS ANALYSES

Electrical, electronic, and electromechanical (EEE) parts as applied in circuits within each component shall be subjected to stress analyses to assess conformance with the derating guidelines of MIL-STD-975 and the parts and materials requirements of the contract. These analyses shall be performed at the most stressful part-level parameter values (tolerance limits for most critical parameters) that can result from the specified performance and environmental requirements on the assembly or component (including component qualification). The analysis shall be performed in close coordination with the packaging reviews (par. 1A313) and shall be required input data for component-level design reviews (par. 1A314). The stress analyses shall be documented and updated as stated in Appendix B.

1A306 WORST-CASE ANALYSES

Worst-case analyses shall be performed for critical design parameters that are subject to variations that could degrade performance. Adequacy of margins in the design of electronic circuits, optics, and electromechanical and mechanical items shall be demonstrated by analyses and/or test. The analyses shall consider the critical parameters set at worst-case limits including initial tolerance, purchase tolerance, aging effects, and environmental effects for the parameter or operation being evaluated. The analyses shall be updated as the design changes. On request, both the analyses and updates shall be made available to the procuring NASA installation as required by Appendix B.

1A307 TREND ANALYSES

The contractor shall assess all subsystems and components to determine the measurable parameters that relate to performance stability. These parameters shall be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases of the end items. The parameters shall be monitored within the normal test framework (i.e., during functional tests, environmental tests, etc.). The contractor shall establish a system for recording and analyzing the parameters and any changes from the nominal, even if the levels are within specified limits. A list of parameters to be monitored and the trend analysis reports shall be submitted in accordance with Appendix B. Trend analysis data shall be reviewed with the operational personnel before mission use, and a requirement should be established for operational personnel to continue to record the trends throughout the life of the mission.

1A308 SPECIAL ANALYSES

The contractor shall identify other special reliability-related analyses appropriate for the contract in the Reliability Program Plan (e.g., sneak circuit analysis, fault tree, stress vs. strength). The contractor shall implement these in accordance with approved procedures and provide reports in accordance with Appendix B.

1A309 SOFTWARE ASSURANCE

The contractor shall control the software in accordance with the software assurance requirements for the contract (based on current requirements of NMI 2410.6, "NASA Software Management Requirements for Flight Projects", and related documents). In those assurance areas where software and hardware assurance efforts interface (e.g., problem/failure reporting), the respective assurance plans shall clearly identify the functions to be performed by each assurance system.

1A310 MAINTAINABILITY/SERVICEABILITY AND HUMAN INDUCED FAILURE

1. The contractor shall provide for maintainability/serviceability of the system to the extent required by the contract. Where maintainability/serviceability tasks are required (see the Statement of Work), interfacing reliability program tasks shall be structured and timed insofar as practicable to provide needed source data for, or verification of pertinent tasks in the maintainability/serviceability effort.
2. The contractor shall maintain an effort to eliminate potential sources of human-induced failure from the system throughout the development and mission use. To minimize human induced failures, a systematic effort shall be directed toward making proper and safe use of the hardware and software convenient and toward making improper or unsafe use inconvenient or difficult. This effort should enhance the system's capability to be fabricated, handled, maintained, and operated with maximum facility and minimum hazard to life and equipment. The effort shall cover the design of the equipment, analysis, elimination of reported problems and failures, and all operational and instructional material and training associated with its handling, storage, transportation, checkout, and use.

1A311 ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PARTS

The contractor shall implement a program of activity to ensure the adequacy and quality of EEE parts used in the system. Requirements for this area are specified in the Statement of Work. The reliability program activities and requirements relating to EEE parts shall conform with the stated contractual requirements for that area.

1A312 MATERIALS AND PROCESSES

1. To ensure safety and mission success, the contractor shall implement an effort directed toward the proper selection and treatment of materials of construction. Materials and processes should be selected on the basis of suitability for their uses as determined by past performance, available data, or current tests. For new materials or materials without aerospace use experience, special emphasis shall be placed on verification of their suitability for the prospective aerospace application.
2. The materials and processes control activity shall comply with the applicable requirements of NHB 8060.1B, "Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion", and additional requirements necessary to meet mission needs. The effort shall place particular emphasis on such known problem areas as:
 - a. Flammability.
 - b. Offgassing (either toxic or condensable on optics or detectors).
 - c. Homogeneity of properties (e.g., heat treating uniformity or weld-heat affected zones).

- d. Radiation effects.
 - e. Deterioration with age.
 - f. Stress-corrosion cracking.
 - g. Galvanic corrosion.
 - h. Hydrogen embrittlement.
 - i. Adequacy of lubricants.
3. During the design effort, the contractor shall conduct materials tests as necessary and shall identify necessary materials and process controls on pertinent drawings and specifications. The contractor shall also implement such additional materials and process controls as required by the contract.

1A313 REVIEW OF ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PACKAGING

The contractor shall review the packaging (design, layout, and assembly criterion) of electrical, electronic, and electromechanical (EEE) items used in the system. The review shall be performed at the component level as a part of the input to each component-level Preliminary Design Review (PDR) and Critical Design Review (CDR). It shall evaluate the ability of the packaging concept and design to perform successfully under operating and environmental conditions of the mission as well as all prior testing. It shall deal specifically with the placement, mounting, and interconnection of each EEE part on circuit boards or substrates, including electrostatic discharge considerations (see also DoD-STD-1686, "Electrostatic Discharge Control Program For Protection Of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)" and DoD-HDBK-263, "Electrostatic Discharge Control Handbook For Protection Of Electrical And Electronic Parts, Assemblies And Equipment (Excluding Electrically Initiated Explosive Devices)"). It shall also cover the structural support and thermal accommodation of these boards and substrates and their interconnections in the component design. Provision for protection of the parts and ease of inspection shall be among the specific considerations of the review. The review's technical aspects, including analyses, shall be fully documented as required in Appendix B. The degree of detail of the review shall be appropriate to the state of development of the design at the review milestone: at the PDR, the focus of review shall be the packaging approach to be used in the hardware design; at the CDR, the review shall cover the detail design of the component and the supporting dynamic and thermal analyses of the EEE parts and assemblies within it.

1A314 DESIGN REVIEW PROGRAM

1. DESIGN REVIEWS BY THE CONTRACTOR. The contractor shall conduct a formal program of planned, scheduled, and documented design reviews at the system, subsystem, and component levels. These reviews shall be comprehensive critical assessments of all pertinent aspects of the design of hardware and software. They shall

be conducted at major milestones in the program as prescribed in the Statement of Work. Participation shall be interorganizational, including personnel from design, fabrication, test, assurance areas, and other areas of the contractor's organization. NASA representatives shall also attend at the discretion of the procuring NASA installation. The contractor's reliability organization, and other participating elements of the contractor's organization, shall sign all design review reports to indicate concurrence with their completeness and accuracy. The reliability organization shall also followup on action items to ensure or verify their satisfactory completion. In connection with these reviews, the contractor shall submit the following:

- a. A detailed description of the design review program, including practices and procedures employed, a checklist of design aspects to be covered, identification of the documentation required in the input data package for each milestone category of review (e.g., preliminary design review and critical design review), and schedule of individual reviews. This shall be included or referenced in the Reliability Program Plan and shall be updated as necessary.
 - b. Notification to the procuring NASA installation or its designated representative, when so delegated, 15 working days in advance of each review, as to the system element to be reviewed, scheduled date, time, and location for the review in question. This notification shall be accompanied with copies of the input data package for the review as prescribed in Appendix B.
 - c. Design review meeting minutes, including a listing of representation at the review, a statement of decisions reached, actions to be taken and responsibilities therefor, shall be submitted to the procuring NASA installation as prescribed in Appendix B.
 - d. A design review report, including a summary of discussion and dissenting opinions, conclusions, required actions and their scheduled completions, shall be submitted to the procuring NASA installation as prescribed in Appendix B.
2. DESIGN REVIEWS BY SUPPLIERS. The provisions of par. 1A314-1, shall be imposed on the prime contractor's suppliers required to have formal reliability programs (see par. 1A201-2d). Provisions shall be made for participation of appropriate representatives of the contractor at the contractor's discretion (personnel representing design, reliability, quality, etc.), and for attendance of NASA personnel as observers at all supplier formal design reviews. Notification and reporting requirements of pars. 1A314-1b, c, and d shall be implemented through the contractor.

