General

RELIABILITY PROGRAM STANDARD

November 7, 2012: Revision C

Japan Aerospace Exploration Agency

The official version of this standard is written in Japanese. This English version is issued for convenience of English speakers. If there is any difference between Japanese version and English one, the former has precedence.

This is an English translation of JMR-004C.
If anything in this document is ambiguous, the original document (the Japanese version) shall be used to clarify the ambiguity.

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1. GENERAL

1.1 Purpose

This Reliability Program Standard (hereinafter referred to as the “Standard”) describes general requirements for the reliability program to be planned and implemented by the contractor to satisfy all the requirements and ensure the success of the mission, in accordance with the contract, including design, development, manufacturing, testing, and operation of the launch vehicles and satellites conducted by Japan Aerospace Exploration Agency (hereinafter referred to as JAXA).

1.2 Scope

1.2.1 Applicability

This standard shall be applied in the following cases:

(1) When this standard is called for in contract or procurement specifications.

(2) When the contractor requests implementing the Reliability Program based on this standard, and JAXA approves the request.

(3) When this standard is called for in JAXA’s request for proposal (RFP).

1.2.2 Relationship of this standard to other contract requirements

The relationship of this standard to other contract requirements shall be as follows:

(1) If any conflict exists between the requirements of this standard and those stated in the contract or the procurement specifications, the contractual or procurement statement shall govern.

(2) This standard shall not require duplication of the contractor’s efforts for other program requirements specified in the contract, but shall complement those requirements.

Appendix 1 provides a list of requirements in this standard related to those in the quality assurance program requirements and software quality assurance program requirements, to assist the contractor in complying with these requirements.

1.2.3 Tailoring

(1) JAXA may modify the requirements described in this standard for each contract according to the purpose, function, priority, or cost of contracted items.

(2) The contractor may propose appropriate modifications of the standard in consultation with JAXA. This proposal shall be based on consideration of the factors related to the items described in section (1).

(3) The contractor shall prepare and maintain the Reliability Program Plan requested in section 4.2.2 based on the modification results.

2. RELATED DOCUMENTS

2.1 Applicable Documents

The following documents form a part of this document to the extent specified herein, and the latest version at the time of entering into the contract shall apply unless otherwise specified.

2.1.1 JAXA documents

(1) Notification No. 16-1 from the Managers of the Safety and Mission Assurance Department and the Contract Department, Inspection Implementation Procedure
(2) JMR-005 Quality Assurance Program Standard
(3) JMR-013 Quality Assurance Program Standard (Basic Requirements: JIS Q 9100)
(4) JMR-012 Electrical, Electronic, and Electromechanical Parts Program Standard
(5) JERG-2-130 General Test Standard for Spacecraft
(6) JERG-2-007 Design Criteria for Preventing Human Induced Design Error on a Satellite System
(7) JERG-2-008 Design Criteria for Detecting Human Induced Design Error on a Satellite System
(8) JERG-2-120 Design Standard Single Point Failure and Secondary Induced Failures Prevention
(9) CAA-109028 ASIC/FPGA Development Management Standard

2.2 Reference Documents

Refer to the following documents when implementing the reliability program.

(1) JMR-006 Configuration Management Standard
(2) JERG-0-016 Space Development Reliability Technical Handbook
(3) JERG-0-049 Software Development Standard
(4) JERG-0-050 Quality Assurance Handbook for Imported Parts
(5) JERG-0-051 Quality Assurance Handbook for Imported Components
(6) JERG-2-000 Spacecraft Design Standard
(7) MIL-HDBK-217 RELIABILITY PREDICTION OF ELECTRONIC EQUIPMENT

3. GLOSSARY OF TERMS

Terms used in this standard are defined in Appendix 2.

4. GENERAL REQUIREMENTS

4.1 Fundamental requirements

4.1.1 Fundamental requirements

The contractor shall plan and implement the Reliability Program in order to ensure that the final products will satisfy the functional and performance requirements until the completion of the mission under the environmental conditions required by the contract, and that the reliability-related technical and managerial risks are continuously identified over the whole lifecycle and those risks are reduced.

The fundamental requirements are as follows:

(1) Planning and management of the reliability tasks.
(2) Performing the reliability tasks at each phase of the contracted item's lifecycle.
(3) Timely reporting of implementation status of the reliability tasks, documented in the contract and other reports (including the minutes of meetings).

4.1.2 Actions and prerogatives of JAXA

(1) All the work, data, and documents generated by the contractor or suppliers to implement the contractual tasks shall be subject to examination, evaluation, or technical inspection at any point of the contract's duration by inspectors or assistant inspectors (hereinafter referred to as JAXA Inspectors) appointed according to Notification No. 16-1 under the names of the Director of the Safety and Mission Assurance Department and the Director of Contract Department of JAXA.
(2) The contractor and suppliers at all tiers shall cooperate fully with the JAXA Inspectors, providing access to contractor and supplier facilities so the JAXA Inspectors can do their work.
(3) JAXA reserves the right to use the data of the reliability program generated under the contract.

4.1.3 Reliability program documents

Appendix 3 lists the reliability program documents called for in this standard. The reliability program documents shall be prepared to record, report, and obtain approval for technical information (decision, proposal, and other correspondence).

The reliability program documents required by the contract shall always be available for JAXA Inspectors. Of these documents, those shown in Appendix 4 shall be submitted to JAXA for JAXA's approval, review or information.

(1) Approval Document subject to JAXA's written approval according to the contract prior to application of the document in question.
(2) Review Document subject to JAXA Inspector's review prior to application of the document in question.
(3) Information Document received by JAXA according to the contract.

The contractor and suppliers shall present all documents prepared to satisfy the contract requirements when required by a JAXA Inspector, whether or not submission is specified. The contractor shall identify the documents related to the reliability program, maintain and manage the storage location of the documents, and ensure searchability to facilitate reliability program evaluation by JAXA and the contractor .

4.2 Reliability Program Management

4.2.1 Organization

The contractor shall provide a functional organization (reliability management organization) that will be responsible for the planning and management of the contract reliability program and for ensuring its effective execution. The reliability management organization shall accomplish the following:

(1) be functionally independent of other implementation organizations such as design, manufacturing, and testing.
(2) monitor and ensure that all reliability tasks are effectively executed, regardless of whether or not the reliability tasks are executed by the reliability management organization.

The manager of the reliability management organization shall:

(3) have authority and resources (human resources, budget, etc.) necessary for fulfilling organizational responsibilities; and
(4) coordinate the status and adequacy of the program with the upper level managers of the management organizations.

4.2.2 Reliability program plan

4.2.2.1 Preparation

The contractor shall prepare and maintain the reliability program plan to meet the reliability program requirements specified in the contract, and shall execute the reliability program in accordance with this plan.

4.2.2.2 Contents

The contractor shall include at least the following in the Reliability Program Plan.

(1) Description of all organizations, functions and responsibilities for implementing the Reliability Program using organizational charts and tables. The description should include detailed explanations of the reliability tasks described below in subsections a, b and c. In addition, regarding each task, the principle organization that implements the task, the organization that generates the required documents, and the organization that reviews and approves the documents should be identified, corresponding to each requirement specified in this standard.

a. Identification of the reliability tasks performed by each organization such as Engineering, Reliability, Safety, Manufacturing, Test, or Quality Assurance, and of the organizations that use the task results.
b. A definition of responsibilities among the organizations and functions where more than one organizational element is involved in reliability activities.
c. A definition of the reliability management organization's authority, and organizational and operational relationships to the other organizational elements performing reliability tasks.

(2) Documents describing in detail the contractor's plan for executing and managing each task in the reliability program, as well as milestones and supporting documents. The contractor shall document the policies, methods, and procedures to integrate tasks, and these documents shall be referenced or utilized in the Reliability Program Plan.
(3) A listing of contractor documents (methods, procedures, etc.) that must be originated or modified to meet the requirements of this standard. This shall include a schedule for origination or modification of these documents and its explanation.
(4) Items obtained from suppliers upon the requirements of the Reliability Program must be identified. Also, the Plan shall contain or reference a description of the reliability requirements applicable to the suppliers for every such item.
(5) A listing of items provided by suppliers for which the requirements of the Reliability Program do not apply. For each item listed, documents to control reliability shall be identified, in addition to the responsibilities and duties of the contractor organization for ensuring thorough reliability control.
(6) The scheme to confirm the basis of design decision, design results, verification plan, verification results and other particulars in the lifecycle of the contracted item. Include the following subsections a. to c.

a. Inspection and approval by persons in positions up to the execution manager of the design group as well as related line sections of the project at the contractor.
b. As a part of daily activities, problem confirmation and identification by colleagues or experts in related technical and managerial areas (peer review, etc.) according to the importance and technical difficulty of the contracted item.
c. REVIEW required by the contract in the project lifecycle of the contacted item.

4.2.2.3 facility plans

The reliability program plans for remote test sites and the launch site shall be controlled either by describing them in a dedicated section of the overall Reliability Program Plan or by preparing separate plans for each remote facility and launch site.

The reliability program plan for the remote facility may be included in the quality program plan used there.

4.2.3 Reliability program report

The contractor shall report the management situation of the reliability program at regular intervals. In this report, the contractor shall include important matters concerning the reliability program, as appropriate. For urgent matters, always report them immediately to JAXA.

Also it is necessary to include the information about the reliability program of the suppliers who are required to apply the reliability program.

The reliability program management report may be included in the regular progress report covering the overall contract.

Examples of important matters related to the reliability program are shown below.

(1) The status of reliability program tasks including significant accomplishments and milestones reached during the reporting period.
(2) Problems related to reliability and corrective actions adopted.
(3) Decisions and execution of actions taken affecting the reliability tasks during the reporting period, and an explanation of the anticipated effect on the reliability of the item(s).
(4) Revised schedule related to the reliability program plan, and important actions to be executed in the following reporting period.

(5) Expected schedule delay related to the reliability program, and its effects.

4.2.4 Reliability program audit

The contractor shall audit the progress of the reliability program.

The management of the reliability program shall cover the whole reliability program.

For auditing, the followings shall be considered:

(1) Audits shall be performed on a regular basis according to a previously prepared audit plan. Additional audits shall be performed to effectively evaluate the tasks currently conducted on an as needed basis.
(2) Reliability program auditing may be conducted as a part of an audit covering a broader scope of assurance.
(3) Audits shall be conducted using task procedures, implementation procedures, check sheets, etc.
(4) Audits shall be conducted by personnel who are well acquainted with the procedures, standards, and the reliability program applicable to the tasks being audited.
(5) Audits shall include a review of documentation, activities, items, etc. to confirm the effectiveness of the reliability program activities.
(6) An audit report, including recommendations for correcting problems or nonconformances, shall be submitted to the execution manager of the reliability program. Correction of any problems or nonconformances shall be confirmed and reported to the execution manager of the reliability program.
(7) The audit report shall be maintained and controlled as a reliability program document, and shall be ready to be presented to the JAXA Inspector at JAXA's request.

