JERG-0-062（E）

General

Guideline for Space Application of Commercial Equipment

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Japan Aerospace Exploration Agency (JAXA)

This is an English translation of JERG-0-062 and does not constitute itself.
Whenever this document conflicts with the original document in Japanese, the original document takes precedence.

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Contents

1. GENERAL

1.1 Purpose

This document defines the guidelines as basic requirements for conducting evaluation of compliance with reliability/quality, etc. and technical requirements (hereinafter collectively referred to as “space application compliance evaluation”) for the selection, procurement, and use of commercial equipment (equipment designed, developed, and manufactured primarily intended for ground use) with the aim of integration as functional components for space application (hereinafter referred to as “space application”) in contracts related to the development and manufacture of launch vehicles, satellites, manned space systems(such as manned spacecraft), on-orbit platforms (including the International Space Station), planetary bases, orbital transfer vehicles (hereinafter as “spacecraft etc.”) by the Japan Aerospace Exploration Agency (hereinafter referred to as “JAXA”).

These guidelines apply to contractual cases in which the contractor conducts compliance evaluations for space application to ensure that commercial equipment integrated into the spacecraft, etc., meets the requirements for space application.

1.2 Scope

1.2.1 Applicability

This guideline is applied in the following cases.

(1) When this guideline is cited or applied in a contract, procurement specification or technical specification, etc.

(2) When contractor requests space application of commercial equipment based on this guideline and JAXA approves the request.

(3) When this guideline is cited in JAXA's request for proposal (RFP).

1.2.2 Relationship of this guideline to other contractual requirements

The relationship of this guideline to other contractual requirements is as follows:

(1) When any conflict exists between the requirements of this guideline and those stated in the contract, procurement specification or other document, the contract, procurement specification or other document should take precedence.

(2) This guideline should not require duplication of the contractor’s efforts for other program requirements specified in the contract but rather should complement each other.

1.2.3 Tailoring

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

(2) Contractor may propose appropriate modification of the guideline in consultation with JAXA. Tailoring proposals should be made after consideration of factors related to the purpose, function, priority, cost, and consistency with the requirements of this guideline for the target project, and

should be approved by JAXA.

(3) When this guideline is applied (utilized) by an organization or company that is not involved in a contract with JAXA for the purpose of contributing to spacecraft development, “JAXA” and “contractor” in this guideline should be replaced with the name of the relevant organization or company to which this guideline is applied, or “the organization responsible for spacecraft development or manufacturer that is the ordering party of the commercial equipment, of “ordering party”.

In this case, it is assumed that the organization or company to which this guideline is applied (utilized) has knowledge and technical capabilities related to the relevant spacecraft development.

(4) Preparation and revision of applicable documents required in **section 4.1.4** of this guideline are considered as acts within the scope of this guideline.

2. RELATED DOCUMENTS

2.1 Applicable documents

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

(1) JMR-004 Reliability Program Standard

(2) JMR-005 Quality Assurance Program Standard

(3) JMR-006 Configuration Management Standard

2.2 Reference documents

The following documents should be used as reference in conducting space application compliance evaluation in accordance with this guideline. The latest version at the time of contract should apply unless otherwise specified.

(1) JMR-012 Electrical, Electronic and Electromechanical Equipment Program Standard

(2) JERG-0-052 Handbook of the Use of Commercial EEE Parts in Space Applications (Common Purpose)

(3) JERG-1-010 Handbook of the Use of Commercial EEE Parts in Space Applications (Launch Vehicle)

(4) JERG-2-023 Handbook of the Use of Commercial EEE Parts in Space Applications (Long Life Satellite)

(5) JERG-2-024 Handbook of the Use of Commercial EEE Parts in Space Applications (Scientific Satellite)

(6) JERG-2-130 General Test Standard for Spacecraft

(7) JERG-2-141 Space Environment Standard

(8) JERG-2-143 Desing Standard for Space Environment Effects Mitigation

(9) JERG-2-200 Electrical Design Standard

(10) JERG-2-310 Thermal Control System Design Standard
(11) JERG-2-320 Structural Design Standard
(12) JERG-2-330 Mechanical Design Standard
(13) JERG-2-340 Spacecraft Propulsion System Design Standard
(14) JERG-2-400 Communications Design Standard
(15) JERG-2-500 Control System Design Standard
(16) JERG-2-600 Software Development Standard (Spacecraft)
(17) MIL-HDBK-217 RELIABILITY PREDICTION OF ELECTRONIC EQUIPMENT

3. TERMS AND DEFINITIONS

3.1 Terms and definitions

Terms and definitions used in this guideline are as follows:

Commercial equipment:

A generic term for devices (including semi-assembled equipment, etc. such as board modules) and equipment (component) that have certain characteristics and functions in a state in which multiple parts and materials are assembled and processed for ground use, for which design and manufacturing methods have already been established by the supplier, and for which characteristics and functional performance for ground use are clearly specified.

The evaluation primarily targets commercially available equipment such as COTS items and build-to-order equipment that have sufficient records of sales and operational use on the ground."

Common design (Common model):

Design specifications and product model numbers (P/N or Spec./N) are the same. However, even when the model numbers are different, the products may be treated as equivalent when the supplier's reliable qualitative evidence confirms that the changes are minor changes or upgrades, etc., that do not affect the functional performance of the equipment as a space application at all."

Common lot:

A group of equipment identified by the supplier as the same manufacturing control lot among a group of commercial equipment of the common design (common model). When the supplier does not identify it as a manufacturing control lot, a group of products manufactured on the same manufacturing line at the same manufacturing plant, with the same equipment configuration (used parts, etc.), using the same manufacturing/testing/inspection processes and standards (including manufacturing/inspection personnel) at the same consecutive period of time."

Diversion of heritage equipment:

Onboard use of commercial equipment that has the common design (common model) to the heritage equipment for installation on the relevant spacecraft by conducting space application compliance evaluation in accordance with this guideline.

In addition to the repeat equipment, this includes, for example, the case in which commercial equipment that has been used onboard A spacecraft is used onboard B spacecraft (which has different

technical requirements for space application)."

Flight component acceptance test (FCAT):

See section 4.4.5.2"

Flight equipment:

Equipment that will be incorporated into the relevant spacecraft as function-sharing equipment and used in flight."

Flight lot verification test (FLVT):

See section 4.4.5.1"

Flight lot:

An equipment that is the common lot of flight equipment used onboard the relevant spacecraft among the commercial equipment subject to space application compliance evaluation."

Heritage equipment:

Commercial equipment, other than space equipment, that has onboard experience to spacecraft and operational experience and is of the common design (common model) as the relevant commercial equipment subject to space application compliance evaluation.

Heritage equipment also includes equipment that is developed by educational or research institutions etc. such as university and has been used in space."

Made-to-order product:

Commercial equipment that is manufactured and delivered by a supplier in response to an order from an ordering party, where the design/development of the product has been completed and its design/manufacturing/test/inspection methods, etc., have already been established."

On-orbit evaluation test:

A method of testing and evaluating EUT for evaluation of the relevant commercial equipment in space by some means prior to its use onboard the intended spacecraft mission.

Even when the environmental conditions are different from those that the relevant commercial equipment will encounter in actual spacecraft onboard conditions, the purpose is to evaluate the equipment in a complex environment in space, such as weightless, vacuum, cosmic radiation, and heat radiation environments."

Ordering party:

The relevant organization or company responsible for the development of the spacecraft that places the order (procurement) and conducts the space application compliance evaluation of the relevant commercial equipment for the purpose of use onboard the relevant spacecraft.

It is JAXA when JAXA directly develops spacecraft. It is a manufacturer/company contracting with JAXA when manufacturer/company develop spacecraft as the contractor of the development contract of JAXA. It is the relevant organization/agency/company when an organization/agency/company which is not involved in a contract with JAXA conducts a study of space application for commercial equipment by applying this guideline. It should be assumed that the ordering party has the necessary expertise and technology for spacecraft development."

Qualitative evidence:

The qualitative evidence described in this guideline refers to all reliable information specific to the relevant commercial equipment. They are the document package (test/inspection report, etc.) attached to each procured product when the EUT for evaluation or flight lot equipment of the relevant commercial equipment is procured, as well as various certification documents (material certificates, etc.) and design/configuration information submitted/disclosed by the supplier upon request from the ordering party, test/inspection data, manufacturing process control records, information on the relevant commercial equipment, and records of the implementation status of reliability/quality etc. control by the supplier.

In addition to written information, reliable information obtained at meetings etc. with the supplier, or information confirmed by visiting or observing the manufacturing plant of the relevant commercial equipment may also be considered as qualitative evidence.

Product catalogs, etc., that are made available to the public by the supplier to explain product specifications for the purpose of sales may not be considered qualitative evidence."

Reliability/quality, etc. control:

Control methods necessary to achieve the 17 requirement objectives identified as the source of the requirements of Reliability Program Standard (JMR-004), Quality Assurance Program Standard (JMR-005) and Configuration Management Standard (JMR-006)."

Repeat equipment:

Among the diversion of heritage equipment, this term refers to the relevant commercial equipment (equipment subject to space application compliance evaluation), supplied by the same supplier and has the common design (common model), and is continuously used for launch vehicles/payloads and on-orbit replacement equipment, etc. of the common model and under the same operational conditions for repeated launch operations."