1A315 PROBLEM/FAILURE REPORTING AND CORRECTION

1. REQUIREMENTS OF THE ACTIVITY. The contractor shall employ a controlled system for identification, reporting, analysis, remedy, and recurrence prevention for functional nonconformances and suspected nonconformances which occur throughout specified portions of the contract effort. Hereafter this is called the "problem/ failure reporting system." This system shall be consistent with applicable requirements for nonconforming article and material control as stated in Chapter 8 of NHB 5300.4(1B). If a single system is used for reporting of both problems/failures and nonfunctional nonconformances, the system shall be described only once in either the Reliability Program Plan or the Quality Program Plan and shall be referenced in the other. The problem/failure reporting system shall also satisfy the following requirements:

- a. Cover the hardware and software as specified below, the interfaces between the hardware and this software, and the interfaces between hardware or software and testing or operating personnel. Hardware shall include all flight configured hardware, flight support equipment, ground equipment directly involved in mission operations, and the checkout equipment defined in the Reliability Program Plan. Software items covered shall include computer programs for use in test, checkout, launch, and mission use of the mission hardware. For software items, a separate system of problem/failure reporting shall be used prior to integration with the mission hardware. Requirements for that system are stated in the software assurance requirements appended to the Statement of Work. The interface of that system with the problem/failure reporting system prescribed here shall be defined in both the Software Assurance Plan and the Reliability Program Plan.
- b. Cover all observed functional nonconformances, as well as suspected nonconformances of a functional nature, including unusual conditions occurring in test or handling which are suspected to have an effect on the hardware.
- c. Provide for reporting of each problem/failure within time periods stated in Appendix B.
- d. Provide for investigation and engineering analysis of each reported problem/failure, followed where appropriate by laboratory analysis of failed hardware. The investigation shall be adequate to assess causes, mechanisms, and potential effects of the problem/failure and serve as a basis for decisions on most efficient remedial and preventive actions. The investigations and their conclusions shall be documented. The contractor's parts, and/or materials organizations will participate, as appropriate, in the analysis of reported part or material failures.
- e. Provide for categorizing problem/failures by criticality and for differentiating between functional and nonfunctional nonconformances. It shall also provide for appropriate risk management mechanisms to provide special attention to potentially catastrophic or critical problems or failures.
- f. Recurrent nonconformances from other nonconformance recording systems used under the contract shall be referred to the problem/failure reporting system. Such recurrent nonconformances shall include those of a nonfunctional nature and those of a functional nature that occur during in-process testing (i.e., during fabrication) which are recurrent to the extent defined in the Reliability Program Plan (see par. 1A315-2a) or in Material Review Board procedures (see NHB 5300.4(1B), par. 1B804). Such referred items shall be subject to analysis and closure requirements for other reported problem/failures.
- g. Provide for accomplishment and documentation of remedial and preventive actions.
- h. Provide for a review of problem closure technical decisions on each reported problem/failure by the reliability organization and by higher levels of technical management appropriate to the criticality of the problem/failure involved. This review shall specifically address the criticality of the problem/failure relative to the CIL and the adequacy of the corrective action.
- i. Provide for closeout of each problem/failure within time periods prescribed in Appendix B. Closeout shall at least require that:

- (1) Remedial actions have been accomplished.
 - (2) Necessary preventive design and software changes have been devised and accomplished, and the pertinent engineering change notices referenced on the closeout documentation.
 - (3) Necessary design or computer program changes have been verified in test.
 - (4) Effectivity of preventive actions has been established.
 - (5) The preventive action has been made in existing identical items of hardware to which it is pertinent.
 - (6) The close-out document has been signed off by the appropriate management authority to indicate technical review and by the reliability and/or quality organization to certify completion of all closeout actions.
- j. For hardware problems, all functions of the problem/failure reporting system shall become fully applicable at the time of first application of power (or first test usage for mechanical items) at the lowest level of assembly (above part level) of qualification or flight configuration hardware. For software problems, operation of this problem/failure reporting system shall begin with the first test use of the software item with a hardware item of the mission system at the component level or higher.
 - k. During developmental testing of engineering models or special functional models (e.g., thermal model), the reporting, analysis, and information-storage elements of the system shall be applied. These data are to be used to support investigations of possible related problem/failures occurring in later testing and use of the flight hardware.
 - l. Provide for timely dissemination of problem/failure reports to appropriate elements of the contractor's organization and for rapid retrieval of information, including closure status, on each reported problem/failure. Reports originated at remote test and launch facilities shall be distributed to appropriate organizations at the plant sites.
 - m. Require that individual problem/failure reports generated under subcontracts designated in accordance with par. 1A201-2d be submitted to the prime contractor as a part of the regular distribution at the time these reports are generated.
 - n. Provide for timely distribution to the procuring NASA installation and/or its delegated Government agency copies of contractor and supplier problem/failure reports (and analysis reports) as specified in the contract.
 - o. Reporting and data processing aspects of the contractor's system shall be devised to provide necessary data in the form and manner required by the procuring NASA installation for timely followup of problem failures, for use in pertinent milestone and readiness reviews, and for other reliability data requirements.
2. INFORMATION TO BE SUBMITTED. The contractor shall submit the following information relating to the problem/failure reporting system as well as those used by suppliers required to have a formal reliability program.
 - a. Description of the problem/failure reporting system as a part of the Reliability Program Plan (see pars. 1A201-2a and b). This shall include a description of the

format and system of numbering of reports and show clearly all differences in procedure, responsibilities, and format between the treatment of problem/failures of each criticality and functional category. The description shall clearly spell out ground rules for:

- (1) Categorizing the problem/failure.
 - (2) Reviewing correctness of categorization decisions (e.g., to ensure against categorizing problems as being less critical than they are).
 - (3) Prescribing levels of technical management judgment and review in the closure procedures for each problem/failure category.
 - (4) Referral of recurrent nonconformances from other nonconformance reporting systems to the problem/failure reporting system (see par. 1A315-1f). This description shall reference that portion of the Quality Program Plan (see Appendix A), covering nonconforming article and material control and clearly show the complementary interface in responsibilities, procedures, and practices in this area between the quality program and the reliability program.
- b. Cumulative status summaries covering each reported problem/failure shall be submitted as prescribed in Appendix B. The status summaries shall list each problem/failure report as a separate line item and provide the following data:
- (1) Identifying serial number of the problem/failure report and source (prime or subcontractor) of the report.
 - (2) Test and site where problem/failure occurred.
 - (3) Criticality category (see par. 1A304).
 - (4) Problem/failure occurrence date and closeout date (target or actual).
 - (5) Identification of hardware (or software) item affected, including serial or lot number where appropriate and drawing/part numbers (with revision identification).
 - (6) Identification of end-item if known.
 - (7) Brief description of problem.
 - (8) Status of analysis and closeout actions, including projected dates for completion of these actions.
 - (9) Identification of formal documentation changes supporting closeout (e.g., engineering order number or procedure modification number).

Each status summary shall contain clear identification of its scope, including time span, data exclusions (e.g., supplier data, in some cases), and hardware covered (part numbers and serial numbers).

CHAPTER 4: TESTING AND RELIABILITY EVALUATION

1A400 GENERAL

The contractor shall establish and conduct a program directed toward evaluating reliability of the system and its elements throughout the project life cycle. This shall be accomplished by a project test program conducted in parallel with reliability assessments which will include use of the test results. The reliability evaluation program shall be designed to produce objective data necessary for assessing the degree of system conformance to mission requirements and contractual reliability requirements. Although the contractor's reliability organization may not have primary responsibility for testing, it shall be responsible for the overall reliability evaluation program and for ensuring that the test program provides data and visibility in a timely manner for effective reliability evaluation at appropriate levels of assembly.