4.2.5 Reliability education and training

The contractor shall plan and provide the education and training necessary for the personnel involved in the reliability program activities to meet the reliability program requirements. The plan and results of the education and training shall be recorded. A person who is appropriately trained shall be assigned for the education and training regarding the theories or techniques (e.g., reliability allocation and prediction, and FMEA) specifically required in the reliability program.

4.2.6 Supplier control

4.2.6.1 General

(1) The contractor shall be responsible for ensuring that the reliability of the items acquired from the suppliers meets the reliability requirements of the overall system (including the technical information related to reliability issued by JAXA, which is called “Shinraisei Gijutsu Jouhou”). This requirement shall apply to items acquired from each supplier in every tier, or items obtained from other sections within the contractor’s organization.

When the items are procured from overseas, it will often be necessary to consult in advance with supplier organization about obtaining the reliability source data for design, analyses or failure, and inspection at the supplier’s facilities. Therefore, for the contractor to satisfy the required reliability program, the respective scopes of implementation and implementation activities of the procurer (the contractor, including its agent and inspector) and the supplier shall be clarified and controlled. Regarding imported parts and components to be on-board a satellite (hereinafter referred to as imported parts and components), JERG-0-050 “Quality Assurance Handbook for Imported Parts” and JERG-0-051 “Quality Assurance Handbook for Imported Components” describe the activities to which the contractor should pay special attention at various phases including selection of parts or components, establishment of technical specifications and procurement requirements, review meetings, witnessing manufacturing, and acceptance inspection.. Therefore, the above guidelines shall be referenced and used to establish the reliability program for the suppliers of relevant items.

(2) The contractor shall impose the reliability program requirements upon the suppliers when the suppliers develop any items, such as those higher than the component level, that need to be controlled from the design phase to ensure final product reliability. The contractor shall provide the standards and control methods to ensure the appropriateness of the reliability program and control documents used by the suppliers.

(3) All subcontracts shall include clauses for the technical inspection and confirmation of suppliers’ reliability to be performed by JAXA Inspectors.

4.2.6.2 Reliability program requirements for the supplier that is required to apply the reliability program

Appropriate requirements in this standard shall be imposed by the contractor on subcontractors to whom a reliability program applies (refer to Appendix 5). Requirements for such subcontractors shall include at least the following:

(1) The requirements that the contractor shall impose on the suppliers in this standard.
(2) Supplier data and documents required by the contractor to be received from the supplier or provided to JAXA in this standard.
(3) Rights of the contractor to access the supplier's facilities, as required, for monitoring and evaluating the supplier's reliability program and related activities.

4.2.6.3 Minimum reliability control on the supplier that is not required to apply the reliability program

For the items obtained from suppliers not required to apply the reliability program, the contractor shall assure their reliability in terms of the quality assurance requirements required by the contract and the appropriately selected reliability requirements.

4.2.7 Use of previously designed, fabricated, or flown hardware

When proposing to use an item already proven in terms of its design, fabrication, or flight in the flight system (hereinafter referred to as developed items), the contractor shall submit, along with the proposal document, a document proving that the proposed item will comply with the requirements of the reliability program applied to the contractor, as well as with the functional and performance requirements.

The documents shall include the following.

(1) A comparison of the reliability design requirements for the item to be developed with the requirements or actual performance of the corresponding developed item.
   a. A comparison and contrast of the item required by the contract with the corresponding developed item in terms of design specifications (functions and performance, interface, environmental conditions, operation method, etc.) as well as the certification and test specifications and identify compliance and noncompliance matters.
   b. For the changes to a developed item in order to solve any noncompliance matters or issues, describe and evaluate their influence , state rationales of judgment and prepare a change plan. If there are issues that need not to be resolved, describe the rationales and supporting information for the decision.
   c. If a test or analysis was omitted because of a high technology readiness level (TRL), state the validity for its omission.
(2) A comparison of the requirements of the reliability program applied to the

items to be developed with the corresponding requirements used for or the actual performance of the developed items . For any requirements that are not satisfied, the substantiating documentation shall describe what will be done to achieve compliance or provide a rationale and supporting information stating why noncompliance is acceptable.

(3) A comparison of the proposed manufacturing information for the items to be developed with that of the developed items.

This comparison shall include at least the following:

a. Name and location of the manufacturer
b. Date of manufacture
c. Design changes
d. Changes of parts or materials
e. Modification of packaging techniques
f. Changes of manufacturing or assembly processes

(4) A description of all test and flight results of the proposed hardware, including a description of all failures or anomalies, their causes, and corrective actions taken, as well as proposals for modifications.

4.2.8 Reliability of JAXA-furnished items

When the system includes JAXA-furnished items (components, subsystems, etc.), the contractor shall receive the reliability data necessary for carrying out the reliability design, analysis, and so forth (reliability allocation, prediction, FMEA, etc.) from JAXA Inspectors. The contractors shall notify JAXA Inspectors promptly in writing when the reliability data of the JAXA-furnished items conflict with the reliability requirements.

4.3 Reliability Engineering

4.3.1 General

Reliability engineering consists of a number of interrelated tasks that should be conducted as an integral part of a project’s activities. These tasks begin at the initial phase of the project, and are implemented throughout its lifecycle: preliminary/critical design, manufacturing/tests, launch activities, and operations. These tasks also include establishing optimum design requirements, reliability analysis and design, design review, control of general design practices, and problem correction and prevention.

Reliability analysis should be implemented to meet the reliability required in design activities by analyzing product behavior for stress, dispersion, and time, and to ensure appropriate margins.

Examples of tasks implemented in the lifecycle are shown in Appendix 6.

4.3.2 Basic concept of reliability design

The contractor must carry out an appropriate reliability design according to the importance and severity of a failure's influence on the system to be designed so as to reduce the failure risk to an allowable level. Regarding the design techniques that can be utilized for reliability design, the followings are available. Decide the appropriate reliability design from the viewpoint of safety and mission success. There are important issues that must be addressed, i.e., points (1) and (2) as well as techniques to make those two effective.

(1) Ensuring a design margin and minimizing the failure risk

Reduce the failure risk below the allowable level by employing a design with a margin to account for the stresses imposed on the equipment and by employing any special control of the manufacturing process. In particular, for a single failure of a system which cannot or does not employ redundancy, give consideration to having a design margin.

The considerations for a single failure shall be implemented based on at least JERG-2-120 Design Standard Single Point Failure and Secondary Induced Failures Prevention.

(2) Fault tolerance design

Preparing for failure and human errors, after eliminating failures due to common causes, take an appropriate measures such as redundancy (e.g., ordinary redundancy, standby redundancy, etc.) and other measures to prevent failure propagation so that the system will not go into a critical state.

(3) Quantitative prediction based on reliability allocation and its demonstration

Make a quantitative prediction by MIL-HDBK-217 or a similar standard to satisfy the reliability allocation. For important items, take the method of reliability demonstration as appropriate.

(4) Simplification and standardization

Employ standardized proven designs, parts, materials and processes. After considering the environmental and operational (use) conditions, employ equipment at a high Technical Readiness Level (TRL). By rational design to reduce the number of parts, avoid failure rate increase. If the manufacturing process needs special control, set and evaluate process specifications and standardize them.

(5) Adaptation to operation environment

Define the environmental conditions and operational (use) conditions, and ensure the above-stated items (1) to (4) be optimized under these conditions.

4.3.3 Design specification

(1) The contractor shall create a design specification for each item at the system,

subsystem and component levels, confirming that the mission requirements for each item are specifically stated. In the design specification, describe the physical and functional requirements included in the operational range of the item in question, as well as the requirements for the interfaces with other items (including JAXA's properties) based on the mission requirements. As necessary, record and keep the information that constitutes the rationales for design specification determination, such as the basic concept, preconditions, analysis methods, rationales for selecting the parameters used in analysis, interface conditions, and operational conditions, that are generated in the process of determining the design requirements to be described in design specification . These information shall be ready for presentation on demand for peer review, examination, etc.
Include the following according to the characteristics of the item. Appendix 7 shows examples of reliability design items to be considered when creating the design specification.

a. Relation between the upper-level system configuration and the item in question.
b. Functional, performance and environmental requirements.
c. Qualification stress level requirements and test requirements.
d. Safety margins, derating factors, allocated reliability goals, and unacceptable failure effects (from the criticality standpoint).
e. Physical parameters and constraints.
f. Requirements or fault tolerance criteria for single failure and redundancy.
g. Readiness of tests and testability or requirements for capability to identify presence and position of failure.
h. Requirements for life and operation times.
i. Requirements for parts, materials and processes.

Design specifications shall initially be generated early in the preliminary design phase and shall be reviewed and updated based on the progress of the design, and controlled appropriately with recordation of any changes to subsequent versions.

(2) The contractor's reliability organization shall, in cooperation with the contractor's other sections, systematize the relationship of the system specification or development specification established by JAXA with all the design specifications including the system specifications, subsystem specifications, and component specifications, as well as all the manufacturing drawings created by the contractor to verify that there is no mutual inconsistency through a design review, etc.

This review shall ensure that the set of specifications covers all necessary items, that each specification is complete in its contents, that each specification is functionally and physically consistent with interfacing design specifications, and that the contents of the reliability technical information, “Shinraisei Gijutsu Jouhou,” and applicable data sheets issued by JAXA are reflected in them.

The contractor shall ensure that the changes to documents due to updating satisfy the configuration management requirements.

The review shall be conducted whenever each specification is changed and its results shall be documented. The review documents related to design specifications shall be input into the design reviews of a component and subsystem.

4.3.4 Standardization of design practice

(1) The contractor shall work continuously to standardize and control the designing and manufacturing process. The contractor may use existing standards or specifications when the use of those standards or specifications is considered more economical and effective, after necessary modifications are made to comply with the reliability, quality, and other requirements specified in the contract. When required by the contract, JAXA’s design and manufacturing standards shall be integrated in the contractor’s design standard system to the extent specified in the contract.
These requirements shall be imposed on the applicable suppliers.
The reliability organization or other assurance organization of the contractor shall be responsible for reviewing the design and manufacturing standards used to confirm that they comply with the reliability requirements specified in the contract.

(2) The contractor shall review whether the standards and design practices used by the suppliers required to implement reliability program (see section 4.2.2.2 (4)) are appropriate.

(3) (3) When doing these activities, consider JERG-2-000 Spacecraft Design Standard and other JAXA technical requirement and guideline documents (JERG documents) related to the design of the contracted item.