Space application (of commercial equipment):

Use of commercial equipment as a functional component of the relevant spacecraft while assembled to the spacecraft. Equipment brought into space (by astronauts, etc.) or equipment under test (EUT) for space experiments (on space stations, etc.), which are independent of the spacecraft functions, are not space applications as defined in this guideline."

Space application compliance evaluation test:

A generic term for the evaluation tests conducted to confirm that the relevant commercial equipment complies with the technical requirements for space applications. “Engineering Evaluation Test (EET), Flight Lot Verification Test (FLVT) and Flight Component Acceptance Test (FCAT) using EUT for evaluation.”"

Space equipment:

Equipment that has been developed by U.S. and European space agencies, their affiliates, and JAXA under a spacecraft development contract and has operation records onboard spacecraft."

Space parts:

EEE parts (standard/non-standard parts) specified in JMR-012"

Space-applicable parts:

A generic term for space-applicable parts (for common use) specified in JERG-0-052, space-applicable parts (for long life satellites) specified in JERG-2-023, space-applicable parts (for scientific satellites) specified in JERG-2-024, and space-applicable parts (for launch vehicles) specified in JERG-1-010"

Spacecraft etc.:

A generic term for launch vehicles/payloads, satellites, manned space systems (manned spacecraft, etc.), orbital platforms (including International Space Station (ISS)), planetary bases, orbital transfer vehicles, etc. developed and manufactured by JAXA."

Supplier:

The manufacturer and/or supplier, responsible for the design/manufacture/control/sales of the relevant commercial equipment."

The relevant commercial equipment:

Commercial equipment that is subject to space application compliance evaluation to the relevant spacecraft."

The relevant spacecraft:

Spacecraft carrying commercial equipment that is subject to space application compliance evaluation by applying this guideline"

3.2 Abbreviations

CE/CS: Current Emissivity/Current Sensitivity

COTS: Commercial-Off-The-Shelf

EET: Engineering Evaluation Tests (**Section 4.4.4** "EET")

EMC: Electro Magnetic Compatibility

FCAT: Flight Component Acceptance Tests (see **section 4.4.5.2** "FCAT")

FLVT: Flight LOT Verification Tests (see **section 4.4.5.1** "FLVT")

JAXA: Japan Aerospace Exploration Agency

I/F: Interface

L/N: Lot Number

MDC: Mission Duration Cycle

MDR: Mission Definition Review

N/A: Not Applicable

Preliminary Design Review (PDR)

Pj: Project (spacecraft development project)

P/N (or Spec./N): Part Number (or Specification Number)

RE/RS: Radiation Emissivity/Radiation Sensitivity

SDR: System Definition Review (SDR)

S/N: Serial Number (Serial Number or Product Specific Number)

SRR: System Requirement Review

4. REQUIREMENTS FOR SPACE APPLICATION COMPLIANCE EVALUATION OF COMMERCIAL EQUIPMENT

The space compliance evaluation of commercial equipment is an act of confirming the reliability/quality, etc. of the relevant equipment and its supplier for commercial equipment that is designed and manufactured for the assumed use on the ground (including land, sea, and air) and has sufficient track record of sale and use, as well as confirming the compliance of technical requirements necessary for installing the relevant commercial equipment on the relevant spacecraft and using it as space equipment.

The following shows the requirements in compliance evaluation of space application for commercial equipment.

4.1 Basic requirements

4.1.1 General requirements for space application of commercial equipment

4.1.1.1 Commercial equipment covered by this guideline

For space application of commercial equipment developed/manufactured primarily intended for ground use, the following objectives, target equipment, and method of use are assumed.

(1) Objectives of space application of commercial equipment

In space application of commercial equipment, it is assumed that the equipment will be used for the following objective taking the potential risks into consideration.

Objective 1: By diverting advanced/advanced technologies, etc. that have already been established as ground commercial technologies but have not been known or proven as space technologies to spacecraft, it is expected that the technologies necessary for the relevant spacecraft mission may be acquired and realized (it is practically difficult to design and manufacture such equipment for spacecraft).

Objective 2: To divert commercial equipment, etc. in functional areas of low criticality for the purpose of reducing spacecraft development costs and shortening spacecraft development schedules.

(2) Commercial equipment to be covered by this guideline

The following equipment is assumed to be subject to compliance with space application compliance evaluation based on this guideline.

a. COTS items and custom-made commercial equipment that have been designed and manufactured for ground use (including land, sea and air) and have a sufficient track record of ground use will be used.

b. For the purpose of applying the functions of commercial equipment to space, whose design and manufactured methods have already been established for ground use, design modifications, etc. are made through contracts or joint research and development etc. between JAXA and the supplier of the relevant commercial equipment, etc.

c. Equipment developed/manufactured by universities, schools, organizations, companies, etc. for which design, manufacturing, quality assurance, etc. as space equipment are not necessarily implemented/guaranteed, and whose functional performance at a certain level in space has been confirmed, will be applied to space as heritage equipment. (Including repeat equipment)

(3) Space application methods assumed in the application of this guideline

a. When commercial equipment is used onboard spacecraft without modification (without changing the design or specifications).

b. When minor interface (I/F) modifications, etc. are made to the specifications of commercial equipment to the extent that the intended functional performance characteristics are not affected, and the equipment is then used onboard spacecraft.

c. Cases in which the equipment is used onboard spacecraft after modifications involving design changes through joint research and development etc. with the supplier, for the purpose of utilizing the functional performance of commercial equipment (Note).

(Note) Space applications with design modification that significantly deviate from the main functional performance specifications of the relevant commercial equipment are equivalent to new development and are not subject to compliance evaluation in accordance with this guideline.

4.1.1.2 Consideration of differences between commercial equipment and space equipment

In comparison with space equipment, it is necessary to sufficiently consider that commercial equipment has the effects by the following differences in general.

When it is necessary to avoid these effects, sufficient information exchange and coordination with the relevant commercial equipment supplier should be conducted prior to the start of the compliance evaluation of the relevant commercial equipment.

(1) Deviation from equipment warranty conditions

Generally, commercial equipment has designed, manufactured, and warranted primarily intended for ground use (including land, sea and air). Therefore, even when the evaluation results show its compliance, various Engineering Evaluation Tests (EETs) conducted in environments or conditions that are not guaranteed in the product specifications, as well as any subsequent malfunctions of the relevant equipment or damage caused by such malfunctions, will fall outside the scope of the supplier's warranty, and the supplier may not

be able to repair or address the malfunction.

In particular, when use or modification of the relevant commercial equipment differs from the ordinary use or assembly specification, it is necessary to collect and examine sufficient information, including coordination with the supplier, on how such use or modification will affect the functional performance expected of the relevant commercial equipment in space application.

(2) Constraints on availability of information on reliability, quality, etc.

Commercial equipment whose design and manufacturing methods have been established for ground use generally has a wide range of manufacturing plants and supply chains.

In addition, since constraints on intellectual property rights, etc. are also assumed, information on the relevant commercial equipment and on reliability/quality, etc. of the supplier may not always be available. Therefore, in the space application compliance evaluation of commercial equipment, it is necessary to fully investigate the availability of such information in advance, and to consider the evaluation method according to the constraints of information availability.

The specific method should be in accordance with **section 4.4** " Method of space application compliance evaluation".

(3) Possibility of changes in product specifications during the period of compliance evaluation and after the product has been installed in spacecraft

Since commercial equipment is mainly intended for ground use, it is assumed that the design specifications, manufacturing methods, reliability/quality, etc. control methods, etc. of the relevant commercial equipment will be discontinued or changed frequently and in a short period of time in response to product demand trends.

As a result, it is assumed that there will be a discrepancy between the product specifications at the time of the start of compliance with space applications and the time of procurement of flight equipment, or that it will be difficult to obtain space parts for equipment repair.

In order to avoid these effects, it is necessary to conduct sufficient coordination with the supplier, and to consider procuring EUT for evaluation and flight lots in batches.

(4) Difficulty in changing reliability/quality control methods, equipment design, etc. and manufacturing methods

Since commercial equipment has already established design and manufacturing methods, etc. for ground use, it may be difficult to make those changes, even when there are requests from JAXA or the ordering party.

In particular, when modifications, etc. are required to the technical requirements (I/F characteristics, etc.) of the relevant commercial equipment, it is necessary to consider that the ordering party will be responsible for implementing the necessary modifications, etc. after procurement of the relevant commercial equipment (including EUT for evaluation).

4.1.1.3 Clarification of effectiveness and necessity of space application of commercial equipment

When considering space application of commercial equipment developed/manufactured primarily intended for ground use, the following items should be considered and the effectiveness and necessity of space application should be clarified in consideration of **sections 4.1.1.1, 4.1.1.2,** and **4.1.1.4**.

(1) The functions to be performed by the relevant commercial equipment in the spacecraft system and the reasons for the necessity of such functions

(2) Advantages and disadvantages of space application of commercial equipment (technology, cost, development period, technical constraints, etc.)

(3) Measures to be taken when noncompliance to space applications is found in the process of compliance evaluation (alternative plan, change of project plan, etc.)