1A401 RELIABILITY EVALUATION PLAN

1. As a separate section to the Reliability Program Plan, or as a subsidiary document, the contractor shall submit a plan of the reliability evaluation program. This shall include an outline and milestone schedule of the project testing program (as defined in the project test plan) shown in relation to the technical requirements for reliability assessment and to assessment schedules.
2. The initial version of the Reliability Evaluation Plan shall be updated at program milestones specified in the Reliability Program Plan to reflect more specific plans and schedules for testing of various elements of the system hardware as they are evolved. The plan, submitted in accordance with Appendix B, shall:
 - a. Include all tests which contribute to establishing, measuring, or verifying (qualitative or quantitative) the reliability of the system and its elements.
 - b. Describe the role of each test in the verification of conformance to design specification requirements and in the evaluation of system reliability. This description shall reference the pertinent specifications and identify any characteristics or parameters which require combinations of tests for evaluation; the combination shall be identified.
 - c. Identify test sequences where adherence to sequence is important to reliability evaluation.
 - d. For each component design, show how life testing and stress testing (at material, part, and higher levels) are to be used in the quantitative evaluation of reliability.
 - e. Describe the planned use of test and experience data (i.e., both current project data and other related data) in the assessment of quantitative system reliability.

1A402 TESTING

1. GENERAL. The contractor's test program shall be designed to evaluate all aspects of the performance capability of the system and its elements under simulated nominal values and combinations of extremes of anticipated mission conditions. Testing shall be directed toward:
 - a. Verifying capability of the design.
 - b. Evaluating the susceptibility of the design, the software, and the hardware to failures either through known failure modes and mechanisms or through those which had not previously been revealed in design reviews or reliability analyses.
 - c. Identifying unexpected interactions among components.
 - d. Identifying failure modes which reflect deficiencies in materials, workmanship, or quality control.
 - e. Obtaining failure rates and other reliability data.
 - f. Validating the ability of the hardware and software to function together to meet mission requirements.
 - g. Verifying adequacy of workmanship in the hardware.

Tests shall be planned using statistical design-of-experiment techniques where appropriate and shall be conducted under environmental stress levels and time periods appropriate to the purpose of the test. Test and launch support equipment shall have been acceptance-tested prior to use.

2. QUALIFICATION OF HARDWARE.

- a. General. All elements of the system hardware in their mission configuration shall be qualified at appropriate levels of assembly to ensure the capability of each design to perform its required design functions. Qualification shall be accomplished by test and/or similarity. However, in cases where specified environments cannot be simulated in test, analysis in combination with test may be used. Qualification requirements shall be established on the basis of specification requirements for the item being qualified. Levels of stress appropriate for each environmental and performance parameter shall be selected to characterize the capability of the hardware design being qualified. Levels of assembly at which qualification testing is required and a consistent rationale (project rules) for assigning necessary levels of stress above levels prescribed in the design specifications (see par. 1A301) shall be documented in the project test plan and/or the Reliability Evaluation Plan. For any component or higher level item which is not required to undergo qualification testing, the Reliability Evaluation Plan (or project test plan) shall document or reference documentation of the technical justification for eliminating (or relaxing) the qualification test requirements and shall provide a qualitative evaluation of the risks assumed.

While qualification at a higher level of assembly along with other available data may be considered a justifiable project risk-acceptance rationale for omitting qualification of some lower level items within that assembly, this does not constitute qualification of those lower level items. The contractor shall prepare and maintain a Qualification

Status List as required in Appendix B, which states the basis for qualification and the current qualification status of each component and subsystem. The contractor shall also maintain appropriate documentation supporting qualification.

- b. Parts and Materials Qualification. Qualification shall be in accordance with the parts and materials program requirements referenced in the Statement of Work. Requirements shall be based on specifications prepared for each item rather than on mission application.
 - c. Components Qualification. Qualification at this level shall be based on component-level specifications responsive to mission requirements, including safety margins/factors.
 - d. Subsystems Qualification. Qualification at the subsystem level shall be conducted where practicable in consideration of the nature of the particular subsystem and the overall risk assessment philosophy of the project test plan. Qualification requirements shall be based on the subsystem specification with appropriate safety margins/factors. They shall at least verify the physical and functional adequacy of interfaces between components.
 - e. Systems Qualification. Qualification requirements shall be based on the system specification, with appropriate safety margins/factors. Qualification at this level shall include tests simulating mission environments and conditions, including safety margins/factors, to the degree practicable. Qualification will include application of test results at lower levels of assembly and evaluation of all system operational modes and interfaces.
3. TEST SPECIFICATIONS, PROCEDURES, AND REPORTS. The contractor shall prepare a test specification, a test procedure, and a test report for each test (or series of identical tests) in the testing program and shall be responsible for the adequacy of those generated as a part of test programs of suppliers required to use a reliability program (see par. 1A201-2d). All test specifications and procedures shall conform to detailed requirements stated in NHB 5300.4(1B) pars. 1B702, 1B703, and 1B704 and shall be subject to NASA actions as specified in the contract. Requirements for submittal, format, content, and NASA actions on specifications, procedures, and test reports shall be as prescribed in Appendix B.
 4. LIFE TESTING. Where required, life tests at the component and higher levels will be conducted as prescribed by the contract and will be specifically described in the Reliability Evaluation Plan.
 5. CONTROL OF UNSCHEDULED ACTIVITIES DURING TEST. The contractor shall establish a procedure for controlling, documenting, and approving all test activities that deviate from an approved test procedure. Where problems encountered during test make such changes necessary, the control procedure shall include a requirement for change approval from the same organizations that originally had authority to approve the test procedure; NASA approved test procedures require NASA approval of the changes by a contractually defined process. NASA participation in change of test procedures that were originally subject to NASA review shall also be defined contractually. The contractor shall be alert to the hazard potential of last-minute changes and shall institute controls at appropriate management levels for preventing accident or injury or hardware damage. Such control shall include appropriate real-time decision making mechanisms to expedite

continuation (or suspension) of testing after malfunction, with documented rationale. The control procedure shall be contained in the Reliability Program Plan or project test plan and shall be referenced in each test procedure.

1A403 RELIABILITY ASSESSMENT

At milestones specified in the Reliability Program Plan, the contractor shall assess system reliability. These assessments shall utilize test results, mathematical analyses, and engineering analyses as appropriate to meet current requirements. Assessments shall consider the qualification status of each component, subsystem, and system as well as appropriate revision of failure modes and effects analyses (see par. 1A304) and reliability predictions (see par. 1A303) as necessary to provide an adequate current assessment of system reliability.

1A404 RELIABILITY INPUTS TO READINESS REVIEWS

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

1A405 RELIABILITY EVALUATION PROGRAM REVIEWS

At appropriate milestones scheduled in the Reliability Program Plan, the contractor shall review the reliability evaluation effort (see par. 1A401). This review shall be conducted as a part of the contractor's overall reliability program review activity prescribed in par. 1A202-2. In these reviews of reliability evaluation effort, pertinent tests results will be examined to determine the need for revisions to the Reliability Evaluation Plan and/or to confirm that completed portions of the reliability evaluation effort have adequately accomplished their required purpose. After each review, the contractor will provide the procuring NASA installation a written report of results of the review including actions to be taken, responsibility therefor, and revisions to the Reliability Evaluation Plan. Results of these reviews will also be considered and acted upon in contractor-NASA reliability program management meetings (see par. 1A203-1).

APPENDIX A: INTERFACING AREAS OF RELIABILITY PROGRAMS WITH OTHER ASSURANCE PROGRAMS FOR NASA CONTRACTS

A number of the provisions in this document overlap those in NHB 5300.4(1B) "Quality Program Provisions for Aeronautical and Space System Contractors," and others require complementary or interfacing program provisions. Pertinent cross referencing is provided on the following page to assist the contractor in preparing the Reliability Program Plan and plans for the quality program in such a manner that all requirements will be satisfied without duplication of effort.

In addition to the related NHB 5300.4 interfaces shown in the tabulation which follows, the "Basic Safety Manual," NHB 1700.1 (V1-A) and "System Safety," NHB 1700.1 (V3) and the "Safety Policy and Requirements for Payloads Using the Space Transportation System (STS)," NHB 1700.7, contain requirements related to a number of areas of this publication including analysis, testing, and reviews.