4.3.5 Reliability predictions

4.3.5.1 Implementation of reliability predictions

At the beginning of the design phase, the contractor shall develop reliability prediction

models, and shall perform reliability predictions. Development of prediction models and performance of predictions shall include the following:

(1) These models and predictions shall reflect the results from previous space programs.
(2) They shall be revised as required by the design progress and as additional pertinent data becomes available.
(3) Predictions shall be performed in close coordination with FMEA on the similar items.
(4) The degree of precision in each prediction shall be appropriate to the phase of project life and the intended use of the results.
(5) The final prediction shall consider any effects caused by electrical, mechanical and thermal stress.
(6) Prediction results shall be reported to users within the contractor's organization in time for the uses and decisions that each prediction is to support.
(7) Prediction results shall be used for the following:

a. Comparison of predicted reliability with allocated reliability, and planning a design philosophy as well as the means to meet mission reliability requirements.
b. Identification of potential reliability problems which shall be used as a guide to decide the tradeoffs and redundancies in design.
c. Mission planning, test planning, and reliability assessment planning.
d. Probability-of-occurrence determination when FMEA is performed.
e. Gauge for reliability tradeoffs against maintainability.
f. Estimation of the MTBF used for maintainability analysis and logistic plans.

4.3.5.2 Failure rate data

The contractor shall use the same failure rate data for the analysis and review of reliability, maintainability and safety.

The source of this failure rate, and the plan and procedure for revisions and their application shall be described in the reliability program plan.

4.3.5.3 Reliability block diagrams

The contractor shall utilize reliability block diagrams for performing the reliability predictions. Each block diagram shall indicate the predicted reliability and reliability allocation, as well as other pertinent data for each element.

These diagrams shall be updated with the analysis results.

4.3.6 FMEA (Failure Mode and Effects Analysis) and FMECA (Failure Mode Effects and Criticality Analysis)

(1) In the initial design phase, the contractor shall perform FMEA to determine potential failure modes and the degree of their effect on the target mission. The principal objective of this analysis is to identify critical failure modes and catastrophic failure modes, clarify their causes, and find their preventive measures, thereby eliminating the possibility of such failures or their effects from the system.

This analysis shall be conducted for all items. When independently developing a component whose effect on the system has not been determined, conduct an analysis considering the loss of the component's function to be a catastrophic failure as a general rule. If the item has redundancy, do not lower the degree of its effect, but modify the frequency of failure and preventive measures.

FMECA, which includes criticality, may be performed instead of FMEA. In this case, measures to prevent failures and their effect shall be clarified in the same way as FMEA.

(2) The contractor shall perform FMEA/FMECA (hereinafter referred to as FMEA, etc.) at the interfaces of the system-to-subsystem, the subsystem-to-component and the system-to-Ground Support Equipment (GSE)/facilities.

Potential critical and catastrophic failures at the component level or at the interface between ground test equipment and the system shall be analyzed to the extent necessary to identify Single Failure Points (SFP) that can cause failure. When making an analysis of redundant equipment, all single failure points which have a particularly adverse effect on a cross strap, alternate path, or other redundant design shall be identified.

(3) The results of FMEA, etc. are important considerations in the design review and shall be used as input information as a criterion or data for other typical analyses, design improvements, tests, and safety operation. Important applications are shown below.

a. Review of redundancy, fail-safe, design changes, and derating.
b. Systems safety analysis and hazard analysis.
c. Establishment of safety requirements for tests and operations.
d. Development of a test plan to detect known failure modes or expected potential failure modes.
e. Establishment of tradeoffs between reliability and maintainability.
f. Determination of requirements and necessary monitoring frequency for data recording during a test, checkout or inspection, and mission

operation.

g. Development of an operation plan as to failure detection, isolation and recovery (FDIR) and alternate operation modes.

h. For critical items, establishment of their process control items and inspection items by FMEA, etc., focusing on their manufacturing processes and acceptance.

(4) FMEA, etc. and other related analyses shall be closely coordinated to provide consistency and minimize duplication. The output of the analysis technique selected and FMEA, etc. shall be planned to provide data for related analysis activities with maximum practicable usefulness.

The results of FMEA, etc. and their revisions should be prepared and distributed to the contractor's organization in time for any decisions which are needed to support it.

(5) FMEA, etc. shall be updated periodically at specified milestones, and additionally as required by changes in the design or due to other pertinent data and events.

4.3.7 Parts stress analysis

Electrical, electronic, and electromechanical (EEE) parts (hereinafter referred to as EEE parts) applied in circuits within each component shall be subjected to stress analyses to assess conformance with the derating requirements specified in JMR-012, "Electric, Electronic and Electromechanical Parts Program Standard" 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 (section 4.3.17.11), and shall be required input data for component-level design reviews (section 4.3.14).

4.3.8 Worst-Case Analyses (WCA)

Worst-case analyses (WCA) shall be performed for critical design parameters that could degrade during the mission. Adequacy of design margins of electronic circuits, optics, and electromechanical and mechanical items shall be demonstrated by analyses and/or tests. The analyses shall consider the combinations of critical parameters set at worst-case, including initial tolerance, aging effects, and environmental effects such as temperature or radioactive rays regarding the parameter or operation being evaluated. The analyses shall be updated as the design changes.

4.3.9 Trend analyses

For the items specified as a characteristic control item in Section 4.3.16.3, the contractor shall determine the measurable parameters related to performance stability and continuously monitor those parameters from the start of a test at the component level, or for component level purchased items from their acceptance, until the final test phase at the system level to evaluate their trends.

The contractor shall record, analyze, and evaluate the parameters and any variations from the norm, even if the variations are within specification limits.

A list of parameters to be monitored shall be established and maintained.

Trend analysis data shall be the source data used for system evaluation in the mission operations phase, and shall be included in document packages (see section 4.3.16.4).

4.3.10 Special analysis

4.3.10.1 General

The contractor shall identify in the Reliability Program Plan the detailed reliability-related analyses to be performed, such as life analysis, FTA, cumulative fatigue damage, and sneak analysis, when requested in the contract or judged necessary. The contractor shall implement these analyses using identified procedures, and shall review and revise the analyses according to design changes.

4.3.10.2 Life analysis

The contractor shall perform a life analysis to ensure the life and operating time required in the design specifications. The life analysis shall be performed utilizing the life test results and existing data, with operation conditions taken fully into account.

4.3.10.3 Fault Tree Analysis (FTA)

(1) The contractor shall perform a FTA to analyze the occurrence path of fault modes in each development phase.

(2) The FTA can be divided into two phases: prior analysis and post analysis.

   a. Prior analysis is performed in the design phase for the items identified according to the contract at the system/subsystem/component level (the level of the main element of the analysis). A potential important failure mode shall be selected as a top (the treetop) event and deployed into developmental pathways to identify the ultimate root event and examine the probability of occurrence, etc. The objective of this analysis is to reflect the results in design optimization, manufacturing/testing plan and

operation.

b. Post analysis is performed to determine the nonconformance occurrence route, and reflect the results through remedial actions and countermeasures.

(3) During performance of the analyses, special attention shall be given to the functional connection of reliability between the segments and e the whole system. Analyses shall correspond to the Reliability Block Diagram, and shall consider hardware as well as complex factors which include the factors other than hardware (e.g. human error, etc.).

(4) The analyses performed shall include time and environmental factors, and combined with other types of analysis to ensure valid results.

4.3.10.4 Cumulative fatigue damage

The contractor shall design the items to endure cumulative mechanical fatigue from environmental testing and the flight environment and to preclude functional or performance deterioration.

The contractor shall control the cumulative fatigue of tested flight models, such as the PFM, by performing the protoflight test at a component level or higher to ensure there is no functional or performance deterioration due to cumulative mechanical fatigue from the component test phase through the flight.

4.3.10.5 Sneak analysis

The contractor shall establish and implement design methods, inspections and test methods to eliminate potential sneak faults from interfaces with other systems (especially ground support equipment).

4.3.11 Software reliability assurance

For the software included in the delivered item, the contractor shall perform its design control, identifying it as one element of hardware.

Within the scope where the reliability assurance tasks of hardware and software are mutually related (for example, interaction between hardware and software and their anomaly/fault management), they shall be treated as a part of the reliability analysis and design of this Standard from the viewpoint of the two being integrated together.

The logic circuits implemented in an FPGA, etc. shall also be treated as software and their development shall be managed in accordance with CAA-109028 ASIC/FPGA, “Development Management Standard.”

If assurance requirements are set up separately for the software in the contract, perform development management in accordance with them.

4.3.12 Maintainability

The contractor shall make the system, subsystems and components maintainable by ensuring recovery from nonconformances by securing accessibility after assembly, applying standardization, etc.

If a maintainability program is required in the contract, the contractor shall provide the source data or analysis results required for the maintainability program in a timely manner.

4.3.13 Elimination of human induced failures and prevention and elimination of design errors

4.3.13.1 Elimination of human induced failures

The contractor shall eliminate potential sources of human-induced failure from development to mission operation phases. To avoid human induced failures, the item shall be designed to be easy to use properly and safely, and difficult to be used improperly or dangerously. The system shall be able to be assembled, handled, maintained and operated as simply and safely as possible. This shall cover the equipment design, analysis and elimination of reported problems and failures, and equipment for handling, storage, transportation, checkout, and operation as well as associated training.

4.3.13.2 Prevention and elimination of design errors

(1) The contractor shall provide the means to prevent and eliminate potential design errors in the design phase.

(2) The contractor shall establish a control system to prevent design errors, as well as establish design practices, inspection and/or test methods to eliminate design errors. The contractor shall document the means established in the control system for preventing design errors.

The contractor shall report the design error prevention activities as a result of this control system (use of lessons learned from nonconformances, etc.) to the Design Review Committee.

(3) The contractor shall proceed with design reflecting the Design Error Prevention Standard, and Shinraisei Gijyutsu Jouhou (see section 4.3.2 (2)) in the design process. The Design Error Prevention criteria include the following documents:

a. JERG-2-007 Design Criteria for Preventing Human Induced Design Error

on a Satellite System

b. JERG-2-008 Design Criteria for Detecting Human Induced Design Error on a Satellite System

(4) The contractor shall perform inspections and tests that can verify the required specifications within the operations range, in order to detect design errors in the inspection and test phases. The contractor shall reflect the Design Criteria for Detecting Human Induced Design Error described in item (3) above in performing the inspections and tests.

4.3.14 Design review

4.3.14.1 Design review by contractor

(1) The contractor shall plan, document and perform a design review of the systems, subsystems components, and software (by itself and as installed in hardware) as well as FPGA and other special parts related to the contracted item. For EEE parts, conform to JMR-012 as well.