4.1.1.4 Consideration of potential risks in space application of commercial equipment

Since the equipment covered by this guideline is basically designed and manufactured for ground use, it should be assumed that there are unforeseen risks even when no noncompliance is found as a result of the compliance evaluation. Refer to **section 4.5.3** for space application of commercial equipment and the risks assumed in the evaluation process.

4.1.2 Conditions for assurance of compliance with space applications for commercial equipment

The space application of the relevant commercial equipment to the relevant spacecraft may be guaranteed by confirming the compliance of the following (1) and (2).

(1) The relevant commercial equipment and its supplier have compliance with reliability/quality, etc. requirements, in accordance with the requirements in **section 4.2** and the methods in **section 4.4**.

(2) The relevant commercial equipment has compliance with technical requirements (Note) in accordance with the requirements of **section 4.3** and the method of **section 4.4**. (Note) Compliance with technical requirements is a generic term of compliance with space environment etc. and compliance with functional performance requirements etc. under the conditions of the relevant space environment, etc.

4.1.3 Approval of space application of commercial equipment

Space application of commercial equipment in accordance with this guideline is basically limited to the spacecraft planned to onboard the relevant equipment.

Therefore, the approval for space application and decision to install are considered to be made at the milestone review of each spacecraft project etc. (see **Table 4.4.1-1**).

4.1.4 Preparation and maintenance of compliance evaluation plan documents

The following documents should be prepared as qualitative evidence for the space application compliance evaluation of commercial equipment.

The technical requirements and evaluation test plans described in these documents may be revised according to the progress of the space application compliance evaluation.

However, once the space application compliance evaluation is completed and space applicability is determined, the documents may not be changed or revised and will serve as qualitative evidence to prove the compliance with space application of the relevant commercial equipment.

- Technical requirements document (tentative name), or "Technical specifications (tentative name)" after the completion of compliance evaluation
- Evaluation test plan (tentative name)
- Evaluation result report (tentative name)

The purpose, position and description of each document are shown below.

4.1.4.1 “Technical requirements document (tentative name)"

(1) Purpose and position of "Technical requirements document (tentative name)”

"Technical requirements document (tentative name)" defines the technical requirements for space application compliance evaluation of the relevant commercial equipment, and upon completion of the evaluation, it will serve as the "Technical specifications (Specification document) (tentative name)" for the space application of the relevant commercial equipment.

When a review of technical requirements (addition/deletion or enhancement/relaxation of requirements, etc.) is conducted in the process of preliminary investigation or compliance evaluation, "Technical requirements document (tentative name)" will be revised (reviewed) accordingly.

Therefore, no deviations or waivers for the requirement of "Technical requirements document (tentative name)" will be left after the completion of the space applications compliance evaluation.

(2) Clarification of technical requirements by "Technical requirements document (tentative name)

"Technical requirements document (tentative name)" basically describe the FCAT (see **section 4.4.5.2)** test conditions (excluding life test; compliance evaluation of the required life is conducted in **section 4.4.4**) and (when necessary) the life requirements.

Considerations for the description are as follows.

a. Requirements to be described in "Technical requirements document (tentative name)" should be described as qualitative evidence or test/inspection specifications that may be verified by test/inspection.

b. Technical requirements, etc. in a space environment complex (e.g., high vacuum, weightless, and cosmic radiation) that may not be reproduced by ground-based environmental tests should be broken down into requirements that may be confirmed by ground-based tests/inspections,

as appropriate. When evaluation in a complex environment is required and it is considered difficult to evaluate only by ground tests, **section 4.4.7** "On-orbit evaluation test" should also be considered.

c. In general, onboard equipment on spacecraft operates in a thermal vacuum environment where convection by air and exhaust heat may not be expected. Therefore, requirements for its input/output and operational functional characteristics should be set based on the assumption that the equipment is tested in a thermal vacuum test environment.

d. The technical requirement values specified in the technical requirements document are the input to commercial equipment and output and operating requirements to commercial equipment. The former should be set considering a nominal value and tolerances that take into account input variations expected during operation, and the latter should be set considering acceptable dispersions and variation range as the characteristics of commercial equipment. Flight Lot Verification Test (FLVT) level and reliability margins, etc. are not included.

4.1.4.2 "Evaluation test plan (tentative name)"

"Evaluation test plan (tentative name)" is the planning document for the tests in **sections 4.4.4** and **4.4.5** and should include at least the following.

(1) Identification (product name, Spec./N, L/N, S/N, etc.) of the EUT for EET evaluation (**section 4.4.4**), the EUT for FLVT and flight equipment (**section 4.4.5**).

(2) Identification of the combination of evaluation method according to **Appendix Table-3** of each requirement of "Technical requirements document (tentative name)". For requirements that use qualitative evidence presented by the supplier for compliance evaluation, the contents and the basis for the effectiveness of the qualitative evidence.

(3) Planning of test procedures, etc. to be conducted based on the contents of **sections 4.4.4** and **4.4.5** tests (functional and performance tests, vibration test, thermal vacuum test, life test, limit performance test, etc.)

(4) Clarification of the location, equipment, and responsibility (supplier, ordering party, etc.) for evaluation tests/inspections considering the status of compliance with reliability/quality etc. requirements.

(5) Setting for each test in **section 4.4.4** and for "FLVT" load levels in **section 4.4.5.1.**

(6) Policy for alternative measures and countermeasures when noncompliance is found in each evaluation test.

4.1.4.3 "Evaluation result report (tentative name)"

"Evaluation result report (tentative name)" summarizes the results of the space application compliance evaluation and presents the results of the space applications pass/fail judgment of the relevant commercial equipment, and they serve as qualitative evidence of the compliance with space applications of the relevant commercial equipment.

"Evaluation result report (tentative name)" includes at least the following.

(1) Information on the supplier of commercial equipment subject to space application, equipment name/type number, equipment lot identification information (in case of multiple lots, all of the subject lots), and individual identification information (S/N) of the flight equipment and spare equipment whose compliance with space application has been confirmed by flight equipment.

(2) Effectiveness and necessity for the space application of the relevant commercial equipment that has been considered in **Table 4.4.1-1** procedure <1>.

(3) Availability of information on the relevant commercial equipment and its supplier and investigated results of compliance with reliability/quality etc. requirements.

(4) Results of various evaluation tests (including those based on qualitative evidence provided by the supplier) in accordance with the "Evaluation test plan (tentative name)" in **section 4.1.4.2,** and the results of compliance with technical requirements in the "Technical requirements document (tentative name)" based on the evaluation test results (In principle, noncompliance when there are any items that have not passed or may not be judged.)

(5) Solid-state identification (S/N) of equipment that may be used as flight equipment as a result of evaluation tests (flight equipment that has not been exposed to excessive loads exceeding the technical requirements and whose compliance with technical requirements has been confirmed by the Flight Component Acceptance Test (FCAT) and the common lot of equipment)

(6) Other flight equipment control and security requirements, etc.

4.2 Evaluation requirements of compliance with reliability/quality etc.

The space applicability of commercial equipment is determined by confirming (evaluating) whether or not the relevant commercial equipment satisfies the technical requirements onboard spacecraft by means of qualitative evidence and tests, etc.

The effectiveness of the results of technical requirements compliance evaluation is assumed on the reliability of the design and specifications of the relevant commercial equipment, quality control in manufacturing, testing, inspection, and other handling, and appropriate configuration management to assure the consistency of product quality assurance of the EUT and flight equipment used in the evaluation.

In the development contract for spacecraft and space equipment, JAXA imposes the following reliability/quality, etc. control requirements on the contractors to assure the results of the development and technical evaluation.

- JMR-004 Reliability Program Standard
- JMR-005 Quality Assurance Program Standard
- JMR-006 Configuration Management Standard

The same basic approach is followed in the space application compliance evaluation of commercial equipment.

However, as defined in **section 4.1.1.1**, it is not appropriate to apply JMR-004, JMR-005 and JMR-006, which require management at the design /manufacturing phase, to the commercial equipment covered by this guideline, since it is assumed that the design and manufacturing methods have been established and they are already sold for ground use products.

Therefore, in the compliance evaluation for reliability /quality, etc. of commercial equipment, it is necessary to identify and classify each requirement in JMR-004, JMR-005 and JMR-006 into 17 requirement objectives, and to evaluate the compliance with those requirement objectives through interviews and other investigations according to the availability of information from the relevant commercial equipment supplier.

Table 4.2-1 shows the identified 17 required objectives. The correspondence between **Table 4.2-1** and each requirement item in JMR-004, JMR-005 and JMR-006 is shown in **Appendix Table-2**.

In the space application compliance evaluation of commercial equipment, the effectiveness of the space application compliance evaluation may be assured by conducting a technical requirements compliance evaluation taking into account the results of the compliance with reliability/quality requirements, etc., corresponding to **Table 4.2-1**. The details of these procedures are described in **section 4.4**.

In accordance with **section 4.2.6.3** " Minimum reliability control on the supplier that is not required to apply the reliability program" of JMR-004, although contractors are responsible for ensuring the reliability of relevant items acquired from suppliers without requirement of the reliability program, the reliability of the relevant commercial equipment may be assured by demonstrating compliance according to this guideline.