Provision References		Area of Overlap or Interface
NHB 5300.4(1A-1)	NHB 5300.4(1B)	
Par. 1A201	Par. 1B206	Reliability Program Plan. Quality Program Plan.
Par. 1A201-3	Par. 1B206-3	Reliability Program Plans and Quality Program Plans for Remote Sites.
Par. 1A205	Chapter 5	Control of articles obtained from subcontractors and suppliers.
Par. 1A207	Chapter 13	Government Furnished Property (GFP).
Par. 1A314	Chapter 3	Design reviews.
Par. 1A301-2 1A302	Par. 1B302	Formalization of design changes.
Par. 1A315	Chapter 8 and Par. 1B510	Problem/failure reporting and nonconforming article and material control.
Par. 1A312	Chapter 6	Process specifications and controls.
Par. 1A308 1A402	Chapter 7	Qualification testing. General test controls.
Par. 1A400 1A401 1A402	Chapter 7	Reliability & quality program requirements in project test program.
Par. 1A402-3	Par. 1B702 1B703 1B704	Test specification and procedures.
Par. 1A305		Parts Stress Analyses.
Par. 1A402-2b		Parts and Materials Qualification.
Par. 1A304		FMEA with safety requirements.

APPENDIX B: LIST OF CONTRACTOR-GENERATED RELIABILITY DOCUMENTS REQUIRED BY THIS PUBLICATION

CONTRACTOR GENERATED DOCUMENTATION

The list on pages B-3 through B-5 covers the contract documentation requirements established by this publication. It is structured like a typical Contract Documentation Requirements List (CDRL), and is intended to be used as a reliability program input to the overall contract CDRL for each specific procurement where a tailored version of this publication is invoked. The following pages present a tailorable working model of a reliability CDRL input. NASA users are expected to review and appropriately modify each item, due date, action category, and delivery point to reflect the tailored reliability requirements for each contract where it is applied.

MODEL DESCRIPTION OF REQUIRED DATA (DRD's)

A model set of Description of Required Data (DRD) sheets is provided (see pages B-6 through B-36). To make the DRD sheets and their listed references look more like those on a typical contract, a set of simulated contract document numbers is used to represent project tailored versions of NHB's and a project performance specification. These are shown on page B-2.

MODEL PROJECT DOCUMENTATION LIST		
CDRL NO.	PROJECT DOC.	DESCRIPTION
	NASA-230-002	Performance Requirements for the ABC System.
	NASA-230-014	Reliability Program Requirements for the ABC System (Project tailored version of NHB 5300.4(1A-1)).
	NASA-230-015	Quality Program Requirements for the ABC System (Project tailored version of NHB 5300.4(1B)).
Q-001		Quality Program Plan for the ABC System.
	NASA-230-016	Parts Requirements for the ABC System.
P-001		Parts Control Plan for the ABC System.
	NASA-230-017	Maintainability Program Requirements for the ABC System.
	NASA-230-018	Software Assurance Requirements for the ABC System.
	NASA-230-019	System Safety Requirements for the ABC System (Project tailored version of NHB 1700.1 (V3), "System Safety").
	NASA-230-003	Configuration Management Requirements for the ABC System.
	NASA-230-009	Test Requirements for the ABC System.
T-001		Project Test Plan for the ABC System.

**LIST OF CONTRACTOR-GENERATED RELIABILITY
DOCUMENTS REQUIRED BY THIS PUBLICATION**

ITEM	PAR. REF.	DUE DATE	NO. OF COPIES	* NASA ACTION	DRD NO.
Reliability Program Plan (RPP) (including one copy of each procedure referenced in the plans)	1A201	a. With proposal b. Negotiated chgs. before contract execution c. Update to include negotiated chgs. 30 days after contract execution d. Update as supplier furnished items and their R&QA controls are added to the contract		I A A	R-001
Separate facility program plans (part of RPP)	1A201-3	90 days before use		A	R-001
Reliability survey reports	1A202-2	15 days after survey		I	R-002
Reports of verification of corrective action completions	1A203-2	With periodic progress report		R	R-003
Reliability program progress reports	1A203-2	Monthly		I	R-004
Reliability program control reports	1A203-3	With periodic financial report		I	R-005
Data on previously flown hardware	1A206	a. Initial with proposal b. Update before system PDR		A A	R-006
Design specifications	1A301	a. Initial before PDR b. Update before CDR		I R	R-007
Design and process standards	1A302	Available by CDR		I	R-008
Reliability predictions, models, and functional and/ or equipment block diagrams and apportionments	1A303	a. Before PDR b. Update as prescribed		I I	R-009

* NASA Action Categories:

A = Approval
R = Review
I = Information

See also Par. 1A104

**LIST OF CONTRACTOR-GENERATED RELIABILITY
DOCUMENTS REQUIRED BY THIS PUBLICATION(CONT.)**

ITEM	PAR. REF.	DUE DATE	NO. OF COPIES	NASA ACTION	DRD NO.
Reliability Data Base	1A303-2	Available for review		I	R-010
Failure Mode and Effects Analyses(FMEA)	1A304	a. Initial, 15 days before PDR b. Final, 15 days before CDR c. Update with Class 1 changes		R R R	R-011
Critical Items List	1A304-2	15 days before PDR and CDR		A	R-012
Parts Stress Analyses Reports	1A305	a. Available 30 days before component CDR b. Update with design changes		I A	R-013
Worst-Case Analyses	1A306	a. Available 30 days before component CDR b. Update with design changes		I I	R-014
Trend Analysis	1A307	a. List of parameters to be monitored by CDR b. Trend analysis data due as generated & report in preship review of system		R I	R-015
Packaging Review Report	1A313	a. Preliminary, 30 days before component PDR b. Final, 30 days before component CDR		R R	R-016
Design Review Packages	1A314-1a & b	15 days before each review		I	R-017
Design Review Meeting Minutes	1A314-1c	15 days after each review		R	R-018
Design Review Reports	1A314-1d	30 days after each review		R	R-019
Reports of Supplier Design Reviews	1A314-2	30 days after each review		R	R-020

**LIST OF CONTRACTOR-GENERATED RELIABILITY
DOCUMENTS REQUIRED BY THIS PUBLICATION(CONT.)**

ITEM	PAR. REF.	DUE DATE	NO. OF COPIES	NASA ACTION	DRD NO.
Problem/Failure Reports and Correction Reports	1A315-1	a. Orally, 24 hrs after occurrence b. Initial written report, 3 working days c. Failure analysis and proposed corrective action orally as generated d. Closure report including failure analysis reports, due on **completion of required actions		I I I A	R-021
Reports of Failure Analyses on Parts or Materials	1A315-1d	With failure closure report		I	Ref. R-021
Problem/Failure Status Summaries	1A315-2b	a. With periodic progress reports b. Prior to each readiness review after CDR		I I	R-022
Reliability Evaluation Plan	1A401	a. Initial with Reliability Program Plan (RPP) b. Updates as scheduled in RPP		I R	R-023
Test Specifications and Procedures	1A402-3	30 days before each event		R	R-024
Test Reports	1A402	30 days after each event		I	R-025
Qualification Status List	1A402-2	a. Initial with proposal b. Updates before each design or readiness review		R R	R-026
Reliability Assessments	1A403	a. Before PDR b. Before CDR		I I	R-027
Reliability Evaluation Program Review Reports	1A405	After each review		R	R-028

** See Appendix D, par. 1A315-li. A typical additional statement under "d" might be "within 30 days of occurrence."

DESCRIPTION OF REQUIRED DATA

-
- | | |
|---------------------------------------|-----------------------|
| 1. TITLE:
Reliability Program Plan | 2. R-DRL NO.
R-001 |
|---------------------------------------|-----------------------|
-
3. CITED:
RFP Technical Proposal Instructions
Reliability Program Requirements for the ABC System (NASA-230-014).
-
4. USE:
To provide master planning and control for the reliability program.
-
5. RELATED DOCUMENTS:
Quality Program Plan
Maintainability Program Plan
Parts Control Plan
Software Assurance Plan
System Safety Plan
Project Test Plan
-
6. PREPARATION INFORMATION:
Prepare in accordance with Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A201).