In these design review meetings, the basis of design decisions, design results, verification plan, verification results and other details shall be reviewed to ensure that the contracted item complies with all the development specifications and design specifications.

(2) An appropriate design review shall be conducted considering the following points:

a. Procedure of review meetings

According to the item to be reviewed, employ an explanation meeting prior to the formal review meeting and subcommittees for specific technologies, etc.

b. Review materials

Prepare appropriate review materials (input data packages, drawings, various analysis reports, etc.) according to the item to be reviewed.

c. Closing of the review meeting

Reviewer comments agreed as the most important by the reviewers and the respondents shall be identified and recorded. Obtaining the disposition of these comments shall be required to complete the review meeting.

(3) Design reviews shall be conducted at the major milestones of the project, as Preliminary Design Review (PDR), Critical Design Review (CDR) and Post-Qualification Review (PQR). If, however, a substantial design change occurs, additional reviews shall be conducted as needed even in the course of design changes.

(4) The participants at a review meeting shall include the representatives of the manufacturing, testing, reliability, quality assurance, parts, safety, and other

related departments, as well as those of design departments other than the one in question. Also, as part of JAXA's technical inspection activities, JAXA Inspectors may participate in review meetings. Observers selected by JAXA Inspectors may also participate in review meetings based on coordination between the contractor and JAXA Inspectors.

(5) The contractor's reliability management organization and related departments shall ensure the accuracy and completeness of the design review reports.
The reliability management organization shall also follow up on action items to confirm their satisfactory completion.

(6) The following pertinent documents shall be prepared:
   a. Design Review Implementation Plan
      This plan may be submitted as a part of the Reliability Program Plan.
   b. Notification to JAXA
      The contractor shall notify JAXA of the time, date and place of the review meetings in writing prior to the date specified by the contract. This notification can be included in the Design Review Implementation Plan in a. above.
   c. Input data package
      In the input data package, the contractor shall include materials that indicate compliance with the required specification and show the design results for the design requirements, while describing the basis of design decisions. If the basis cannot be included in the input data package, appropriate references shall be quoted. The evaluation results shall also be included according to Section 4.4, Test and Reliability Evaluation.
   d. Design Review Report (including the minutes of the meetings)

4.3.14.2 Design review by supplier

The requirements in section 4.3.14.1 shall also apply to suppliers for which the reliability program is required (see section 4.2.6). The authorized representatives (the representatives of the design, reliability, quality, or other relevant departments) of the contractor must participate in supplier's design reviews. The contractor shall specify that JAXA Inspectors may attend the supplier's design reviews as part of JAXA's technical inspection activities. The contractor shall also specify that other observers requested by JAXA Inspectors may also attend design review meetings based on coordination between the contractor and JAXA Inspectors.

4.3.14.3 Engineering changes

(1) If an engineering change is made at the contractor after the applicable technical document has been placed under formal design change control, this change shall

be submitted for review and confirmation, according to the Configuration Management Requirements (see JMR-006), to the Configuration Control Board including the representatives of the reliability control organization

(2) An additional design review meeting shall be conducted prior to release of the document for design changes as required (see section 4.3.14.1).

4.3.15 Anomaly/failure control and reporting

4.3.15.1 Anomaly/failure control

The contractor shall identify a anomaly/failure as nonconformance, and shall perform a series of control activities such as reporting, analyses, measurements, and recurrence prevention consistent with the nonconformance processing system required in JMR-005, Quality Assurance Program Standard or JMR-013, Quality Assurance Program Standard (Basic Requirements: JIS Q 9100).

For each anomaly/failure, the contractor and supplier shall perform a anomaly/failure analysis and document the results. The document shall describe clearly the category of the anomaly/failure and the related anomaly/failure analysis document numbers.

(1) Anomaly/failure control shall cover the hardware, software and various interfaces. Hardware shall include all flight hardware, ground equipment directly involved in mission accomplishment, and checkout equipment. Software shall include the software used for test, checkout, inspection, and launch and the software used in flight hardware. The various interfaces shall include interfaces between hardware and software, and interfaces between hardware/software and personnel.

(2) Anomaly/failure control shall cover all observed functional nonconformance, as well as suspected nonconformance of a functional nature including unusual conditions occurring in testing or handling that are suspected to affect the items.

(3) Organizations with expertise shall participate in failure analysis (see section 4.3.17.9).

(4) Adequacy for anomaly/failure closure technical decisions on each reported anomaly/failure shall be assessed by the reliability management organization, as well as by any technical organization appropriate for the nature of the anomaly or failure.

(5) Close-out of each anomaly or failure shall require at least all of the following:

   a. Corrective actions have been accomplished.

   b. Necessary preventive changes have been devised and accomplished, and the pertinent engineering change notices have been referenced on the close-out documentation.

   c. Appropriateness of necessary design or software changes is proven by test.

d. The effectiveness of preventive actions has been proven.
e. The preventive action has been appropriately made in existing similar items.
f. The close-out document has been signed off by the appropriate management authority to ensure completion of a technical review and by the reliability or quality organization to confirm completion of all actions.

(6) The anomaly/failure control shall be applied from the beginning of manufacturing at the assembly phase of the flight items or the items for qualification.

(7) During developmental testing of engineering models or functional models such as the thermal engineering model, anomaly/failure analysis, reporting, and information-storage shall be conducted. The data are to be used to support investigations of possible related anomalies or failures occurring in later testing and use of the flight items.

(8) The contractor shall monitor the status of actions taken for the anomalies/failures, and prepare and maintain the status list for use in appropriate development phases and reviews. The status list shall be submitted to JAXA in the form and means required by JAXA, as needed.

4.3.15.2 Anomaly/failure reporting

The contractor shall make the following anomaly/failure control-related reports:

(1) Immediately report the occurrence of a major anomaly/failure orally or by any other means to JAXA.
(2) Report analysis results of the anomaly/failure, and corrective action to be taken.
(3) On completion of corrective action, present or submit to JAXA Inspectors a copy of documents including the anomaly/failure analysis results.
(4) Submit all the reported anomalies/failures in the form of a list included in the reliability program report described in section 4.2.3. In addition, report on the anomalies or failures of the items provided by the suppliers as specified in section 4.2.6.

The contractor shall require the suppliers to report the anomalies/failures to the contractor.

4.3.15.3 Input to JAXA database

The contractor shall input the anomaly/failure information to be submitted according to section 4.3.15.2 into the JAXA database (see section 4.9.13 of JMR-005 or section 2.2.14.1 of JMR-013).

4.3.16 Items requiring special control

4.3.16.1 General

According to sections 4.3.16.2 and 4.3.16.3, the contractor shall identify the critical

items and reliability control items, determine the characteristics to be controlled, and ensure their reliability by evaluating their control results. For the items received from a supplier or JAXA, the contractor shall identify, in coordination with the other party, the characteristics to be controlled continuously and continue control.

4.3.16.2 Critical Items (CI)

4.3.16.2.1 Identification of Critical Items

From the results of reliability/safety analysis, etc., as well as the results of design review and anomaly/failure data, etc., select items that require special attention to reduce the risk of the item in question, considering the following matters.

(1) An item that, if it fails, can cause a loss of human life, important properties or the mission or have serious effects on the achievement of the mission.

(2) An item with very high risk for project management

Some of the reliability control items in section 4.3.16.3 may be included as CI in an overlapped manner.

4.3.16.2.2 Critical item list (CIL)

The selected Critical Items shall be itemized in the Critical Item List (CIL). The CIL shall describe the measures in the various phases of design, manufacturing, inspection, test and operation. If there are important quality characteristics, important processing parameters, or other characteristics to be monitored or controlled, they shall be specified.

For preparation and management of a CIL, refer to JERG-0-016 Space Development Reliability Technical Handbook.

The CIL shall be created at the preliminary design phase and maintained and revised as the development proceeds. It shall be input into the reviews subsequent to the Preliminary Design Review according to the control requirements of the CIL in question.

4.3.16.3 Reliability Control Item (RCI)

4.3.16.3.1 Identification of Reliability Control Item

The contractor shall identify the Reliability Control Items which requires reliability assurance by controlling the important characteristics through various phases such as manufacturing, inspection, test and operation., The Reliability Control Items f include following.

(1)Limited life item

An item for which quality degradation, performance degradation, drift, and such

like is expected to occur with its operation or as the calendar day proceeds and which therefore a record needs to be kept of its operation, storage, etc. and be assured of usability within the specified calendar day.

a. Operating life Limitation Item (OLI)

An item with an useful life, and as its operation proceeds (elapsed time or cycles), quality degradation, performance degradation, drift or the like will or may affect the specified performance requirements. A record needs to be kept of its operation time and operation cycles to verify that its residual life at the launch time satisfies the necessary life for mission achievement.

b. Storage Limitation Item (SLI)

For an item with an useful life that will experience quality degradation, performance degradation, drift or the like as the calendar day proceeds, record the number of calendar days (years and months) from its manufacture to its assembly, delivery, launch, and mission completion to verify that its residual life at the launch time to the mission completion lies within its useful life.

(2) Characteristics control item

An item having characteristics that affect the mission significantly, and it is necessary to record those characteristics chronologically to evaluate and confirm their qualitative and quantitative trend. This record is used to verify that the variations expected at the end of the mission lie within the allowable range. For the specified characteristic (or parameter) values, evaluate them using trend analysis (see section 4.3.9).

(3) Critical Attachment Hardware

A structural or mechanical connecting part and if broken could lead to a mission failure. It is necessary to record the results of the prescribed inspection at every occasion of inspection as well as after every attachment and detachment until the launch, thereby eliminating structural defects in the attachment hardware.

(4) Pre-launch operating time/cycle control item

An item subject to the burn-in and wear-in test according to the requirements in section 4.4.3.4. It is necessary to keep a record of its accumulated operation time, number of operations, etc., until the launch, to confirm that the quality is stable by ensuring that the specified operation time and number of operations are satisfied.

4.3.16.3.2 Reliability control item list

(1) The contractor shall create an item list for each type of item at the critical design phase and maintain it. This list shall be maintained and revised as the development phase proceeds and be inputted, together with its control requirements, into the reviews subsequent to the Critical Design Review.

(2) The selected item shall be identified in materials such as the design specification

of the item to ensure that its control requirements are deployed.

4.3.16.4 Control details of item requiring special control

The contractor shall control each identified type of item according to the following:

(1) For critical items, perform special control so that the content described in the column of measures in the CIL can be effectively evaluated. Of the critical items, identify those, if any, which should be subject to control as limited life item, characteristics control item, critical attachment hardware or prelaunch operation time control item, and control them individually.