Section 4.2.1 to **section 4.2.3** describe the "requirement objectives" compliance evaluations for each of reliability, quality and configuration.

Table 4.2-1 Classification of reliability/quality etc. requirements by requirement objectives

No.	Requirement objectives of compliance with reliability/quality etc.
1	Review/audit by JAXA (ordering party)
2	Review/audit by independent reliability/quality assurance system at the supplier
3	Design, fabrication based on planning documents and technical requirement documents, preparation and maintenance of the records
4	Configuration management/identification of equipment and implementation of product identification inspections
5	Training design, manufacturing, test and inspection personnel and maintenance and improvement of their skills
6	Management of suppliers of procured parts, materials, etc. and implementation of acceptance tests/inspections
7	Recording results of various works and test/inspection data and maintenance
8	Corrective actions and continuous improvement for malfunctions and complaints
9	Equipment reliability and service life evaluation through the use of reliability engineering
10	Reliability assurance of software
11	Quality control through statistical methods and collection and analysis of part and material quality information
12	Manufacturing process control
13	Marking and handling control of goods
14	Ensuring reliability/quality in testing/inspection
15	Program management of parts, devices, materials and processes
16	Identification and control of special processes and critical Items
17	Ensuring maintainability and post-delivery response

4.2.1 Compliance evaluation of the reliability program

The reliability program is a requirement necessary to ensure that the results of compliance with technical requirements, etc., for the relevant commercial equipment may be satisfied throughout the entire life cycle of a spacecraft mission.

The correspondence between JMR-004 (Reliability Program Standard), which is the source of these requirements, and the 17 requirement objectives in **Table 4.2-1** is summarized in **Appendix Table-2.**

Compliance evaluation of the reliability program for the relevant commercial equipment and supplier is conducted with reference to **Appendix Table-2**, which corresponds to each requirement in **Table 4.2-1**, to the extent that the ordering party considers necessary to ensure the effectiveness related to the evaluation of the relevant commercial equipment.

The procedure for conducting the technical requirements compliance evaluation, based on the implementation and results of the evaluation, is described in detail in **section 4.4**.

4.2.2 Compliance evaluation of the quality assurance program

The quality assurance program is implemented to ensure the effectiveness of the evaluation results obtained by the EUT for evaluation and to ensure that the flight equipment onboard spacecraft has a product quality that validates the evaluation results.

The correspondence between JMR-005 (Quality Assurance Program Standard), which is the source of these requirements, and the 17 requirement objectives in **Table 4.2-1** is summarized in **Appendix Table-2.**

Compliance evolution of the quality assurance program for the relevant commercial equipment and supplier is conducted with reference to **Appendix Table-2**, which corresponds to each requirement in **Table 4.2-1**, to the extent that the ordering party considers necessary to ensure the effectiveness related to the evaluation of the relevant commercial equipment.

The procedure for conducting the technical requirements compliance evaluation, based on the implementation and results of the evaluation, is described in detail in **section 4.4**.

4.2.3 Compliance evaluation of the configuration control

Configuration management is a technical management process to identify the functional and physical characteristics of the relevant commercial equipment during its entire design, manufacturing, test, and operation life cycle, and to maintain, record, and provide up-to-date status at all times.

Without proper configuration management throughout the entire process of design, manufacturing, inspection, space application compliance evaluation, and acceptance of flight equipment, there could be inconsistencies between the results of the space application compliance evaluation of the relevant commercial equipment and the flight equipment's compliance with technical requirements.

The correspondence between JMR-006 (Configuration Management Standard), which is the source

of these requirements, and the 17 requirement objectives in **Table 4.2-1** is summarized in **Appendix Table-2.**

Compliance evaluation of the configuration management for the relevant commercial equipment and supplier is conducted with reference to **Appendix Table-2**, which corresponds to each requirement in **Table 4.2-1**, to the extent that the ordering party considers it necessary to ensure the effectiveness related to the evaluation of the relevant commercial equipment.

The procedure for conducting the technical requirements compliance evaluation, based on the implementation and results of the evaluation, is described in detail in **section 4.4.**

4.3 General requirements for technical requirements compliance evaluation

The technical requirements compliance evaluation is the act of confirming that the relevant commercial equipment will demonstrate the intended functional performance, etc. under the conditions of space environment, etc. onboard the relevant spacecraft.

Therefore, space applications are not allowed unless the compliance to all the technical requirements set as the requirements are confirmed.

Technical requirements are described/specified in the "Technical requirements document (tentative name)" (**section 4.1.4.1**).

Technical requirements for commercial equipment onboard spacecraft are spacecraft mission-specific requirements, and their specific technical requirements are outside the scope of this guideline. However, this guideline specifies general requirements to be considered in conducting technical requirements compliance evaluation.

4.3.1 Basic requirements

4.3.1.1 Technical requirements compliance evaluation

Technical requirements compliance evaluation consists of space environment compliance evaluation and functional performance compliance evaluation as described below.

(1) Space environment compliance evaluation

Confirmation of compliance and environmental resistance of the relevant commercial equipment to various environmental conditions (including launch environment, space environment, and ground handling and various environmental tests after completion of manufacturing of the relevant commercial equipment) encountered onboard spacecraft (or constituent subsystems and equipment).

Refer to JERG-2-141 "Space Environment Standard" for general space environment, but the actual space environment that is likely to be encountered varies greatly depending on its mounting status and mission.

The environmental conditions required for space application of the relevant commercial equipment should be specified in "Technical requirements document (tentative name)" taking into account the results of the study on the mitigation of environmental conditions in spacecraft

system design.

The technical requirement provisions should be verifiable by ground tests and inspections.

(2) Functional performance, etc. requirements compliance evaluation

This includes confirmation of I/O I/F, onboard I/F, external I/F, safety requirements, etc., in addition to various operational functional performance requirements for observation, control, etc., required for the relevant commercial equipment.

In general, the operational functional performance of commercial equipment is evaluated under the ground conditions (atmospheric, 1G), whereas in space applications, it is necessary to conduct compliance with space applications under various space environment conditions (thermal vacuum, cosmic radiation, weightless, electro-magnetic compatibility (EMC), etc.) onboard spacecraft. Therefore, it is necessary to consider the possibility that the specifications and functional performance characteristics may differ from that of the relevant commercial equipment provided by the supplier.

4.3.1.2 Establishment of technical requirements

Technical requirements are set in order to conduct technical requirements compliance evaluation. In the setting technical requirements, the following should be considered at least and specified in "Technical requirements document (tentative name)" (**section 4.1.4.1**) for the relevant commercial equipment.

(1) In principle, technical requirements should be requirements that may be quantitatively measured/evaluated by tests or inspections on the ground of the EUT and flight equipment for evaluation.

When evaluation by analysis, etc. is required, compliance with reliability/quality etc. requirements should have been confirmed for the data used in the analysis and qualitative evidence related to the configuration.

(2) Technical requirements should consider all conditions of space environment, etc. and functional performance requirements, etc. that flight equipment is expected to encounter during its entire life cycle from the time of completion of manufacturing to the end of its operation onboard spacecraft.

When it is important to evaluate the flight equipment in a space environment complex (weightless + thermal vacuum + cosmic radiation, etc.), which is difficult to conduct in a ground-based test, it may be necessary to plan for an "on-orbit evaluation test" as described in **section 4.4.7**.

(3) In setting the values of technical requirements to be verified by tests and inspections (environmental conditions, input conditions, output/operating characteristics, etc.), nominal values and the ranges that will be encountered (or required) during operation of the relevant spacecraft should be specified.

In the technical requirements compliance evaluation for commercial equipment, compliance

will be determined based on whether it falls within the technical requirements, taking into account the characteristics of the relevant commercial equipment and dispersions and variations caused by individual differences, etc.

Tolerances (allowable sigma, etc.) due to dispersions and variations should be set to the most appropriate and realistic conditions according to the characteristics of the relevant equipment and functional requirements, etc.

(4) When setting the values of technical requirements using the equipment specifications, etc. (qualitative evidence) as the source provided by the supplier, the effectiveness should be evaluated by the tests, etc., using the EUT for evaluation taking into account the effects of conditions of space environment, etc. on the equipment functional performance. (Except when reliable qualitative evidence for evaluation in the relevant environment as commercial equipment is available)

(5) Even when (at the preliminary investigation stage) the performance, etc. of commercial equipment meets (or encompasses) the performance required onboard equipment, there is a possibility that functional limitations or performance degradation may occur due to differences in various I/F conditions onboard the relevant spacecraft or differences between the ground environment and the conditions of space environment, etc.

Therefore, in establishing technical requirements, the possibility of design changes of the spacecraft system (subsystem) and sufficient tolerance should be established, taking such variations into consideration at the stage of evaluation tests, etc.

4.3.2 Compliance evaluation for space environment, etc.

Since commercial equipment is not generally intended to be used in space environment, evaluation tests using EUT for evaluation and anti-environmental tests, etc. are required for space environment compliance evaluation.

In addition, it is necessary to evaluate the effects of long-term exposure to these special environments, such as degradation over time, service life, and cumulative damage, etc.