DESCRIPTION OF REQUIRED DATA

-
- | | |
|---|-----------------------|
| 1. TITLE:
Reliability Survey Reports | 2. R-DRL NO.
R-002 |
|---|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014,
par. 1A202-2).
-
4. USE:
To provide NASA with the results of contractor conducted reliability
program surveys.
-
5. RELATED DOCUMENTS:
Quality Program Plan
Quality Program Requirements for the ABC System (NASA-230-015)
-
6. PREPARATION INFORMATION:
Prepare in accordance with par. 1A202-2 of NASA-230-014.
-

DESCRIPTION OF REQUIRED DATA

-
- | | |
|---|-----------------------|
| 1. TITLE:
Verification of Corrective Actions | 2. R-DRL NO.
R-003 |
|---|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A202-2b).
-
4. USE:
To document for contractor and NASA management that corrective actions for problems have been implemented and to provide the rationale for closeout of reported problems and failures.
-
5. RELATED DOCUMENTS:
Problem/Failure Reports (R-021)
Test Reports
-
6. PREPARATION INFORMATION:
Prepare and submit reports for verification of corrective actions in accordance with par. 1A202-2b of NASA-230-014. The report shall include:
- a. Reference to (or part of) the problem/failure report,
 - b. A description of the problem,
 - c. The results of the analysis,
 - d. The corrective action and any test results, verification of completion of corrective action on the failed hardware/software,
 - e. Schedule for incorporation of corrective action in existing identified hardware items, and
 - f. Report may be a final iteration of a multiple action problem/failure report (PFR) form where documentation of closeout is part of the approved form.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|--|-----------------------|
| 1. TITLE:
Reliability Program Progress Report | 2. R-DRL NO.
R-004 |
|--|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A203).
-
4. USE:
Provide status information concerning contract progress in reliability program areas.
-
5. RELATED DOCUMENTS:
Monthly Progress Reports
-
6. PREPARATION INFORMATION:
Prepare in accordance with NASA-230-014, par. 1A203. The report shall include:
- a. Technical progress of each reliability task including significant accomplishments and milestones reached during the reporting period.
 - b. Reliability program problem areas and proposed corrective actions.
 - c. Decisions and actions during the reporting period having impact on the reliability efforts and description of their anticipated effect on the hardware.
 - d. Anticipated slippages in reliability activities and their effects.
 - e. Supplier performance and problems.
 - f. Nonstandard part approval requests (NSPAR) status.
 - g. Parts or materials procurement or screening activities.
 - h. Notification of impact on the program of problems reported by other sources in the Government/Industry Data Exchange Program (GIDEP) alert system.
 - i. Progress in closure of failure reports.
 - j. Review summary of contractor's reviews.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|--|-----------------------|
| 1. TITLE:
Reliability Program Control Reports | 2. R-DRL NO.
R-005 |
|--|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A203-3).
-
4. USE:
To provide management with a comparison of planned reliability resource utilization vs. actual resources expended on a task by task basis.
-
5. RELATED DOCUMENTS:
Reliability Program Plan
Periodic financial and management reports
-
6. PREPARATION INFORMATION:
Prepare in accordance with par. 1A203-3 of NASA 230-014. The report shall comply with the cost/performance measurement system or other contract approved program control system. As a minimum, each report shall include:
- a. A comparison of the planned resources vs. the expended resources for each reliability task.
 - b. Revised projections for future expenditures.
 - c. A breakdown of reliability resources expended by other organizations to accomplish reliability tasks.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|--|-----------------------|
| 1. TITLE:
Previously Designed, Fabricated, or Flown Hardware Data | 2. R-DRL NO.
R-006 |
|--|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A206).
-
4. USE:
To demonstrate that previously designed, fabricated, or flown hardware which is proposed for use, complies with the Reliability Program Project and Mission Requirements for the ABC System.
-
5. RELATED DOCUMENTS:
Performance Requirements for the ABC System
-
6. PREPARATION INFORMATION:
Prepare in accordance with the Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A206).

DESCRIPTION OF REQUIRED DATA

-
- | | |
|------------------------------------|-----------------------|
| 1. TITLE:
Design Specifications | 2. R-DRL NO.
R-007 |
|------------------------------------|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A301).
-
4. USE:
To define design and interface requirements for each subsystem, component, and payload instrument in the system.
-
5. RELATED DOCUMENTS:
Performance Requirements for the ABC System (NASA-230-002)
Quality Program Requirements for the ABC System (NASA-230-015)
-
6. PREPARATION INFORMATION:
Prepare in accordance with the requirements of par. 1A301 of NASA-230-014. Each design specification whether at the system, subsystem, or component level shall include the local physical and functional requirements seen by the external interface of the item being specified. These specifications shall be updated to reflect refinements and changes and shall include:
- a. Local functional and environmental requirements,
 - b. Test requirements,
 - c. Safety margins, derating factors, apportioned reliability goal, and unacceptable failure effects (from a criticality standpoint),
 - d. Physical parameters and constraints,
 - e. Fault tolerance criteria, and
 - f. Testability/diagnostic requirements.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|---|-----------------------|
| 1. TITLE:
Design and Process Standards | 2. R-DRL NO.
R-008 |
|---|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A302).
-
4. USE:
To establish formal documentation and baselining of (1) general design requirements not detailed on each drawing; and (2) provide procedures, materials, parameters, and quality requirements.
-
5. RELATED DOCUMENTS:
Quality Program Requirements for the ABC System (NASA-230-015)
-
6. PREPARATION INFORMATION:
Using the contractor's procedures and formats, document and identify by unique documented number and revision number the contractor standards and procedures applicable to the contract effort (see par. 1A302 of NASA-230-014).

DESCRIPTION OF REQUIRED DATA

-
- | | |
|---|-----------------------|
| 1. TITLE:
Reliability Predictions, Block Diagrams, and
Apportionments | 2. R-DRL NO.
R-009 |
|---|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014,
par. 1A303).
-
4. USE:
To document the contractor's methodology and analytical basis for the
design of equipment capable of meeting mission reliability goals.
-
5. RELATED DOCUMENTS:
Performance Requirements for the ABC System
-
6. PREPARATION INFORMATION:
The reliability predictions, block diagrams, and apportioning shall be
accomplished and documented in accordance with par. 1A303 of NASA-230-014,
Reliability Requirements for the ABC System.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|---|------------------------------|
| 1. TITLE:
Reliability Data Base | 2. R-DRL NO.
R-010 |
|---|------------------------------|
-
3. **CITED:**
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A302-2).
-
4. **USE:**
To provide a single uniform data base for use in the reliability, maintainability, and safety analyses, and other related studies for the contract effort.
-
5. **RELATED DOCUMENTS:**
Maintainability Requirements for the ABC System
Parts Requirements for the ABC System
System Safety Requirements for the ABC System
Reliability Program Plan for the ABC System
Maintainability Program Plan for the ABC System
Parts Control Plan for the ABC System
System Safety Plan for the ABC System
-
6. **PREPARATION INFORMATION:**
The contractor shall have a common data base for data in the reliability related areas. It shall be updated as more current data becomes available. The data shall be documented and/or recorded on software media and shall be available and accessible for NASA evaluation and/or reference use. The data base shall contain explanations of all symbols and acronyms used and shall be maintained and accessed by consistent procedures described in its governing documents.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|---|-----------------------|
| 1. TITLE:
Failure Mode and Effects Analyses (FMEA) | 2. R-DRL NO.
R-011 |
|---|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A304).
-
4. USE:
To identify potential failure modes and effects so as to guide preventive design actions.
-
5. RELATED DOCUMENTS:
System Designs
Hazard Analyses
Maintainability Analyses
-
6. PREPARATION INFORMATION:
Prepare in accordance with the Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A304).

DESCRIPTION OF REQUIRED DATA

-
- | | |
|----------------------------------|-----------------------|
| 1. TITLE:
Critical Items List | 2. R-DRL NO.
R-012 |
|----------------------------------|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A304).
-
4. USE:
To provide a list of critical items which require the highest level of attention in design, fabrication, verification, and problem correction during the development, handling, and mission use of the system.
-
5. RELATED DOCUMENTS:
Reliability Program Requirements for the ABC System
System Safety Requirements for the ABC System
Maintainability Program Requirements for the ABC System
Parts Requirements for the ABC System
-
6. PREPARATION INFORMATION:
Prepare in accordance with par. 1A304 of NASA-230-014 and any special requirements defined in the system specification.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|------------------------------------|-----------------------|
| 1. TITLE:
Parts Stress Analyses | 2. R-DRL NO.
R-013 |
|------------------------------------|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A305).
-
4. USE:
To demonstrate that environmental operational stresses on parts comply with project derating requirements.
-
5. RELATED DOCUMENTS:
Design Review Packages
EEE hardware drawings and specifications
-
6. PREPARATION INFORMATION:
This documentation shall report analysis of each component (black box) in accordance with par. 1A305 of NASA-230-014 to determine the adequacy of the application of parts. This analysis report shall include:
- a. Consideration of all expected environmental stresses,
 - b. Consideration of all significant operating parameter stresses at extremes of anticipated environments; and
 - c. Use of derating guidelines of MIL-STD-975 as defined in NASA-230-16, Parts Requirements for the ABC System.