(2) General control requirements for reliability control items

a. To ensure reliability, the reliability-related data and records shall be controlled and maintained in accordance with the quality assurance program established based on JMR-005 or JMR-013.

b. Create and control the document package which logs the equipment history, inspections and test data after the manufacturing phase. In this document package, include at least its history of nonconformance, equipment history (historical logs of work and inspection execution) and inspection records.

c. Maintain the document package according to JMR-005 or JMR-013 and submit it together with the item.

(3) Individual requirements for reliability control items

a. For a limited life item, include its life control status in the document package.

b. For a characteristics control item, include the trend record of its characteristic values (characteristics control table) in the document package.

c. The inspections and confirmation of critical attachment hardware shall be in accordance with the requirements in the applicable drawings. A record of its inspection results and attaching/detaching until the launch shall be included in the document package.

d. For a prelaunch operating time/cycle control item, its records of accumulated operating time and accumulated cycle of operations shall be juxtaposed with the required accumulated values and included in the document package.

(4) For a contracted item whose reliability must be assured continuously after the item delivery, it shall be assured that the reliability of the item in question is maintained in accordance with the requirements of the contract.

4.3.16.5 Report and evaluation of item which requires special control

The contractor shall confirm the control status, and evaluate the results at the review

performed at each milestone. Evaluation results that must be used in reliability assessment shall be reported in the review report or document package. For critical items, perform the measures at each phase described in the CIL and evaluate the results for each item.

4.3.16.6 Collection and use of operating data of reliability control item

(1) Collection of operating data

For a reliability control item, the contractor shall maintain its reliability data also during the operating period based on the requirements of the contract. The contractor shall analyze and evaluate the data as needed.

(2) Use of operating data

Based on the requirements of the contract, the contractor shall evaluate and analyze the reliability data of the reliability-control item that the contractor takes charge of in the contract throughout the whole lifecycle including the operating period and use them as historical data.

4.3.17 Program for parts, devices, materials and/or processes

4.3.17.1 General

For the parts, devices and materials (hereinafter referred to as Parts) and the processes used for the item, the contractor shall set up a program for Parts and process to satisfy the requirements in this section, detail it clearly in the reliability program plan or other plan, and perform control.

For EEE parts other than those developed newly, satisfy JMR-012 and section 4.3.17.11 of this Standard.

4.3.17.2 Use of expert organization

The contractor shall use an expert organization qualified to give advice to the design organization for selecting and applying the Parts and processes. The expert organization shall also be used for establishing and implementing the program.

4.3.17.3 Selection of parts

(1) The contractor and suppliers shall select the Parts and processes with the appropriate specifications that conform to the requirements and have been qualified. The variety of the Parts and processes shall be minimized.

The Parts and processes that have good results under similar conditions, or are included in existing lists, shall take priority in selection.

(2) As for the Parts and processes that have been qualified already, special attention shall be given to the following points:

Data is not obsolescent.
Qualification criteria are appropriate.
Specification is adequate.

(3) Evaluate selection results to determine qualification test requirements to be added. In addition, the results shall be reflected in preparing a list of the Parts and processes to be used.

(4) In the selection process, the contractor shall identify and list any critical processes from the all processes to be used. For critical processes in particular, the contractor shall ensure that the series of process programs required in section 4.3.17 are implemented.

(5) As for parts which must be newly developed, the necessity, elements to be developed, and development plan shall be well-defined in the initial design phase.

4.3.17.4 Specification

(1) Apply appropriate specifications which describe the details and control of all Parts and process to be used. If an appropriate specification does not exist, the contractor shall develop the specification in consultation with JAXA.

(2) The specifications shall conform to the requirements for the performance, reliability, or quality that apply to the Parts and processes. Each specification shall also adopt easily measurable criteria to determine if the specification is properly followed.

4.3.17.5 Qualification

(1) The contractor shall, when any appropriate qualification test data are not available, plan and perform the qualification test to ensure that the Parts and processes conform to the requirements described in the relevant specification in consultation with JAXA, and shall establish the criteria for the Acceptance Test (AT).

(2) The contractor shall prepare the qualification test specifications for the Parts and processes for which the test will be performed. Re-qualification tests shall be performed, if necessary, to assure that all the design, materials, manufacturing processes, and quality control have been controlled continuously since the first qualification test was performed.

(3) The contractor shall store all qualification data for the Parts and processes used in the project, and list the qualification status (see section 4.3.17.6).
The contractor shall report the status of the Parts and processes for which qualification or re-qualification tests are required as part of the periodic status report.
The contractor shall also prepare qualification reports for the Parts and processes on an individual basis.

4.3.17.6 List of Parts and processes used in the project

Based on the activities described in the previous sections (4.3.17.1 to 4.3.17.5), the contractor and suppliers required to have the reliability program (see section 4.2.2.2(4)) shall prepare and maintain a list of the Parts and processes used in the project.

As these factors add constraints to design and item reliability, all the Parts and processes necessary shall be selected and qualified in the initial phase of the project as far as possible, and shall be determined by the beginning of the critical design phase at the latest.

To finalized selection, qualification at each level of the Parts and processes shall be included. When the contractor and suppliers would like to add any Parts and processes, prior to adding those to the list, a report regarding specification qualification and application shall be submitted to JAXA.

4.3.17.7 Application review

(1) The contractor, and the suppliers if necessary, shall perform the application review of the Parts and processes for each component design at the appropriate milestones of design and development to ensure that the application of the Parts and processes to the system design is adequate.

(2) In the application review of the Parts and processes, the design requirement applied shall be compared to the rated performance.

When confirming the application adequacy, consideration shall be given to the required life, functional and environmental stress in use, and failure history (i.e., analysis results of the Parts and processes that failed in the same type of component, subsystem, system or project).

(3) Special attention shall be paid to parts not selected by the parts selection standard, but nevertheless recommended for the project. The application review report shall prove that the application of all these parts is appropriate.

(4) The contractor shall immediately correct any nonconformance that is found.

(5) A review report including a detailed explanation shall be prepared after the application review. The application review report shall be included in the input data package for design review at the component level (see section 4.3.14.)

4.3.17.8 Handling

The contractor shall specify the minimum requirements for controlling the storage and installation procedures of the Parts. The control requirements shall specify how the Parts will be prevented from being used in systems under improper conditions.

The control requirements shall also specify how the deterioration of the parts will be prevented due to environmental conditions, and improper manufacturing or assembly techniques.

4.3.17.9 Failure analyses

The expert organization of the contractor for the Parts and processes shall, for part failures that occurred during procurement and after assembly, participate in cause investigation as well as planning of corrective actions and recurrence prevention measures.

The expert organization shall evaluate and document the effect of failure on the same type of parts or materials used in the system, and potential for secondary failures.

4.3.17.10 Control of Materials and processes

(1) The contractor shall, with special attention, select and control the structural materials and processes to ensure the safety and success of the mission.

When the materials or processes are selected based on past performance, available data or the latest test results, the adequacy of the application shall be considered. For new materials or any material that has not been used in outer space, there will be an emphasis to confirm the adequacy of its application for outer space.

(2) Control activities for the materials and processes shall comply with the requirements for out-gassing, combustibility of the materials in a flammable environment, odor, off-gassing, and test procedure requirements, as well as additional requirements according to the mission.

In control activities of the Parts and processes, the points below shall be emphasized.

a. Flammability
b. Out gas/off gas (toxicity on agglutination on optical subsystem, and detector)
c. Homogeneity of the materials such as homogeneity of heat treatment, or effects of welding heat
d. Effect of radiation
e. Age deterioration
f. Stress corrosion
g. Electric corrosion
h. Hydrogen embrittlement
i. Lubrication adequacy
j. Migration

(3) The contractor shall perform the material or process evaluation test, and shall define the control necessary for the materials and processes based on appropriate drawings and specification.

The contractor shall perform additional control of any materials and parts when it is required by the contract.

4.3.17.11 EEE parts packaging review

The contractor shall review the packaging (design, arrangement, and assembling standard) of the EEE parts to be used.

The review shall be performed as part of the, PDR and CDR at each component level. In the PDR, packaging methods to be used and applicability of the standard shall be focused. In the CDR, the review shall cover the critical design of the component and the supporting structure of the EEE parts and assemblies, considering the mechanical and thermal environments actually applied.

During the reviews, the following shall be emphasized:

(1) Evaluating whether the packaging concept and designed capability can be satisfactorily exerted under all applicable testing conditions in addition to mission operations conditions and environmental conditions.
(2) Discussing placement, mounting and interconnection of each EEE part on the circuit board or substrate, especially considering static discharge, whiskers and migration.
(3) Discussing the structural support and thermal accommodation of the boards and substrates and their interconnections in the component design.
(4) Taking special consideration of the rules for parts protection and inspectability.
(5) Documenting any technical aspect subject to the review.

4.3.17.12 Manufacturing process review

(1) The contractor shall select review items from a list of critical items having important quality characteristics and/or important processing parameters considering at least a to c below and conduct a manufacturing process review. The review shall be carried out as a part of PDR and CDR. When a prototype model is fabricated to conduct a qualification test, the manufacturing process review results shall be re-examined at the PQR.
   a. The effect upon the novelty of process and significant quality and characteristics
   b. The magnitude of restriction of function and performance verification in the test and inspection processes
   c. The frequency of nonconformance of similar products in the past
(2) The following activities shall be carried out for this review:
   a. Conducting a manufacturing process analysis (process FMEA, etc.) to identify latent defects in the manufacturing process and eliminate risks involved in manufacturing defects.

b. Identifying the location of a potential defect and specifying measures to correct the defect if a non-destructive inspection cannot be conducted and thereby the quality depends on the process.
c. Checking the application review (see section 4.3.17.7) results of individual processes that comprise the manufacturing process.
d. Incorporating the findings obtained through past experiences including the process quality evaluation (see JMR-005 or JMR-013) results as well as lessons learned during the development tests of engineering models and other models.
e. Evaluating the baseline of the manufacturing process and the changes made after its establishment.

4.4 Testing and reliability assessment

4.4.1 General

The contractor shall establish and conduct the tasks directed toward assessing the reliability of the system and its elements throughout the project lifecycle. These tasks must be set up so that the objective data necessary for evaluating the system's degree of compliance to the mission requirements and reliability requirements in the contract can be obtained and consists of the testing and the reliability assessment for the project.

The test shall allow an effective reliability assessment to be done, and therefore it must be planned so that the assembly data at the appropriate level are provided in a timely manner and made visible.

The reliability assessment shall be conducted using design and analysis results as well as the data obtained from the results of the test performed according to the test plan, and the supplemental analysis results.

4.4.2 Preparation of reliability assessment plan

The contractor shall prepare a plan for the reliability assessment.

The reliability assessment plan shall contain a milestone schedule which shows the relationship of the reliability assessment items with their assessment timing.

It is necessary to include at least the following items in the reliability assessment.