JERG-2-141 "Space Environment Standard" is useful for the space environment that spacecraft system encounters and JERG-2-143 "Design Standard for Space Environment Effects Mitigation" is useful for the radiation resistance design of spacecrafts.

However, in the compliance evaluation of the relevant commercial equipment, it is necessary to consider the influence of their combined environment and the mitigation of environmental conditions in the spacecraft onboard condition, etc. and to set the standards individually in the relevant spacecraft project.

The basic requirements for compliance evaluation with space environment, etc. are shown below.

4.3.2.1 Setting the conditions of space environment, etc.

The conditions of conditions of space environment, etc. in the compliance evaluation for the relevant commercial equipment should be set considering ground handling by the supplier, including storage and transportation after production (by the ordering party), acceptance test environment, installation of spacecraft (or subsystems and equipment) and subsequent various ground tests, the environment encountered throughout the entire life cycle including the burden of dealing with defects, etc., in addition to various space environment that encounter in the launch and on-orbit operation of the flight component.

For general consideration of the space environment, it is recommended to refer to JERG-2-141 "Space Environment Standard" and JERG-2-143 "Design Standard for Space Environment Effects Mitigation", but it may not always be appropriate to specify the space environment to be encountered in each spacecraft mission uniformly (i.e., the requirements may be extremely severe than the actual environment).

Therefore, in setting the conditions of space environment, in order to set the conditions of environment that are appropriate for mission of the relevant spacecraft, careful examination and effective use of the latest observation data and research information should be considered.

The set conditions of environment for commercial equipment should be described in **section 4.1.4.1**, "Technical requirements document (tentative name)".

At this time (except in cases where on-orbit evaluation tests are assumed), the requirements should be described with the conditions that may be confirmed/evaluated on the ground tests/inspections.

4.3.2.2 Consideration of onboard I/F conditions for commercial equipment in spacecraft design

The environment that the relevant commercial equipment encounters in condition of onboard spacecraft depends largely on the environment of the launch vehicle and the design of the onboard I/F of the spacecraft system (or subsystem or equipment) for the relevant commercial equipment.

When examining the suitability of the relevant commercial equipment for installation on spacecraft, it is necessary to conduct sufficient consideration to the design of the spacecraft system (or subsystem) so as to mitigate as much as possible the environmental conditions (vibration, radiation, heat, etc.) that the commercial equipment will encounter.

When modifications (onboard I/F, input/output I/F, etc.) of the relevant commercial equipment are required for spacecraft installation, the modifications should be kept to the minimum extent necessary so as not to affect the functional performance of the relevant commercial equipment, thereby taking care not to affect the functionality and performance of the relevant commercial equipment.

4.3.2.3 Consideration of special space environment conditions not dependent on spacecraft onboard I/F

Notwithstanding **section 4.3.2.2**, weightless (microgravity) environments, cosmic radiation (especially high-energy heavy particles) environments, and high vacuum environments (excluding pressurized equipment) are generally difficult to avoid/mitigate in spacecraft system design prerequisite onboard commercial equipment I/F conditions.

This should be fully considered at the stage of considering whether or not space application of commercial equipment is necessary.

Examples are shown below.

Example 1: Mechanical alignment variation due to differences between 1G environment and microgravity environment

For example, concerning commercial equipment that requires mechanical alignment accuracy of equipment, the functional performance and characteristics are generally guaranteed in 1G environment on the ground, and therefore, in weightless (microgravity) environment in space, changes in characteristics and deviations from functional performance requirements may occur due to the effects of gravity.

Example 2: Disappearance of fluid convection phenomena in weightless environment

In weightless space environment, convection caused by fluid (gas or liquid) temperature differences do not occur, and heat conduction characteristics due to refrigerant circulation behave differently than on the ground.

In addition, the exhaust heat from equipment and the inside of equipment, which on the ground is dominated by heat transfer by convection in the surrounding atmosphere, should rely on contact heat conduction and radiation because heat transfer by convection (even under pressurized conditions) is not available.

Example 3: Prominent dependence on surface tension of liquid materials in weightless environment

For example, mechanical fuses in general commercial equipment, etc. interrupt the current path by melting the metal due to thermal energy from excessive current, but it is known that in weightless environment, the molten metal adheres to the inside of the fuse container wall due to surface tension and may not interrupt the current path.

Electrolytic capacitors, etc. that use electrolytic liquid also require caution.

Example 4: Effects of radiation and high-energy heavy particle environments

The effects of cosmic radiation such as X-rays and γ-rays in the space environment may be reduced to a certain extent by using protective structures such as metal containers (enclosures). However, there are limitations in the design of protection for high-energy heavy particles (alpha rays, etc.) and neutron rays, which may require equipment-specific evaluation and countermeasures as single-event countermeasures. In particular, they may have a significant impact during periods of high solar activity.

For the assumed radiation environment and countermeasures, refer to JERG-2-141 "Space Environment Standard" and JERG-2-143 "Design Standard for Space Environment Effects Mitigation".

Example 5: Effects of buoyancy due to the Earth's atmosphere

When measuring the weight (mass) of equipment intended for ground use in the Earth's atmosphere, note that in addition to the effect of Earth's gravity, the weight is reduced by the buoyancy force due to the Earth's atmosphere.

Although the weight measurement results for commercial equipment are usually not corrected for buoyancy, it may be necessary to consider the effect of buoyancy, etc., for large, closed container structures (equipment installed in a closed pressurized container, etc.).

4.3.3 Compliance evaluation of functional performance and other requirements

For commercial equipment selected as a candidate for space application, basically, it is considered that the various operational functional performance, etc. of the relevant commercial equipment are consistent with or similar to the shared functional performance required for the relevant spacecraft in question.

However, the functional performance that may be obtained from the supplier's disclosed information and qualitative evidence is basically based on the assumption for ground use.

Therefore, compliance evaluation of functional performance, etc. for space application should be conducted separately in accordance with the technical requirements established in consideration of **section 4.3.2**.

General requirements for conducting compliance evaluation of functional performance, etc. of commercial equipment are shown below.

4.3.3.1 Basic requirements for setting functional performance etc. requirements

The functional performance, etc. requirements for technical requirements compliance evaluation of commercial equipment should be set at least for the following functional performance, etc. under the space environment, etc. requirements in **section 4.3.2**.

In the consideration of technical requirements, it is desirable to fully understand the design rationale and considerations, etc. for the functional performance characteristics of the relevant commercial equipment as ground-based commercial equipment, through coordination with the supplier.

(1) Functional performance required for the relevant commercial equipment (observation function, operation function, control function, etc.)

(2) Main characteristics required for the relevant commercial equipment (shape (envelope), mass properties, power consumption, etc.)

(3) Input/output I/F required for the operation of the relevant commercial equipment (power, signal,

fluid, operation, etc.)

(4) Onboard spacecraft I/F of the relevant commercial equipment (mounting, power, signal, fluid, heat transfer, drive mechanism, etc.) and external I/F required for compliance evaluation of the relevant commercial equipment. (EMC, thermal radiation, radiation, disturbance, contamination, etc.)

(5) Reliability apportionment and required life of the relevant commercial equipment (when necessary)

(6) Maintainability requirements for the relevant commercial equipment (when considering repair, replacement, etc.)

(7) Safety requirements of the relevant commercial equipment (including toxicity and corrosion)

(8) Others

In addition, in setting functional performance, etc., quantitative evaluation should be possible by ground tests or measurements, etc.

When evaluation by analysis, etc. is required, the effectiveness of the configuration and various data, etc. used for evaluation as qualitative evidence have been confirmed.

Various design standards, etc. that may be used as references in setting requirements are listed below.

- JERG-2-200 Electrical Design Standard
- JERG-2-310 Spacecraft Thermal Control System Design Standard
- JERG-2-320 Structural Design Standard
- JERG-2-330 Mechanical Design Standard
- JERG-2-340 Spacecraft Propulsion System Design Standard
- JERG-2-400 Communications Design Standard
- JERG-2-500 Control System Design Standard
- JERG-2-600 Software Development Standard (Spacecraft)

4.3.3.2 Evaluation considering variations and dispersions in functional performance characteristics

In the functional performance compliance evaluation of the relevant commercial equipment, taking into account the requirements of **section 4.3.1.2(3)**, it is necessary to consider the evaluation of changes/variations in various input/output characteristics and the surrounding environment (temperature, vacuum, mechanical environment, etc.) related to the relevant commercial equipment and dispersions due to differences between lots and individual pieces of equipment, etc.

At least, the following should be considered.

(1) Output variation and operating behavior characteristics due to input variation of the relevant commercial equipment, as well as limit performance, behavior, and safety in the event of

deviation from specifications.

(2) Understanding of EMC (RE/RS, CE/CS) behavior of electrical/electronic equipment (including behavior and safety in the event of deviation from standards for input/output and the surrounding environment) and compliance evaluation

(3) Understanding of behavior under space environment and other conditions (thermal vacuum, cosmic radiation, vibration/disturbance, weightless, etc.) expected in spacecraft onboard conditions, and compliance and safety evaluations.

4.3.3.3 Evaluation of reliability, life limit, and tolerance limit/limit performance

For the purpose of evaluating the effects of the relevant commercial equipment on the reliability of spacecraft system, ensuring the appropriate derating and margins to life and flight equipment technical requirements and security evaluation, the reliability, life and cumulative damage rate of the relevant commercial equipment should be evaluated by the following methods, etc.