The stress analyses shall be updated concurrently as part of the design changes.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|----------------------------------|-----------------------|
| 1. TITLE:
Worst-Case Analyses | 2. R-DRL NO.
R-014 |
|----------------------------------|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A306).
-
4. USE:
To demonstrate the adequacy of margin in the design of electronic and electrical circuits, optics, and electromechanical and mechanical items.
-
5. RELATED DOCUMENTS:
Reliability Program Plan for the ABC System
Design Review Packages
-
6. PREPARATION INFORMATION:
These analyses shall address the worst case conditions for the analysis performed on each component. Each analysis shall encompass the mission life and consider the critical parameters set at maximum and minimum limits and include the effect of environmental stresses on the operational parameter being evaluated.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|-----------------------------|-----------------------|
| 1. TITLE:
Trend Analysis | 2. R-DRL NO.
R-015 |
|-----------------------------|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A307).
-
4. USE:
To indicate to operations personnel which parameters should be monitored during testing and mission use in order to assess (and assure) the stability of end item performance.
-
5. RELATED DOCUMENTS:
Performance Requirements for the ABC System (NASA-230-014)
Test Reports
-
6. PREPARATION INFORMATION:
Prepare in accordance with the Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A307).

DESCRIPTION OF REQUIRED DATA

-
- | | |
|--------------------------------------|-----------------------|
| 1. TITLE:
Packaging Review Report | 2. R-DRL NO.
R-016 |
|--------------------------------------|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A313).
-
4. USE:
To provide an evaluation of the contractor's packaging concept and design to perform successfully under the anticipated operating and environmental conditions.
-
5. RELATED DOCUMENTS:
Performance Requirements for the ABC System
Parts Requirements for the ABC System
Test Requirements for the ABC System
-
6. PREPARATION INFORMATION:
The packaging review shall be accomplished and documented in accordance with par. 1A313 of NASA-230-014.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|-------------------------------------|-----------------------|
| 1. TITLE:
Design Review Packages | 2. R-DRL NO.
R-017 |
|-------------------------------------|-----------------------|
-
3. CITED:
Design Review Program Requirements par. 1A314, "Reliability Program Requirements" for the ABC System (NASA-230-014).
-
4. USE:
To document the status of the design and identify/present the detailed technical data supporting it and the review milestone in question.
-
5. RELATED DOCUMENTS:
Multiple documentation
-
6. PREPARATION INFORMATION:
1. Prepare in accordance with NASA-230-014, par. 1A314, and include data required by related requirements for each review. Each design review package shall include as a minimum:
 - a. Agenda.
 - b. Responses to action items and recommendations generated at prior reviews.
 - c. Presentation material (e.g., viewgraph copies) for the subject review.
 - d. Analyses and reports required at the reviews.
 - e. Support material. Where support material has been submitted prior to or concurrent with this requirement, such material may be incorporated within this requirement by reference.
 2. The minutes and results of the reviews with action items and responses shall be submitted. In addition, the following items shall be submitted for the indicated review:
 - a. Systems Concept Review (SCR)
 - System definition, analysis, and specification
 - Interaction of major elements of the overall system
 - Design approaches and operational concepts

- b. Preliminary Design Review (PDR)
 - Pertinent drawings, schematics, block diagrams, and specifications
 - Single point failure summaries with risk assessment rationale
 - Systems safety hazards analyses and hazards identification matrix
 - Safety compliance data package
 - Summary of NSPAR's submitted and approval status
 - Materials and Processes lists
 - Items required at the PDR
 - Summary of deviations or waivers requested
 - FMEA
 - Proposed Test Plan
- c. Critical Design Review (CDR)
 - Component level CDR, include at least the following:
 - Component specifications, designs, schematics, and diagrams
 - Design adequacy data (drawings, analyses, and testing plans)
 - Parts, devices, and materials application review reports
 - Worst case analyses
 - FMEA
 - Test Plans
 - Subsystem and higher assembly level CDR
 - Items required at CDR
 - Updates of data items required for PDR
 - Single point failure summaries with risk acceptance rationale
 - Actions to control or eliminate identified system safety hazards
 - Test Plans
- d. Pre-environmental Review (PER)
 - Updates of items from earlier reviews
 - Test and Calibration Program description and results
 - Failure report summaries including status of action and rationale for closure of each report
 - As-built documentation summary

- e. Mission Operations Review (MOR)
 - Updates of items from earlier reviews
 - Review of ground systems, operations, and interfaces
- f. Preshipment Review (PSR)
 - Updates of items required for earlier reviews
 - Test program results
 - Failure report summaries including status of action and rationale for closure of each report
 - Status of preparations for remote facility activities
 - End-item data packages (submit a summary of the package content prior to review and have package available for inspection at the review)
- g. Flight Operations Review (FOR)
 - Updates of items from earlier reviews
 - Final orbit operations plan
 - Compatibility of spacecraft, flight support equipment, ground support equipment, and operational ground equipment
- h. Instrument Preshipment Review (IPSR)
 - Updates of items from earlier instrument reviews
 - Test and calibration program results
- i. Flight Readiness Review (FRR)
 - Completions/dispositions (closures) of open items from Preshipment Readiness Review, Flight Operations Review, and Instrument Preshipment Review
 - Disposition of new open items from pre-launch test and preparations

DESCRIPTION OF REQUIRED DATA

-
- | | |
|--|-----------------------|
| 1. TITLE:
Minutes of Design Review Meetings | 2. R-DRL NO.
R-018 |
|--|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A314-1c).
-
4. USE:
To document and provide interim history of meetings, resulting decisions, and action items.
-
5. RELATED DOCUMENTS:
Reliability Program Plan
-
6. PREPARATION INFORMATION:
Prepare in accordance with par. 1A314-1c of NASA-230-014. Pertinent information to be included in the minutes includes:
- a. A listing of all attending representations,
 - b. Statement of decisions, and
 - c. Actions to be taken.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|-----------------------------------|-----------------------|
| 1. TITLE:
Design Review Report | 2. R-DRL NO.
R-019 |
|-----------------------------------|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A314-1d).
-
4. USE:
To provide formal history of design review meetings.
-
5. RELATED DOCUMENTS:
Reliability Program Plan
-
6. PREPARATION INFORMATION:
Prepare in accordance with par. 1A314-1d of NASA-230-014. The report shall include:
- a. A summary of the discussion,
 - b. Dissenting opinions,
 - c. Conclusion, and
 - d. Required actions and a completion schedule.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|--|-----------------------|
| 1. TITLE:
Report of Supplier Design Reviews | 2. R-DRL NO.
R-020 |
|--|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 314-2).
-
4. USE:
To document reviews of suppliers required to have formal design reviews.
-
5. RELATED DOCUMENTS:
Reliability Program Plan for the ABC System (see R-001 for contents)
Quality Program Requirements for the ABC System (NASA-230-015)
Quality Program Plan for the ABC System
System Safety Requirements for the ABC System (NASA-230-019)
System Safety Plan
Test Requirements for the ABC System (NASA-230-009)
-
6. PREPARATION INFORMATION:
A report of each review shall be prepared and submitted to NASA. As a minimum the report shall adhere to the requirements of pars. 1A314-1b,c, and d of NASA-230-014 and shall include:
- a. A summary of the discussion;
 - b. Problem areas;
 - c. Conclusions; and
 - d. Required actions and a completion schedule.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|---|-----------------------|
| 1. TITLE:
Problem/Failure Reporting and Correction Reports | 2. R-DR# NO.
R-021 |
|---|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A315).
Quality Program Provisions for the ABC System (NASA 230-015).
-
4. USE:
To provide a controlled documented system for monitoring corrective action and closure of all malfunctions and failures.
-
5. RELATED DOCUMENTS:
Quality Requirements for the ABC System (NASA-230-015)
Software Assurance Requirements for the ABC System (NASA-230-018)
-
6. PREPARATION INFORMATION:
1. The Problem/Failure Report shall conform with the requirements of NASA-230-014 pars. 1A315 and 1A315 lo. A consistent contractor format meeting the requirements of NASA-230-014 paragraphs shall be used. It shall contain as a minimum:
 - a. Affected unit name, identification number, and manufacturer.
 - b. Next assembly name and identification number.
 - c. Operation where malfunction/failure occurred or was detected.
 - d. Environment where malfunction/failure occurred.
 - e. Date and time of occurrences.
 - f. Unit operating hours at time of occurrences.
 - g. Description of malfunction/failure.
 - h. Cause of failure.
 - i. Corrective actions taken to prevent recurrence including reference to design or software changes incorporated to correct the condition.
 - j. Failure analysis reports, test data, or other information to support closure.