(1) Means of verification (test, inspection, analysis, etc.) of compliance to requirements in design specification

The considerations in the case where testing is employed as a means of verification are as follows:

a. If a combination test is required for performance characteristic evaluation, identify the performance characteristic to be evaluated and the tests to be combined.
b. It is necessary to identify the test order when the order of tests is important for reliability assessment.
c. It is necessary to describe how the life test and stress test (of materials, parts or higher-level items) are used quantitatively in the reliability assessment for each individual component design.
d. It is necessary to describe the utilization plan of test and flight data used for quantitatively assessing the system reliability.

(2) Design changes and improvements

(3) Reliability analysis (reliability prediction, FMEA/FMECA, part stress analysis, worst case analysis, special analysis, etc.)
(4) Reliability assurance of software
(5) Maintainability
(6) Elimination of human-induced failures
(7) Anomalies/failures
(8) Critical items and reliability control items
(9) Parts, devices, materials and processes
(10) Qualification of individual components, subsystems and systems
(11) Reflection of Shinraisei Gijyutsu Jouhou, applicable datasheets, etc.
(12) Burn-in/wear-in and life

4.4.3 Testing

4.4.3.1 Test plan

The contractor shall develop a test plan so that the tests will evaluate all aspects of the performance characteristics of the system and its elements under both nominal and expected worst-case scenario conditions. The purpose of test shall be as follows:

(1) Verifying the adequacy of the design, functions and performance.
(2) Confirming the tolerance of test specimens (design, software or hardware) for the failures due to known failure modes, or mechanisms or due to those which have not been clarified in past design reviews or reliability analyses.
(3) Identifying interactions among components which have not been foreseen during the design phase.
(4) Detecting failure modes due to defective materials, workmanship or quality control.
(5) Obtaining the reliability data serving as sources for reliability analysis typically including the parts data, and the historical data related to the reliability control item.
(6) Confirming capability of the hardware and software that will function together to satisfy the mission requirements.
(7) Evaluating the adequacy of overall workmanship, including procedures and manufacturing methods.

The tests shall be performed under environmental stress levels and time periods appropriate to the purposes of the testing. Statistical design-of-experiment techniques shall be used when feasible and practical. Test equipment and launch support equipment shall be maintained and inspected prior to use.

4.4.3.2 Qualification of hardware belonging to mission configuration

(1) General

a. Each good shall be qualified in its mission configuration at the appropriate levels of assembly to ensure the capability to perform its required function. Qualification shall take place based on a test or on the similarity of hardware. If, however, the specified environment cannot be simulated in the test, an analysis combined with the test may be used. Qualification requirements shall be established on the basis of specification requirements for the hardware to be qualified. Levels of stress applied for each environmental and performance parameter shall be selected to evaluate the design performance of the hardware to be qualified.

b. Consistent theoretical rationales for specifying the assembly levels at which qualification testing is required and the necessary stress levels (project rules) shall be documented in the applicable test plan or the reliability assessment plan. For any component for which qualification testing is not required and any higher-level hardware, technical justification for omitting (or relaxing) the qualification test requirements shall be described or referenced in the reliability assessment plan (or test plan), and in addition, the results of the qualitative evaluation of expected risks shall be provided.

c. Qualification at a higher level of assembly utilizing other valid data while omitting qualification of some lower level hardware within that assembly may be justifiable as acceptance rationale considering project risk. However, this does not constitute qualification of the lower level hardware. The contractor shall prepare and maintain a Qualification Status List, which states the basis and the current qualification status of each component and subsystem.

(2) Parts, devices and materials qualification

Qualification at this level shall be conducted in accordance with section 4.3.17.5. The qualification requirements shall be based on the specifications (see section 4.3.17.4) prepared for each item rather than on mission application. JAXA shall be consulted when the item is provided for flight only with the qualification at the component level since the qualification at the parts, devices or materials level is not considered appropriate. For the EEE parts for which the act of qualification is specified in JMR-012, follow that standard.

(3) Component qualification

Qualification at this level shall be based on the component level specification corresponding to mission requirements which contain an appropriate design margin.

(4) Subsystem qualification

Qualification at the subsystem level shall be conducted considering the particular nature of the subsystem and the overall risk assessment philosophy of the project test plan, when practicable. Qualification requirements shall be based on the subsystem specifications having an appropriate design margin. These requirements shall at least verify the physical and functional adequacy of interfaces between components.

(5) System qualification

The qualification requirements at this level shall be based on a test plan or reliability assessment plan which considers the appropriate design margin for the mission environmental conditions. Qualification at this level shall include tests under simulated mission environments and conditions, including safety margins/factors, to the degree practicable. Qualification shall include application of the test results at lower assembly levels and an evaluation of all system operational modes and interfaces.

4.4.3.3 Test specifications, procedures, and reports

The contractor shall prepare a test specification, procedure, and report for each test (or series of identical tests) in the test plan. The contractor shall be responsible for the adequacy of similar documents generated by suppliers upon whom the reliability programs are imposed (see section 4.2.2.2(4)). All test specifications and procedures shall meet the detailed requirements stated in section 4.8 of JMR-005 or in section 2.1 and 2.2.10-2.2.13 of JMR-013 and shall be subject to JAXA's disposition as specified in the contract.

4.4.3.4 Running-in (burn-in and wear-in) test

The contractor shall provide a running-in (burn-in and wear-in) test in the reliability assessment plan, according to JERG-2-130, "General Test Standard for Spacecraft" to eliminate initial failures and defects due to workmanship, thus stabilizing quality. Running-in test conditions including test environment, test time, test intervals, and test counts shall be determined based on the design specification.

4.4.3.5 Life test

If required, the contractor shall conduct a life test at the component and higher levels in addition to the life analysis to ensure the life required in the design specification. This life test shall be clearly detailed in the Reliability Assessment Plan.

4.4.3.6 Control of unscheduled activities during test

The contractor shall establish procedures to control documents and have approval for

any activities that deviate from established test procedures. The control procedure shall include the requirement for change approval from those organizations that originally had authority to approve the test procedures, so that the contractor can deal with changes during the tests. JAXA-approved test procedures require JAXA approval of the changes through the contractually defined process.

4.4.4 Performance of reliability assessment and result review

The contractor shall assess the reliability of contracted items according to the reliability assessment plan. The assessment results shall be used as input data in the major reviews (PDR, CDR, PQR, etc.)

The contractor shall perform reviews of the reliability assessment results at the milestones specified in the reliability program plan. These reviews shall be held as part of the contractor's overall reliability program audit task described in section 4.2.4.

4.5 Pre-shipment and pre-delivery reviews

If required in the contract, the contractor shall verify at the pre-shipment review and pre-delivery review that the contracted items satisfy all the matters required in the contract. If there are changes to the reliability assessment results in section 4.4.4 prior to the pre-shipment and pre-delivery reviews, those changes shall be included in the scope of the review.

5. DETAILED REQUIREMENTS

Not applicable.

6. NOTES

Not applicable.

Appendix 1

Relation to other quality assurance programs under JAXA contracts

This standard includes many paragraphs which overlap, or are required to complement or dovetail with paragraphs of JERG-0-049, “Software Development Standard” or JMR-005,” Quality Assurance Standard” or JMR-013, “Quality Assurance Standard (Basic Requirements: JIS Q 9100)”. The following table shows the correlation of these standards to meet all requirements when the contractor prepares each program plan, avoiding overlapping activities.

For the interfaces with JMR-012, ”Electrical, Electronic, and Electromechanical Parts Program Standard”, the contractor shall refer to JMR-012.

Reference Paragraphs				Overlapping or Interfacing Requirements
JMR-004	JERG-0-049	JMR-005	JMR-013	
4.2.1	6.3.1.1	4.3.1	2.1	Organization
4.2.2	5.3.1 6.3.1.2	4.3.2	2.2.1 2.2.2	Reliability Program Plan Software Development Plan Quality Assurance Program Plan Quality Assurance Activity Plan
4.2.2.3	—	4.3.2.4	2.2.2	Separate facilities plans
4.2.3	6.3.1.1	4.3.5	2.1	Status report of reliability management Implementation and validation report of the reliability assurance
4.2.4	6.7	4.3.6	2.1	Assessment process is not an audit, but to make sure that the assessment is carried out, is an audit act. Assessment is an activity to assess the suitability of the standard have been implemented to extract the noticeable improvements.
4.2.5	6.3.4.1	4.3.7	2.1	Education and training
4.2.6	6.3.4.2	4.6	2.1	Control of items obtained from supplier
4.2.7	6.3.4.4	4.3.8	2.2.4	Previously developed, reuse software
4.2.8	6.3.4.3	4.16	2.1	JAXA-furnished items
4.3.14	5.3.5.5 5.3.6.5 5.3.8.5 5.3.11.5 6.6.3.1	4.4	2.1 2.2.4 2.2.5	Design review
4.3.3	5.3.3 5.3.4	-	-	System requirement analysis System architecture design
4.3.3 4.3.14.3	6.2.3 6.2.4 6.2.5	4.4.2	2.2.5	Change control
4.3.11	All chapter	-	-	Software development
4.3.15	6.8	4.9 4.6.10	2.2.14	Anomaly/failure report, resolution process , control of nonconformance items and materials
4.3.16.3	—	4.14.8.2	2.2.16	Document package
4.3.17.4	—	4.7.5.2	2.1	Process specification and control documents
4.3.17.5 4.4.3	5.3.11 5.3.13 5.3.15	4.8	2.1 2.2.10 2.2.11	Qualification test, Control of general tests, Acceptance test
4.4.1 4.4.2 4.4.3	6.3 6.4		2.2.12 2.2.13	Reliability and quality program requirements at tests
4.4.3.1	5.3.11 5.3.13	4.8.2	2.1	Test plan
4.4.3.3	5.3.11 5.3.13	4.8.3 4.8.4	2.1	Test specification and procedures
4.5	—	4.4.3.3	2.2.6	Pre-shipment review

Appendix 2

GLOSSARY OF TERMS

Terms used in this standard are defined below.

Anomaly

Functionally questionable indication.

Approval (for the documents submitted)

The documents in this category need a formal approval along with JAXA review and approval notification prior to application.

Audit

One of the reliability program jobs to confirm and evaluate that the documents are prepared according to the requirements, and that the tasks are performed in accordance with appropriate documents, as well as to amend or recommend corrective actions as necessary.

Catastrophic failure

A failure resulting in loss of life or mission.

Component

A combination of parts, devices, and structures that performs a distinctive function in operating the overall equipment such as a transmitter, attitude control equipment, or power distributor.

Configuration management

Engineering management activities to control functional and physical characteristics of systems or configuration items. Refer to JMR-006.

Contractor

An individual or corporation who enters into a prime contract with JAXA.