(1) Establishment of reliability apportionment requirements, and reliability evaluation

In order to evaluate whether the reliability required to the relevant spacecraft system is ensured in the condition that the function of the relevant commercial equipment is incorporated as one of the functions that constitute the relevant spacecraft system, establishment of reliability apportionment requirements and reliability evaluation of the relevant commercial equipment should be conducted according to the following methods A through C.

a. Evaluation of reliability using part failure rate data

In accordance with the reliability requirements of JMR-004, when all information on the parts and design (drawings) used in the relevant commercial equipment is available and the failure rate may be calculated using MIL-HDBK-217, etc., the calculated results should be used as reliability apportionment values and reliability prediction values.

b. Evaluation of reliability based on actual use and qualitative evidence of commercial equipment

(a) Establishment of reliability apportionment

Establish by using an appropriate allocation method that takes into account the functional requirements of the relevant commercial equipment in spacecraft system (or subsystem).

(b) Reliability prediction

When reliability evaluation based on MIL-HDBK- 217, etc. is not possible due to the availability of equipment configuration or component information, and instead, information on use records and equipment failure rates as qualitative evidence from the supplier is available, the values should be used when the information is judged to be reliable.

However, it is necessary to take into account the possibility of a decrease in reliability due to environments that are not considered in actual ground use, such as a vacuum environment or a radiation environment.

c. Evaluation when reliability may not be estimated

In cases where information on materials and reliable usage records for evaluating the reliability of the relevant commercial equipment, etc. is not available, and no improvement measures such as replacement of parts may be taken (corresponding to Information Availability Level 2 or 3), the use of the relevant commercial equipment is basically limited, and the following should be applied.

(a) Reliability apportionment

The functional layout should be designed to minimize the reliability apportionment of the relevant commercial equipment to the spacecraft system/subsystem by one of the following design considerations.

i. The equipment should be located at the end of the reliability block diagram of the spacecraft system (subsystem or equipment) or should be independent of it.

ii. All or part of the functional performance of the relevant commercial equipment is designed to be substituted or complemented by other functions.

iii. The relevant equipment should be able to separate failures from connected and peripheral equipment, and malfunctions and scratches in the relevant equipment should not affect or propagate to connected and peripheral equipment.

(b) Reliability prediction

Basically, reliability prediction will not be performed, provided that space application compliance is judged in accordance with these guidelines.

However, in order to minimize the risk of unexpected malfunctions, that are caused by the noncompliance due to dispersion in equipment and variation in characteristics etc., life and the reduced reliability of parts, this is subject to the condition that the test evaluation in (2) below is also included.

(2) Evaluation of life, aging and cumulative damage

By conducting the life limit and aging verification test using an EUT for evaluation of the common design as the flight equipment of the relevant commercial equipment (flight lot verification test if possible) and a limit performance test or overload test that provides basic data for evaluating the cumulative damage rate of the flight equipment, it should be confirmed that the relevant commercial equipment is designed to have a sufficient operational life and tolerance.

4.4 Methods of space application compliance evaluation

4.4.1 Procedures for space application compliance evaluation

4.4.1.1 Evaluation procedures

The procedures and implementation outline of the space application compliance evaluation for commercial equipment is shown in **Table 4.4.1-1**. The relevant items, recommended implementation phases and completion dates are indicated in the Table.

Refer to the relevant items for details of the implementation work.

The implementation phases and completion dates are for reference only and should be set as appropriate in consideration of the spacecraft development plan.

Table 4.4.1-1 Procedures of space application compliance evaluation for commercial equipment

Procedure No.	Implementation Item	Implementation outline (Related section)	Implementation Phase	Date of completion
＜1＞	Consideration of the necessity of space application to commercial equipment	(1) Clarification of effectiveness and necessity **(section 4.1.1.3)** (2) Survey and selection of candidate equipment **(section 4.1.1)** (3) Investigation of information availability **(section 4.4.2.1)**	Mission requirement study	MDR
＜2＞	Technical requirements study (Note 1)	(1) Technical requirements study **(section 4.3)** (2) Preparation of "Technical requirements document (tentative name)" **(section 4.1.4)**	System requirements study	SRR
＜3＞	Preliminary investigation study (Note 2)	(1) Investigation of reliability/quality etc. compliance **(sections 4.2** and **4.4.2)** (2) Preliminary compliance evaluation to technical requirements (3) Test site/facility, etc. study (4) onboard I/F for spacecraft study (2) to (4): **sections 4.4.3** to **4.4.8)**	System conceptual study	SDR
＜4＞	Study of evaluation test plan (Note 3)	(1) Study on the combination of technical requirements compliance evaluation methods according to the status of reliability/ quality compliance **(section 4.4.2)** (2) Study of evaluation test plan **(sections 4.4.3** to **4.4.8)** 3) Revision of "Technical	System Design review	Project sift review

		requirements document (tentative name)" **(section 4.1.4)** 4) Preparation of "Evaluation plan (tentative name)" **(section 4.1.4)**		
< 5 >	EET using equipment under test	(1) Evaluation by qualitative evidence **(section 4.4.3)** (2) Procurement of equipment under test **(section 4.4.1.2)** (3) Implementation of modification, etc. **(**when necessary) (s**ection 4.4.1.2)** (4) Implementation of EET (s**ection 4.4.4, 4.4.6, 4.4.7)** (5) (when necessary) incorporation of EET results into spacecraft design **(section 4.3.1.2)** (6) Revision of "Technical requirements document (tentative name)" **(section 4.1.4)** (7) Go-NoGo decision to Procedure 6 **(section 4.5)**	Basic Design	PDR
< 6 >	FLVT/FCAT (Note 4)	(1) Procurement of flight lot **(section 4.4.1.2)** (2) Implementation of FLVT **(section 4.4.5)** (3) Review and set of FCAT conditions **(section 4.4.5)** (4) Implementation of FCAT (including spare equipment) **(section 4.4.5)** (5) Finalization of "Technical requirements document (tentative name)" **(section 4.1.4)** (6) Go-NoGo decision for space application **(section 4.5)** (7) Preparation of "Evaluation result report (tentative name) **(section 4.1.4)**	Basic Design	PDR
< 7 >	Approval of space application	Review and approval based on “Evaluation result report (tentative name)” **(section 4.1.3)**	Basic Design	PDR
< 8 >	Installation to spacecraft and operation	(1) Assembly and test on spacecraft (2) Inspection/maintenance (when necessary) (3) Corrective activities (when necessary) (1) to (3): **section 4.5)**	Detailed Design Maintenance design Operation	-

Note 1) The results of the technical requirements study should be clearly stated as "Technical requirements document (tentative name)" (see **section 4.1.4.1**).

Note 2) Preliminary study conducted for the purpose of obtaining/collecting various information and technical data necessary for the procedure 4.

Hearing and coordination with the supplier of the candidate commercial equipment, collection of technical information on the candidate equipment, procurement of candidate commercial equipment and simplified evaluation of technical requirements compliance through tests/inspections, etc., as necessary, investigation of test locations and methods, and preliminary investigation/study of the spacecraft interfaces conditions for installing the relevant commercial equipment should be conducted.

(Note 3) The implementation plan for the various evaluation tests to be conducted in Procedures 5 and 6 and the number of EUT required for the evaluation should be studied (see **section 4.4.1.2**).

If part of the technical requirements to be evaluated may be confirmed by reliable quality evidence provided by the supplier, the corresponding test items may be reduced.

The results of the study should be clearly documented in the "Evaluation test plan (tentative title)" (see **section 4.1.4.2**).

(Note 4) FLVT/FCAT

Flight Lot Verification Test (FLVT) and Flight Component Acceptance Test (FCAT) (including spare equipment) using the flight lots is conducted.

After confirming the effectiveness of the FCAT test conditions (basically the same as the test requirements) using the FLVT results, the FCAT, including spare equipment, should be conducted.

Flight-lot equipment for which compliance has been confirmed by FCAT (and which has not been exposed to loads exceeding the FLVT conditions) may be used as flight equipment for installation on the spacecraft..

4.4.1.2 Consideration of commercial equipment procurement plan

The concept for determining the required procurement quantity of commercial equipment in space application compliance evaluation is shown in **Table4.4.1-2**.

Basically, since the commercial equipment subject to evaluation in this guideline is equipment with sufficient manufacturing and sales track records as ground use products. Therefore, no modification or design changes, etc. after procurement is required. When the space application compliance of the relevant flight lot has been confirmed and the cumulative damage rate at the time of flight is judged to be sufficiently small, all such equipment may be used for flight by confirming compliance through FCAT.

Accordingly, the difference at the time of procurement of the relevant commercial equipment are the difference in manufacturing lot (L/N) and solid state difference (S/N).

In cases where modification are implemented after procurement for the space application of the

relevant commercial equipment (including the case where the equipment is modified by the equipment supplier) , the identical design and specifications should be applied to both test articles and flight equipment, and the equipment should subsequently be subjected to the various evaluation tests, etc.