k. Signature and organization of initiator, and persons verifying and approving required actions at successive states of corrective action and closure.

1. Closure status.

2. Problem/failure reporting to the procuring activity or designated representative shall commence at program initiation and continue throughout the term of the contract.

3. Open problem/failure reports shall be submitted for review within 5 days of generation except that an advance copy of critical malfunction/failure reports (those that may affect mission, function, schedule, or cost) shall be transmitted by facsimile transmission within 24 hours of initiation or update.

4. Problem/failure reports shall be submitted at the time of occurrence, at completion of analysis and assignment of corrective action, and at closure.

5. Problem/failure reports submitted to the procuring activity for closure shall include a copy of all referenced data and shall indicate that all corrective actions have been accomplished and verified.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|---|-----------------------|
| 1. TITLE:
Problem/Failure Status Summaries | 2. R-DRL NO.
R-022 |
|---|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A315-2b).
-
4. USE:
To document for contractor and NASA project management the status of reported problems and failures and actions being taken.
-
5. RELATED DOCUMENTS:
Quality Program Requirements for the ABC System (NASA-230-015)
Maintainability Program Requirements for ABC System (NASA-230-017)
Software Assurance Plan for the ABC System
Software Assurance Requirements for the ABC System (NASA-230-018)
-
6. PREPARATION INFORMATION:
Prepare in accordance with par. 1A315-2b of NASA-230-014. As a minimum the summaries shall:
- a. List each problem/failure report as a line item,
 - b. Provide the unique serial number and source of each report,
 - c. Test and site where problem/failure occurred,
 - d. Criticality category,
 - e. Problem/failure occurrence data and closeout date (target or actual),
 - f. Hardware or software affected, including serial number or lot number and drawing/part number,
 - g. End item identification, if known,
 - h. Brief description of problem,
 - i. Status of analysis and closeout action, and
 - j. Documentation changes supporting closeout (engineering, effectivity, procedure modification number, etc.).

DESCRIPTION OF REQUIRED DATA

-
- | | |
|--|-----------------------|
| 1. TITLE:
Reliability Evaluation Plan | 2. R-DRL NO.
R-023 |
|--|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A401).
-
4. USE:
To describe the role of the planned tests in verification of system conformance to design specification requirements and in the evaluation of system reliability.
-
5. RELATED DOCUMENTS:
Design Specifications
Project Test Plan
Failure Mode and Effects Analyses
-
6. PREPARATION INFORMATION:
Prepare the Reliability Evaluation Plan in accordance with par. 1A401 of NASA-230-014. The plan whether submitted as part of the Reliability Program Plan or submitted as a separate document shall be updated at program milestones and shall include:
- a. All tests which contribute to establishing, measuring, or verifying the reliability of the system and its elements,
 - b. A description of the role of each test in verifying conformance to design specification requirements and in evaluating system reliability,
 - c. A description of the plan for qualification of the hardware and validation of the software (or reference to the project test plan paragraph which describes this),
 - d. Identity of test sequences when adherence to sequence is critical to reliability evaluation,
 - e. Show how life testing and stress testing are to be used in the qualitative evaluation of reliability, and
 - f. A description of the use of test and experience data (i.e., both current project data and other related data) in the assessment of qualitative system reliability.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|---|-----------------------|
| 1. TITLE:
Test Specifications and Procedures | 2. R-DRL NO.
R-024 |
|---|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014,
par. 1A402-3).
-
4. USE:
To document the technical requirements and procedural requirements
for each test.
-
5. RELATED DOCUMENTS:
Reliability Evaluation Plan
Project Test Plan (NASA-230-009)
Design Specifications
-
6. PREPARATION INFORMATION:
Prepare the test specifications and procedures in accordance with
NASA-230-014, par. 1A402-3.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|---------------------------|-----------------------|
| 1. TITLE:
Test Reports | 2. R-DRL NO.
R-025 |
|---------------------------|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014,
par. 1A402).
-
4. USE:
To document the results of each test.
-
5. RELATED DOCUMENTS:
Reliability Evaluation Plan
Test procedures
Test specifications
Project Test Plan
-
6. PREPARATION INFORMATION:
Prepare in accordance with Reliability Program Requirements for the ABC
System (NASA-230-014, par. 1A402).

DESCRIPTION OF REQUIRED DATA

-
- | | |
|--|-----------------------|
| 1. TITLE:
Qualification Status List | 2. R-DRL NO.
R-026 |
|--|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A402).
-
4. USE:
To provide a mechanism for determining the current qualification status of each component and subsystem.
-
5. RELATED DOCUMENTS:
Design Specifications for the ABC System
Reliability Evaluation Plan
Project Test Plan (NASA-230-009)
Report of Previously Flown Hardware (par. 1A206 of NASA-230-014)
-
6. PREPARATION INFORMATION:
Prepare the qualification status list in accordance with par. 1A402-2 of NASA-230-014. The list shall indicate the basis of qualification and the status of qualification for each component and subsystem used in the contract end item.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|--------------------------------------|-----------------------|
| 1. TITLE:
Reliability Assessments | 2. R-DRL NO.
R-027 |
|--------------------------------------|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A403).
-
4. USE:
To document the current reliability of the system at scheduled milestones specified in the Reliability Program Plan.
-
5. RELATED DOCUMENTS:
Design specifications for the ABC System
Failure mode and effects analyses
Reliability prediction models and functional and/or equipment block diagrams and apportionments
Test plans and results of engineering analyses
-
6. PREPARATION INFORMATION:
Prepare in accordance with par. 1A403 of NASA-230-014. Each assessment shall be available prior to the milestones specified in the Reliability Program Plan.

DESCRIPTION OF REQUIRED DATA

-
- | | |
|--|-----------------------|
| 1. TITLE:
Reliability Evaluation Program Review Reports | 2. R-DRL NO.
R-028 |
|--|-----------------------|
-
3. CITED:
Reliability Program Requirements for the ABC System (NASA-230-014, par. 1A405).
-
4. USE:
To document the results of Reliability Evaluation Program Reviews and revisions in the plan for evaluation of system reliability.
-
5. RELATED DOCUMENTS:
Design Specifications for the ABC System
Failure mode and effects analyses
Reliability prediction models and functional and/or equipment block diagrams and apportionments
Test plans and the results of engineering analyses
-
6. PREPARATION INFORMATION:
Prepare each Reliability Evaluation Program Review Report in accordance with par. 1A405 of NASA-230-014. As a minimum, the report shall include:
- a. The results of the review,
 - b. Actions to be taken,
 - c. Organizations responsible for actions, and
 - d. Identification of and required revisions to the Reliability Evaluation Plan.

APPENDIX C: GLOSSARY OF TERMS

The following definitions apply to terms as used in this publication.

COMPONENT. A combination of parts, devices and structure, usually self-contained, which performs a distinctive function in the operation of the overall equipment. A "black box" (e.g., transmitter, encoder, cryogenic pump, star tracker).

CRITICAL GROUND SUPPORT EQUIPMENT. Critical ground support equipment is defined as that mission peculiar ground support equipment that interfaces with the flight system in any way which, through its malfunction, can damage or functionally impair the flight system.