Critical Failure

A failure that greatly impairs mission success or severely injures personnel.

Critical Item

Items that have a serious adverse effect on human life, important property, mission achievement, if failed and items with very high project management risks (cost, schedule, etc.) which include the followings.

a. Single failure point (A structural system like a body structure usually is a single failure point. However. when the sufficient design margin is ensured by using widely-known design, manufacturing, and test methods, it may not be identified as a critical item after consulting with JAXA Inspectors.
b. Items whose risk is not reduced due to common causes even after achieving redundancy with multiple devices.
c. Items being forced to degenerate the operation when a part of the redundant devices with the same function fail.
d. Items having no flight heritage including newly developed items.
e. Items whose required functions and performance cannot be confirmed by testing.
f. Items to be used in the vicinity of the allowable limits of performance specifications.
g. Items that caused a serious failure in the past and the items with similar designs to those items.
h. Items which may experience a human error in the manufacturing process or later

(for a example, a device that has a specific mounting direction).

i. Items having critical quality characteristics and important processing parameters.
j. Items that require special consideration in the work environment

(cleanliness, temperature and humidity, vibration during transportation, etc.).

k. Items which are difficult to evaluate the performance on the ground (pyrotechnics, etc.).
l. Software that controls a catastrophic hazard.
m. Items requiring safety consideration in transportation and operation(hydrazine tank, etc.).

Critical Process

A process that may affect critical performance as well as a newly adopted process for a critical item, an item for which conformity with design requirements cannot be ensured by inspection alone, or an item designated as a fracture control item.

Criticality Number、Risk Priority Number

Number obtained by multiplying severity with the probability of occurrence of a

factor that may hinder system function or preclude mission success.

Design Specifications

General title for specifications that usually describes functional and physical requirements for one component or upper level assembly. An initial design specification usually describes physical function requirements and test requirements. The design specifications shall be maintained and improved, reflecting the latest requirements for performance, design, configuration and testing throughout the project lifecycle. In many projects, the end item specifications shall satisfy all purposes specified in the design specifications for the contract end items. Design specifications for items not designated as end items in the contract shall be used as a basis for technical and engineering management.

Design Review

Organizational activities to confirm that the design quality and the processes of manufacturing, testing, installation, service or maintenance planned to materialize the design quality are ready to proceed to the next phase. In these activities, cost and delivery timing shall be considered objectively, and any points to be improved shall be proposed. The design reviews are basically the Preliminary Design Review (PDR), Critical Design Review (CDR) and Post-Qualification test Review (PQR) according to the design progress.

Preliminary Design Review (PDR)

A review performed prior to the start of Critical Design and after Preliminary Design is almost complete. The review shall confirm that the products, the result of the Preliminary Design, can be developed satisfying the system or development specifications, and that development is ready to proceed to the Critical Design phase.

Critical Design Review (CDR)

A review performed prior to prototype manufacturing and after the Critical Design is almost complete. The critical design results such as manufacturing drawings, specifications, the test results of the engineering model are evaluated to confirm that the critical design results satisfy the contract and technical specification requirements and ready to proceed to the prototype production phase.

Post Qualification Test Review (PQR)

A review performed after a prototype is fabricated based on the proto-type drawings, specifications, and manufacturing processes, and after the

Qualification Test is conducted. In the review, the Qualification Test results are evaluated to confirm that the product satisfies the development specification requirements, and that the specified manufacturing drawings, specifications or manufacturing processes are established.

Device

A combination of one or more parts and structures that performs a specific function in a component or subsystem. It is usually simpler than the component. The device can be dismantled in many cases, and may comprise several types such as electrical and mechanical, electrical and physical, or electrical and chemical. The same type of item can be considered as a single device within one assembly, or a single component focusing on the system's complexity or relative criticality. The device may include a valve, relay, small motor, bearing or encoder.

Failure

The state in which a system or element does not satisfy the required function.

Failure Mode and Effects Analyses (FMEA)

The methods to analyze effects of potential failures in each element that comprise the system (failure modes) on other system elements and missions. There are different FMEA types according to the purposes such as functional FMEA, detailed FMEA, interface FMEA and process FMEA.

Fault tolerance

The ability of a system to continue to operate as previously specified when viewed from outside the system despite the presence of failures.

Fault tolerance level

Level at which system function and capability are retained after failures take place, according to the required reliability requirement level. The retained levels include failure shutdown, complete recovery, partial recovery, hazard avoidance and data completeness.

Fault Tree Analyses (FTA)

The analysis methods used to predict faults qualitatively or quantitatively s by logically subdividing phenomena critical (hazardous) for a product or system into observable basic elements (cause of fault).

Fault-Detection, Fault-Isolation, and Recovery (FDIR)

Method to allow the mission to continue to the extent possible by ensuring safety and reducing the operational burden. When a failure occurs, it is detected real-time and automatically, isolated to prevent its spread , and recovered from anomalous state. to.

Failure Mode Effects and Criticality Analysis(FMECA)

Technique to rationally determine priority of the measures. using the the "criticality" calculated by adding the probability of occurrence of a failure mode to the results of FMEA.

Human Induced Design Error

An error caused by simple human mistake (human error) in design. A fault in the documents such as specifications, drawings, or procedures on which design results are recorded, and provided as engineering orders to other organizations including design, manufacturing, testing or inspection organizations.

Information (of document to be submitted)

The documents in this category shall be timely submitted to JAXA to report various states of progress or other communication related to the project.

Input Data Package

The documents describing the design process implemented to materialize design policy, or evaluation of design adequacy, that are prepared and submitted beforehand to facilitate the design review. These documents summarize design or analyses results to facilitate understanding of the reviewers, providing overall view..

Important quality characteristic:

Characteristics of items, components, or materials (half-finished or finished goods) for which the variations seriously affect the performance, service life, or the achievement of the mission, etc. For example, the amount of lubricant injected into a bearing unit, the operation (activation) timing and leakage amounts of valves in the assembly of engines, are such types of significant quality characteristics.

Important processing parameter:

A controllable factor (parameter) in processing that seriously affects the significant quality characteristics of an item. For example, brazing temperature and heating time, and arc welding current value and speed are significant processing

parameters.

Lifecycle

The length of time which lasts from design for a system and its elements, manufacturing, test, inspection, launch site work, up to the end of on orbit operation.

Maintainability

A indicator of the ease and rapidity with which a system or equipment can be restored to operational status after a failure takes place. It includes characteristics of equipment and facility, availability of personnel with the required skill levels, adequacy of maintenance procedures and test equipment, and the physical environment under which maintenance is performed.

Milestone

Any significant event in the project lifecycle or the associated reliability program used as a control point for measuring progress and effectiveness or for planning or redirecting future efforts.

Mission Configuration

Configuration for implementing the mission. The mission configuration includes launch configuration as well as on-orbit configuration of launch vehicles and satellites.

Nonconformance

An anomalous condition of an item in which one or more characteristics do not conform to specified requirements. Nonconformance includes anomalies, failures, discrepancies, defects, shortages and malfunctions

Observer (in design reviews)

A person who participate in design reviews to support technical inspection conducted by JAXA inspectors. Observers can be JAXA personnel from related organizations, and personnel external to JAXA such as a joint developer or user. An observer is not a JAXA Inspector and is not allowed, as a general rule, to make suggestions or comments, which should be made by JAXA Inspectors as part of a technical inspection.

Packaging

Arranging and mounting EEE parts on a circuit board or substrate, or

interconnecting such parts.

Parts

A combination of one or more elements that usually cannot be taken apart without destroying the intended purpose.

Part Counting Method

A method to calculate the failure rate of equipment or other devices by adding up the failure rate of each part.

The following equation will apply to calculate the failure rate of equipment or other devices using data source of MIL-HDBK-217:

$$\lambda S = \Sigma^{n}_{i=1}\{Ni(\lambda G \times \pi E \times \pi Q)_i\}$$

λS = Failure rate of equipment incorporated

Ni = The number of the i^{th} part.

λG = Failure rate of the i^{th} part.

πE = Environmental factor of the i^{th} part.

πQ = Quality level of the i^{th} part.

n = The number of part types.

Peer review

One of the standard mechanisms to effectively manage the programs and projects which are technically very complex and advanced. Advice and objective evaluation are obtained from both inside and outside the organization, or between members of the development team. Peer review exists in various forms, from something like a mere request for an opinion to an official review meeting.

Process analysis:

The act of clarifying the relationship between characteristics in a process (the result of the process) and factors (control parameters that affect characteristics) to optimize and stabilize the process.

For process analysis, approaches such as process FMEA, cause and effect diagram, regression analysis, principal component analysis, and experimental design are employed.

Qualification

Determination that an item can meet all prescribed requirements. The objects of qualification includes design, manufacturing, inspection, testing and the associated

technical documents.

Qualification Test

A test, or series of tests, performed to determine that an item can comply with all requirements specified.

Redundancy (of the design)

The existence of more than one means to perform a given function before an item loses its functionality in case of more than one failure.

Reliability

Characteristic of a system or system elements expressed as the probability of accomplishing the required functions under the specified time and conditions within the specified operation period.

Reliability Apportionment

Apportioning the reliability target values to subsystems and their elements within the system to achieve the system's total reliability target, if each target value assigned to the subsystems and their elements can be achieved.

Reliability Control Item

General term associated with the items, such as Limited Life Items, Operating Life Limited Items, Storage Limitation Items, Characteristics Control Items, Critical Attachment Hardware, and Pre-launch operating time/cycle control items, for which reliability must be ensured by controlling their important characteristics (critical manufacturing, tests, inspections, special treatment, etc.) during manufacturing, inspection, testing, maintenance and operations phases.

Reliability Prediction

To numerically analyze and predict the reliability of the system or its elements. This is essentially the same as the reliability assessment, except for the following:

a. The prediction is always quantitative
b. The prediction is performed in the initial design phase when directly applicable test data is not available

Reliability Task

Reliability tasks include reliability program management, reliability design and analysis work, testing and inspection work and reliability evaluation work.

Review (of the documents submitted)

Documents in this category require JAXA's review prior to application. When JAXA judges such documents inadequate after reviewing them, the contractor shall amend the documents.

Safety

A degree of hazard control to avoid factors that may result in an accident.

Severity Level

Severity to give to the achievement of the mission or function of the system.

Single Failure

The failure that results in the loss of system, subsystem or component due to a single failure mode on the component.

Single Failure Point

The location or equipment with a single failure mode that may lead to a single failure.

Sneak Circuit Analysis

An analysis method to evaluate hardware and software systems to identify the circuits or conditions that may prevent the demonstration of required functions or cause an undesirable function. This analysis method includes sneak path analysis, digital sneak circuit analysis, and software sneak path analysis. An appropriate method should be used for the applicable system.