Table 4.4.1-2 Concept of the required number of commercial equipment to be procured in space application compliance evaluation (for reference)

Procedure	Equipment Purpose of use	Modification, etc. (when necessary)	Flight lot	Number of items procured	Remarks
3	Preliminary investigation	None	N/A	Approximate 1 set	For preliminary investigation of commercial equipment specifications
5	Equipment under test for design evaluation (Note 1)	After modification	N/A (Note 2)	Number required (Note 3)	(Note 1) EET, life evaluation test, reliability evaluation test, etc. (Note 2) Test results using flight lots may be allocated to FLVT results (Note 3) The number of equipment consumed due to destructive/overload tests, etc. should also be considered.
6	FLVT Equipment under test (Note 4)	After modification	Flight lot	3 or more sets (Note 5) (Note 6)	(Note 4) In principle, diversion to flight equipment after FLVT level loading is not allowed. (Note 5) Includes evaluation of individual equipment (S/N) differences. The number of equipment under test may be reduced when the performance (tolerance, power variation range, etc.) of the commercial equipment has a sufficient safety

					margin (safety side) with respect to the technical requirements. (Note 6) In cases where flight equipment is distributed in multiple lots, in principle, evaluation is required for each lot.
6	FCAT Equipment under test (Note 7)	After modification	Flight lot	Number required (Note 7)	(Note 7) Equipment for flight and spare

4.4.2 Method of technical requirements compliance evaluation based on compliance with reliability/quality etc. requirements

4.4.2.1 Classification of information availability level

The availability of information on reliability/quality, etc. and technical information on the design, etc. of the relevant commercial equipment may differ depending on the supplier, and the evaluation method should be considered taking into account of the difference in availability.

The differences in the availability of information on commercial equipment and the supplier are classified as follows.

[Information Availability Level 0] (All information on reliability/quality, etc. is available, and improvement actions may be taken.)

All necessary information is available from the supplier, and it is possible to improve or review the reliability/quality, etc. control methods based on the ordering party's requirements.

[Information Availability Level 1] (All information on reliability/quality, etc. is available, but improvement actions are not possible.

All necessary information is available from the supplier, but it is difficult to review established and proven reliability/quality control methods based on the ordering party's requirements.

[Information Availability Level 2] (Some information on reliability/quality, etc. is not available, and improvement actions are not possible.

There are some restrictions/limitations on the availability of information from the suppliers. And improvement actions are not possible in principle.

[Information Availability Level 3] (Information on reliability/quality, etc. is not available)

It is difficult to obtain information on reliability/quality, etc. other than basic specifications (catalogs, instruction manuals, data sheets, etc.) and company information disclosed to the public by the supplier, and improvement actions are impossible.

4.4.2.2 Compliance evaluation of reliability/quality, etc. according to the level of information availability

The method for compliance evaluation of reliability/quality, etc. considering the level of information availability of the relevant commercial equipment is shown in **Appendix Table-1**.

Compliance evaluation of reliability/quality, etc. should be conducted in accordance with **section 4.2.**

Items to be considered in the compliance evaluation of reliability/quality, etc. are as follows

(1) When it is confirmed that management is being conducted in accordance with each of the 17 requirement objectives in **Table 4.2-1**, through coordination and hearings, etc. with suppliers and detailed information may be obtained whenever necessary, it may be considered to be in compliance.

(2) When the existence of information is unknown or difficult to obtain, it should be treated as nonconformance.

(3) Compliance evaluation of reliability/quality, etc. may be subdivided according to the configuration and functional performance of equipment.

(For example, qualitative evidence may be used for evaluation of functional performance of A, while functional performance of B requires a separate test or capability tests because qualitative evidence may not be used, etc.)

4.4.2.3 Technical requirements compliance evaluation based on the results of compliance evaluation of reliability/quality, etc.

Technical requirements compliance evaluation should be conducted by an appropriate combination of the following methods: by checking the qualitative evidence provided by the supplier based on the results of compliance evaluation of reliability/quality, etc. (**section 4.4.3**); by EET using EUT for evaluation with the common design (common model) as the flight equipment (**section 4.4.4**); by FLVT/FCAT conducted after procurement of the flight equipment (**section 4.4.5**).

Appendix Table-3 summarizes the items to be considered for the combination of technical requirements compliance evaluation methods in the case of nonconformance for each of the 17 reliability/quality, etc. requirements classified in **Table 4.2-1**.

When noncompliance exists in more than one of the 17 requirement objectives at the same time, it is necessary to find noncompliance that relates to all objectives. (Note 1).

In addition, it is also possible to evaluate them independently/subdivided by the physical configuration, functional performance configuration, etc. of the relevant commercial equipment (Note 2).

Note 1) For example, when there are requirements for which qualitative evidence is noncompliance and requirements for which technical evaluation is noncompliance, neither qualitative evidence nor technical evaluation may be applied as a compliance

evaluation method.

Note 2) For example, the mechanical operating characteristics of the relevant commercial equipment and the test/evaluation test/evaluation method of the supplier has reliable/quality compliance. However, when the electrical characteristics do not have compliance, the supplier's qualitative evidence may be used for the mechanical operating characteristics, but not for the electrical characteristics. In this case, the ordering party needs to consider an appropriate evaluation test plan.

4.4.3 Evaluation method by qualitative evidence

When conducting an evaluation using qualitative evidence (see **section 3**, Terms and definitions), it should be confirmed that the information provided by the relevant qualitative evidence may be used in the evaluation described in **section 4.4.2.**

For example, even when test/inspection reports are attached to the relevant commercial equipment, when the evaluation test results in accordance with **Appendix Table-3** indicate that the qualitative evidence is not usable, these inspection results, etc. may not be used and should be confirmed by a separate test/inspection, etc. under the control of the ordering party.

When the qualitative evidence (inspection report, test data, etc.) provided by the supplier has been confirmed to have sufficient reliability through the evaluation in **section 4.4.2** and may be used as data for technical requirements compliance evaluation in "Technical requirements document (tentative name)" (see **section 4.1.4.1**), in some cases, the test in **section 4.4.4** for the relevant technical requirement item may be deleted or relaxed.

Note that when modifications, etc. are conducted for space application (see **section 4.1.1.1**), the qualitative evidence presented by the supplier may become unusable (depending on the modifications) even when there is no problem with the compliance with reliability/quality etc. of the relevant commercial equipment.

4.4.4 Method of Engineering Evaluation Test (EET) using EUT for evaluation

Engineering Evaluation Test (EET) using the equipment under test (EUT) for evaluation is conducted as part of the space applications compliance evaluation of the relevant commercial equipment. Its purpose is to evaluate to what extent the relevant commercial equipment has capability (margin) to meet the technical requirements for space application as a manufacturing specification (not taking into account product lot and individual differences). (Depending on the method of use, conditions may deviate from the specifications of the relevant commercial equipment.)

Considerations for conducting the test are described in **section 4.4.6**, "Considerations in conducting space application compliance evaluation test".

EUT for technical evaluation does not necessarily have to be a flight lot when it is of the common design (common model) as the flight equipment, but when evaluation is conducted using a flight

lot, it may be part of the FLVT in **section 4.4.5**.

When some of the technical requirements may be confirmed by reliable qualitative evidence provided by the supplier (**section 4.4.3**), it may be possible to omit some of the test items, relax the test conditions, or reduce the number of EUT.

Considerations for conducting evaluation tests are shown below.

4.4.4.1 Modification, etc. of the relevant commercial equipment

When modifications, etc. are required for space application of the relevant commercial equipment, the necessary modifications should be completed prior to the start of evaluation tests and inspections of all EUT (EUT and flight lot for evaluation).

The modifications should be the same for all the relevant commercial equipment.

When a noncompliance is discovered during the evaluation test and a retrofit is performed as a countermeasure, it is necessary to confirm that the retrofit does not affect other functional performance characteristics of the relevant commercial equipment concerned by a FLVT using a different EUT than the flight equipment.

In this case, when the functional performance characteristics of the post-modification flight lot differ significantly from those of the pre-modification FLVT results, a re-evaluation by retest (when necessary, including modification of the flight lot) as specified in **section 4.4.5.1** is necessary.

4.4.4.2 Identification of evaluation items and test evaluation items by qualitative evidence

In the space applications of commercial equipment, it is difficult to use the quality evidence and data provided by the supplier for ground use directly in the technical requirements compliance evaluation, due to the basic differences between the ground environments and the space environments (such as high vacuum, microgravity, and radiation, etc.).

However, there are cases in which the commercial equipment has functional performance characteristics that allow the differences between the ground and space environments may be ignored provided that its mechanical properties and its tolerance to the space environment have been confirmed.

In such cases, it may be possible to evaluate technical requirements compliance using qualitative evidence (**section 4.4.3**) provided by the supplier instead of the test evaluation using EUT for evaluation.

When technical requirements compliance is evaluated by qualitative evidence, it should be clarified at the stage of planning the test program.

4.4.4.3 Consideration of test plan and implementation of test

EET using EUT for evaluation is conducted to confirm the functional performance or capability specified in **section 4.1.4.1**, "Technical requirements document (tentative name)", by conducting

the various tests specified in **section 4.4.6**.