DESIGN SPECIFICATION. Generic designation for a specification which describes functional and physical requirements for an article, usually at the component level or higher levels of assembly. In its initial form, the design specification is a statement of functional requirements with only general coverage of physical and test requirements. The design specification evolves through the project life cycle to reflect progressive refinements in performance, design, configuration, and test requirements. In many projects the end item specifications serve all the purposes of design specifications for the contract end-items; for articles not designated contractually as end-items, design specifications provide the basis for technical and engineering management control.

DESIGNATED REPRESENTATIVE. An individual (such as a NASA plant representative), firm (such as an evaluation contractor), DoD plant representative, or other Government representative designated and authorized by NASA to perform a specific function(s) for NASA. As related to the contractor's reliability effort, this might include evaluation, assessment, design review participation, and/or approval/review of certain documents or actions. (However, NASA approval or review authority will not be delegated to non-Government organizations.)

FAILURE MODE AND EFFECTS ANALYSIS. Study of a system and working interrelationships of its elements to determine ways in which failures can occur (failure modes) and the effects of each potential failure on the system element in which it occurs, on other system elements, and on the success of the system's mission.

MAINTAINABILITY. The quality of the combined features of equipment design and installation which facilitates the accomplishment of inspection, test, checkout, servicing, repair, and overhaul necessary to meet operational objectives with a minimum of time, skill, and resources in the planned maintenance environments.

MILESTONE. Any significant event in the project life cycle or in the associated reliability program which is used as a control point for measurement of progress and effectiveness or for planning or redirecting future effort.

MISSION SYSTEM. The mission system comprises the flight hardware and software, the flight support equipment, mission unique ground operating equipment, and mission operations software.

NONCONFORMANCE. A condition of any article or material, or service in which one or more characteristics do not conform to requirements. Includes failures, discrepancies, deficiencies, defects, and malfunctions.

PART. One piece or two or more pieces joined together which are not normally subject to disassembly without destruction of design use.

QUALIFICATION. Determination that an article or material, with its associated software, is capable of meeting all prescribed design and performance requirements as stated in pertinent specifications.

QUALIFICATION TEST. A test or series of tests conducted to determine whether an article or material, with its associated software, meets qualification requirements.

REDUNDANCY (OF DESIGN). The use of more than one means of accomplishing a given function where more than one must fail before the article fails to perform.

RELIABILITY. A characteristic of a system, or any element thereof, expressed as a probability that it will perform its required functions under defined conditions at designated times for specified operating periods.

RELIABILITY APPORTIONMENT. The assignment of reliability subgoals to subsystems and elements thereof within a system which will result in meeting the overall reliability goal for the system if each of these subgoals is attained.

RELIABILITY ASSESSMENT. An evaluation of reliability of a system or portion thereof. Such assessments usually employ mathematical modeling, directly applicable results of tests on system hardware, estimated reliability figures, and nonstatistical engineering estimates to ensure that all known potential sources of unreliability have been evaluated.

RELIABILITY DEMONSTRATION. Statistically designed testing, with specified confidence level, to demonstrate the degree to which a system or element thereof meets the established reliability requirement.

RELIABILITY PREDICTION. An analytical prediction of numerical reliability of a system or element thereof similar to a reliability assessment except that the prediction is always quantitative and is normally made in the earlier design stages where very little directly applicable test data are available.

SINGLE FAILURE POINT. A single element of hardware, the failure of which would result in loss of objectives, hardware, or crew, as defined for the specific application and/or project for which the single failure point analysis is performed.

SOFTWARE. The computer programs and their governing documents associated with the design, handling, test, and use of the mission hardware.

SUBCONTRACT. A contract or purchase order entered into under a Government prime contract by a supplier. May include orders issued to activities or subdivisions within the contractor's organization.

SUPPLIER. A subcontractor, at any tier, performing the contract services or producing the contract articles for the contractor.

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. (A system may also be an organized and disciplined approach to accomplish a task, e.g., failure reporting system.)

APPENDIX D: REQUIREMENT DETAILS TO BE SPECIFIED IN THE RFP OR CONTRACT

It is intended that individual projects tailor the requirements of this document to justifiable project needs. The pars. cited below should be given particular attention in this process.

- | | |
|----------|--|
| 1A103-3 | Identify and prescribe specific contractor effort required (other than normal voluntary participation) in support of data exchange programs. |
| 1A104 | For each document required to be generated by the contractor (see Appendix B), specify dates or milestones by which the document will be generated and updated. Also specify whether it is to be submitted or be available on request. For each document required to be submitted, specify the NASA action category (approval, review, or information) the number of copies required, the point(s) of delivery and addressee(s), the time requirements on submittal, and who will take required NASA action. |
| 1A200 | On projects where combined management of the contractor's assurance efforts is desired, modify this paragraph accordingly in the RFP. Then consider changing it to accommodate the contractor's existing management system if it is considered effective. |
| 1A201-2 | Modify to reflect any project-peculiar changes. |
| 1A201-2e | Specify in Appendix B the frequency of updating the list of items not using a formal reliability program. |
| 1A202-1b | Specify intervals for updating reliability program control data. |
| 1A203-3 | Ensure that requirements for reliability program control data are spelled out or referenced in contract financial and management reporting requirements. On projects where contractor DoD-compliant cost/performance measurement system (CPMS) is involved for the NASA effort, ensure that the contract Work Breakdown Structure (WBS) and subsidiary CPMS work planning packages for the reliability program provide necessary visibility for control of the work, resources, and schedules. This should be done as part of the overall project review of the CPMS structure for the contract. |
| 1A205 | Ensure that reliability program provisions imposed on suppliers required to have a reliability program at least include the equivalent requirements of pars. 1A103, 1A201, 1A202, 1A203, 1A205-3, 1A301, 1A304, 1A305, 1A306, 1A308, 1A309, 1A311, 1A312, 1A313, 1A314, 1A315, 1A402-2-3, and 1A404. |
| 1A302 | Specify what NASA or other standards are required to be used by the contractor and suppliers. Also, where appropriate, specify which suppliers the contractor shall impose these standards on. |

- 1A303 In regard to failure rate data sources, mission profiles, and ground rule assumptions for the analysis, specify that the contractor is to propose these as a part of the description of method, or, if appropriate, prescribe them to the contractor.
- 1A304 Provide more comprehensive definitions of critical failures (categories) where needed to meet program requirements.
- 1A306 Where necessary to meet project needs, provide more comprehensive statement of worst case analysis requirements.
- 1A308 This par. may be used to solicit contractor proposals of additional analyses or to identify project requirements for specific special analyses. Otherwise, delete the par.
- 1A312 Identify specific materials and process controls required for the contract effort or delete the last sentence of par. 1A312.
- 1A315-1a Provide for defining or identifying checkout equipment to be covered by the problem/failure reporting system.
- 1A315-le Specify categorization of failures.
- 1A315-li Specify the number of days within which a failure is required to be closed, barring special complications. For closeouts burdened by such complications, identify the ground rules and authority for extending the required failure closure interval.
- 1A315-lj Where it is desired to use effectivity requirements for problem/ failure reporting other than those specified in this par., specify those desired.
- 1A315-1k Specify whether the problem/failure reporting system is to be applied during developmental testing, and delineate extent of its application in such tests.
- 1A315-1m Specify problem/failure reports to be submitted to NASA. State which iterations (initiation, analysis, correction, and/or closeout copies), time intervals between event occurrence and receipt by NASA of report, number of copies, and points of delivery.
- 1A315-1o Specify requirements for format and information content on problem/ failure reports (and reports of subsequent actions on each) to obviate the need for reformatting of information by NASA.
- 1A315-2 When specifying frequency and manner of submittal of cumulative status summaries of reported problem/failures, consider providing for increased frequency of status reporting in critical schedule periods.
- 1A402-2 Specify project-unique qualification requirements if appropriate.
- 1A402-3 Specify requirements for submittal, format, content, and NASA actions on test specifications, procedures, and reports.
- 1A402-4 Provide for establishing requirements for life tests.
- 1A403 Define assessment requirements for each project milestone.
- 1A405 Prescribe review schedule for Reliability Evaluation Plan, if used.