Sneak Condition

A condition in which an unintended movement occurs, or an intended movement does not occur even though all components and software are functioning normally, electrically, mechanically and chemically. To analyze such a condition, sneak circuit analysis is available.

Software

Computer programs that process tasks on computer systems, data, procedures, and its related documentation.

Stress

Factors affecting functions of systems, equipment or parts such as temperature,

voltage, vibration or impact.

Subcontract

A contract or purchase order between a contractor and a supplier under a JAXA prime contract. The subcontract includes orders issued to other organizations of the contractor.

Supplier

A person, company or business office dealing directly with the contractor and supplying the items and materials under a JAXA prime contract . The suppliers include other business units of the contractor company or a company working in collaboration with the contractor.

System

A basic functional entity, consisting of the project hardware, software, and associated operational services within a project or flight mission. Generally, a system is the preliminary subdivided unit of a project's activities. A subsystem has the principal functions in the system. (A subsystem is also said to be the organized and controlled schematic structure to accomplish a given task such as a failure reporting system.)

Tailoring

The act of modifying requirements to comply with applicable objectives by selecting or rewriting the existing requirements in consideration of new and unique conditions.

Technical inspection

Inspection of technical matters including design verification in the development/test processes, design validation, and reliability management. Technical inspections are performed on a continual basis.

Appendix 3

List of the reliability documents to be prepared by the contractor requested in this document

Documents	**Applicable paragraphs**
Reliability Program Plan (RPP)	4.2.2.1
Separate facility Plan (a part of RPP)	4.2.2.3
Reliability control report	4.2.3
Reliability program audit plan and report	4.2.4
Training plan and implementation result	4.2.5
Proof documents for use of the items which are previously designed, fabricated or flown elements	4.2.7
Design specification	4.3.3
Design standard and process standard	4.3.4
Reliability prediction model	4.3.5.1
Data for failure rate	4.3.5.2
Reliability block diagrams, Predicted reliability value, and Reliability apportionment	4.3.5.3
FMEA/FMECA	4.3.6
Part stress analysis report	4.3.7
Worst case analysis	4.3.8
Trend analysis	4.3.9
Life analysis	4.3.10.2
FTA	4.3.10.3
Cumulative fatigue damage	4.3.10.4
Analysis report for sneak fault elimination	4.3.10.5
Design review implementation plan	4.3.14.1
Input data package	4.3.14.1
Design review minutes	4.3.14.1
Design review report	4.3.14.1
Supplier’s design review minutes or report	4.3.14.2
Nonconformance report, and Anomaly/failure analysis report	4.3.15.1
Status report for trouble or failure	4.3.15.2

Critical items List	4.3.16.2.2
List of reliability control items	4.3.16.3.2
Document package	4.3.16.4
List of characteristic value control	4.3.16.4
Evaluation and report of reliability control items	4.3.16.5
Program plan for Parts and processes	4.3.17.1
Development plan for newly developed parts	4.3.17.3
Specification for parts, devices, materials and processes	4.3.17.4
Specification and report of qualification test for parts, devices, materials and processes	4.3.17.5
List of parts, devices, materials and processes for which qualification test is requested	4.3.17.5
List of parts, devices, materials and processes used for the project	4.3.17.6
List and data of items proposed to be added to the list of parts, devices, materials and processes used for the project	4.3.17.6
Review report for application of parts, devices, materials and processes	4.3.17.7
Failure analysis report for parts, devices, or materials	4.3.17.9
Review report for packaging	4.3.17.11
Reliability evaluation plan	4.4.2
Test plan	4.4.3.1
Qualification status report	4.4.3.2
Test specification and procedures	4.4.3.3
Test report	4.4.3.3

Appendix 4

List of documents to be submitted

Documents	Applicable paragraphs	Action to be taken by JAXA
Reliability Program Plan	4.2.2.	Approval
Reliability program audit report	4.2.3.	Review
Reliability control report	4.2.4	Information
Proof documents for use of the items which previously designed, fabricated or flown elements	4.2.7	Review
Design Review Implementation Plan	4.3.14.1	Review
Input data package	4.3.14.1	Review
Design review report (including minutes)	4.3.14.1	Review
Nonconformance report, and Anomaly/failure analysis report	4.3.15	Information, and Review
Program plan for Parts and processes	4.3.17.1	Review
List of parts, devices, materials and processes used for the project	4.3.17.6	Review
Review report for application of parts, devices, materials and processes	4.3.17.7	Review

Note: This list is a general requirement. Document title, due date and JAXA's action will clarified in the each contract specification.

Appendix 5

Detailed requirements to be prescribed in the supplier's contract

To meet the project requirements, the contractor shall specify in detail, or negotiate with the supplier when entering into a supplier contract, the requirements described in this document. Special attention shall be paid to the steps described below.

4.1.3 The date or milestone for preparation and revision of each document which the supplier is requested to prepare (refer to Appendix 3) shall be specified. Whether these documents are submitted or presented shall also be specified. As for documents requested to be submitted (refer to Appendix 4), the document title, contractor's action (Approval, Review or Information), and due date shall be specified.

4.2.1 Determine the management system for any project for which management combined with supplier assurance activities is required at the time of the contract.

4.2.2.2 Discuss any changes specific to the project when entering into the contract.

4.2.2.2 (5) Specify that the supplier shall revise the reliability control method if necessary when supplier-furnished items and associated reliability requirements are added to the contract or changed.

4.2.6 Fundamental requirements for the reliability program applied to suppliers that must have a reliability program are described in the following sections:
Sections 4.1.2, 4.2.2, 4.2.3, 4,2,4, 4.2.6.3, 4.3.3, 4.3.6, 4.3.7, 4.3.8, 4.3.10, 4,3,13, 4.3.14, 4.3.15, 4.3.16, 4.3.17, 4.4.2,4.4.3.2, 4.4.3.3

4.3.4 Specify the applicable JAXA standards or standards of other official organizations. The contractor shall specify to which supplier these standards are to be applied, if necessary.

4.3.5 The contractor shall specify that the source of failure rate data, mission profile and assumed fundamental rules should be submitted as a part of the explanations for the predicted analysis.

4.3.6 More specific definitions for critical failures (categories) shall be made to satisfy the requirements of the project, if necessary.

4.3.8 More specific requirements for worst case analysis shall be prescribed to satisfy the requirements of the project, if necessary.

4.3.10 This section applies to requesting proposals of supplier's additional analysis or identifying the requirements of the project for special analysis.

4.3.15.1 (1) Identify the applicable items of an anomaly or failure reporting system.

4.3.15.1 (6) Identify the timing for which an anomaly or failure report system is applied.

4.3.15.1 (7) Specify that an anomaly or failure report system shall be applied during the development testing period when appropriate.

4.3.15.2 (3) Specify the requirements for the format and information described in the nonconformance report (and anomaly or failure analysis report) to standardize the information provided.

4.3.15.2 (4) Specify how submission and frequency of the cumulative situation list of anomaly / failure reported. In an important schedule period, the frequency of status report shall increase.

4.3.16 Specify the transfer for items requiring special control.

4.3.17.6 Specify the requirements for supplier use of the JAXA Preferred Parts List (PPL), and for the frequency of the update of a supplier's list of parts, devices, materials and processes. Also, specify the requirements for supplier's submission date of proposed new parts, devices and materials to the JAXA inspectors.

4.3.17.10 Identify control of materials and processes specifically required for the tasks specified in the contract.

4.4.3.2. Specify qualification requirements specific to the project if applicable.

4.4.3.3 Specify the requirements for submission, formats and content of the test specifications, procedures and report, and contractor's action.

4.4.3.4 Establish the requirements for the Running-in (burn-in and wear-in) test.

4.4.3.5 Establish the requirements for the life test.

For imported parts and components that are subject to (4) JERG-0-050 "Imported Parts Quality Ensuring Handbook" and (5) JERG-0-051 "Imported Component Quality Ensuring Handbook" see the above guidelines to set the detailed requirements.

Appendix 6

Examples of the relation between lifecycle phases and reliability engineering

Paragraphs Activities	Lifecycle phases				
	Concept design	Preliminary design	Critical design	Manufacturing /Test	Launch activities/Operations
4.3.3 Design specifications			Update and revision		
4.3.4 Standardization of design practice					
4.3.5 Reliability predictions		Trade-off			
			Prediction	Update	
4.3.6 FMEA/FMECA	Outline		Details	Update	
4.3.7 Parts stress analysis					
4.3.8 Worst-Case Analyses (WCA)					
4.3.9 Trend analyses			Items identification	Characteristic value control	On-orbit control
				Update and	
4.3.10.2 Life analysis					
4.3.10.3 FTA		Pre-analysis			
				Post-analysis	
4.3.10.4 Cumulative fatigue damage			Design/ Prediction	Analysis/ Control	
4.3.10.5 Sneak analysis					
4.3.11 Software assurance					
4.3.12 Maintainability				Update	
4.3.13.1 Elimination of human induced failures					
4.3.13.2 Prevention and elimination of design errors					
4.3.14 Design review		PDR	CDR	PQR	▽PSR
4.3.15 Problem/failure control and reporting	Update and revision				
4.3.16 Reliability control items		Identify/Mitigation			On-orbit control
			Mitigation/Control		
4.3.17 Programs for parts, devices, materials and/or processes				Update	

PDR:Preliminary Design Review

CDR:Critical Design Review

PQR:Post Qualification Test Review

PSR:Pre Shipment Review

Appendix 7

Reliability design example items that should be considered in the design specifications

(1) Prevention for failure

- Failure Modes and Effects Analyses (FMEA)
- Failure tree analysis(FTA)
- FDIR
- Prevention for secondary failure
- Durability and survival design(refer to (9))
- Exclusion of common cause failure

(2)Life time related

- Design life time
- Life time control
- Life test

(3) Quantitative evaluation

- Reliability
- Trend analysis

(4) Qualitative evaluation

- TRL

(5) Verification

- End-to-End test
- Validity by analysis and the degree of simulated on-orbit environment

(6) Margin by design

- Worst case analysis
- Derating
- Cumulative fatigue damage
- Environmental(launch and space) effect analysis (vibration, shock, thermal cycle, ,radiation (TD, SEU, SET), atomic oxygen, vacuum, micro-gravity and charging

(7) Human error

- Prevention of design error
- Polarity control

(8) Control for parts, devices, materials and/or processes

- Program for parts, devices, materials and/or processes

(9) Items to be considered in the durability and survival design

- Short mode of primary power output
- Evaluation for debris
- Design of power harness
- Grounding of the MLI

- Power control of solar array paddle and LLM
- Increase of TLM items for anomaly
- Consider visibility of ground station

(10) Non-conformance analysis

- Fault Tree Analysis (FTA)
- Failure analyses