The following should be considered in the study of test plans

(1) Consideration of test plan and implementation of test

a. All technical requirement items specified in "Technical requirements document (tentative name)" except for the items to be confirmed by qualitative evidence specified in **section 4.4.4.2** above should be confirmed by tests or inspections.

b. At this time, since it is necessary to evaluate that the relevant commercial equipment has no problem with technical requirements compliance with FLVT/FCAT conditions in **section 4.4.5** as its design specifications, reliability and life tests are also conducted. (Environmental load range and allowable input/output range (tolerance)for technical requirements is evaluated under stricter conditions. Also, conducting limit performance/destructive test of equipment.)

c. When flight equipment covers multiple lots and flight lot verification tests may not be specified, or when variations in functional performance characteristics are expected due to differences among individual pieces of equipment, etc., or due to the operating environment, etc., evaluation tests and tests of a sufficient number and frequency to statistically evaluate lot differences, individual piece differences, and variation amounts, etc. should be considered.

(2) Review of "Technical requirements document (tentative name)”

Regarding "Technical requirements document (tentative name)" prepared in step < 2 > of **Table 4.4.1-1**, when it is determined that there is a possibility of noncompliance with the technical requirements due to the progress or results of this evaluation test, and that compliance may be ensured by deleting or relaxing and reviewing the technical requirements (by addressing the spacecraft system side, etc.), compliance may be ensured by reviewing (revising) "Technical requirements document (tentative name)" taking into account the functional performance characteristics of the relevant commercial equipment.

(3) Preparation of "Evaluation test plan (tentative name)”

Based on the results of the test plan study, "Evaluation test plan (tentative name)" (see **section 4.1.4.2**) should be prepared, and tests should be conducted in accordance with the relevant test plan.

When the test plan needs to be changed due to the progress of evaluation tests, the plan should be reviewed as appropriate.

4.4.4.4 Determination of EET results

As a result of the EET, when it is determined that technical requirements compliance may not be ensured even after reviewing the technical requirements in **section 4.4.4.3**, the relevant commercial equipment is noncompliant to space application.

4.4.5 Evaluation Method by Flight Lot Verification Test (FLVT)/ Flight Component Acceptance Test (FCAT)

The Flight Lot Verification Test (FLVT) is a test to verify product compliance evaluation by considering solid-state differences (S/N differences) between equipment.

In the case of commercial equipment, even when evaluation test (**section 4.4.4**) with a group of equipment of the common design (common model) confirms compliance with technical requirements, it is necessary to consider differences in characteristics between manufacturing lots and the possibility of silent changes (unnotified design changes, etc.).

In case that flight lot is manufactured under almost the same conditions as the flight equipment, the risk of functional performance characteristic variations due to these possibilities may be minimized.

Therefore, evaluation tests using flight lots are conducted to understand the tolerance range for dispersions and variations caused by individual differences in equipment (the range in which output and operating range may be maintained within technical requirements against environmental and input variations) and evaluate the effectiveness of the technical requirement conditions (FCAT conditions).

After that, a Flight Component Acceptance Test (FCAT) is conducted for the technical requirements specified in "Technical requirements document (tentative name)" for the equipment to be used in the flight, and when selecting flight equipment, the suitability of the relevant flight equipment for space application is guaranteed.

4.4.5.1 Flight Lot Verification Test (FLVT)

(1) Test conditions for FLVT

The FLVT conditions should be in accordance with **section 4.4.6.1**.

They shall be set within the limits (or less) of the environmental resistance and functional performance of the relevant commercial equipment evaluated in the reliability evaluation tests (overload tests, limit performance tests, destructive tests, etc.) and life tests in **section 4.4.4**, and within the range that encompasses the technical requirements for the space application of the relevant commercial equipment (see **section 4.1.4.1**).

When the limit performance and tolerance of the relevant commercial equipment are sufficiently large with respect to the technical requirement conditions, it is desirable to set test conditions on the risk side of ±50% or ±3 dB (this will contribute to relaxing spacecraft I/F design conditions and FCAT conditions (technology requirements)) regardless of the technical requirements range in **Table 4.4.6-1**.

(2) Number of EUT for FLVT

When evaluation of dispersions due to solid (S/N) differences for flight lot, the number of EUT

for FLVT should be three or more. When evaluation of variations due to time and environment differences, etc. is required, it should be evaluated by measuring three of more times.

However, when it is clear from qualitative evidence or the results of tests in **section 4.4.4**, etc., that the effects of variation due to dispersions of individual differences and time differences, etc. are negligible with respect to the allowable performance and technical requirements of the equipment, it may be possible to reduce the number of EUT.

Note that when the flight equipment (including spare equipment) is spread over several lots, it is necessary to evaluate each lot.

For the number of EUT for FLVT procured, refer to **Table 4.4.1-2**.

(3) Diversion of EUT for FLVT for flight equipment

In principle, flight equipment (including spare equipment) may not be diverted, because the EUT for FLLVT is exposed to an overloaded environment with respect to the technical requirements (FCAT conditions).

However, when the proviso in (2) above may be applied to all the technical requirement conditions, and the relevant EUT is not exposed to an environment that exceeds the FLVT conditions, and the cumulative damage rate as flight equipment may be determined to be sufficiently small, it may be possible to divert it as flight equipment.

(4) Diversion of section 4.4.4 EET results to FLVT results

When some or all of the EUT for EET in **section 4.4.4** are flight lot equipment and any of those flight lot equipment has been confirmed all the technical requirements compliance for the relevant commercial equipment under evaluation test conditions that satisfy (1) above, then the relevant equipment and its evaluation test results may be diverted to as one of the EUT for FLVT (out of the three set).

(5) Determination of FLVT results

a. Evaluation of FLVT results

By passing the FLVT (including the prescribed number of tests and the prescribed number of times), it may be determined that the relevant commercial equipment has the necessary technical and product quality compliance with space application to the relevant spacecraft for the common design (common model) of the FLVT equipment group.

b. Review and re-evaluation of FLVT conditions

When the results of FLVT show noncompliance with the test conditions described in (1) above (e.g., deviation from the expected value of the flight lot evaluation of output variation characteristics that were assumed to be within the limit performance range based on the evaluation in **section 4.4.4** for the applied input variations), and when compliance may be ensured by relaxing/reviewing the FLVT conditions, etc., it is possible to re-evaluate the FLVT by reviewing the FLVT conditions, etc.

However, in this case, it is necessary to make sure to reflect the review of technical requirement conditions (FCAT conditions) (review/relaxation of nominal conditions and tolerance

conditions, etc.) as necessary (**section 4.1.4.3**).

c. Accidental malfunctions during FLVT

When the cause of noncompliance discovered during FLVT is considered to be due to an accidental malfunctions of parts (e.g., noncompliance in one of three sets of EUT), then when compliance may be confirmed with an additional FLVT (e.g., the fourth set), evaluation according to (2) above may be conducted.

When it may be determined that the malfunction that occurred during the FLVT is not directly related to the compliance evaluation of the relevant commercial equipment (e.g., malfunction due to a cause other than the commercial EUT) and when the integrity of the relevant EUT is not impaired, the results of evaluation test are valid.

d. Noncompliance with unknown cause

When the cause of noncompliance is unknown (may not be specified) and the above retests (1) and (2) show noncompliance, the relevant commercial equipment is noncompliance to space application, and even for flight lot equipment whose compliance was confirmed by the FCAT in **section 4.4.5.2**, it may not be used in flight in principle because of the high risk of noncompliance being discovered after being placed onboard spacecraft.

4.4.5.2 Flight Component Acceptance Test (FCAT)

The Flight Component Acceptance Test (FCAT) confirms that the flight equipment (including spare equipment) scheduled to be onboard a spacecraft meet all the technical requirements (excluding life requirements), on the assumption that the flight lot of the relevant commercial equipment conforms to the technical requirements for both product specifications and product quality based on the results of the evaluation tests in **sections 4.4.4** and Test evaluation.

Basically, flight lot equipment that has not been exposed to excessive loads (conditions deviating from FLVT conditions) that affect the functional performance characteristics of the equipment, is determined to have a sufficiently low cumulative damage rate for flight, and is maintained under appropriate control, may be used onboard spacecraft by passing the FCAT.

(1) Test Conditions for FCAT

FCAT conditions for commercial equipment are the environmental and functional performance requirements that the relevant commercial equipment will encounter onboard spacecraft and are the technical requirements in "Technical requirements document (tentative name)" (**section 4.1.4.1**) for the relevant commercial equipment.

Therefore, FCAT conditions do not include reliability margins, etc.

In addition, all technical requirements for FCAT should be able to be evaluated/confirmed by ground tests and inspections.

(2) Equipment under test (EUT) for FCAT

EUT for FCAT is the equipment selected from flight lots that have been completed compliance

evaluation of technical specification and product quality through the evaluations up to **section 4.1** to **section 4.4.5.1**, have not been exposed to an excessive space environment that may affect the functional performance of the equipment, and are properly controlled.

These equipment may be used onboard spacecraft only when their compliance with technical requirements may be verified by FCAT.

Therefore, flight equipment need not necessarily be limited to equipment that was assumed to be flight equipment at the time of procurement.

Refer to **Table 4.4.1-2** for procurement of flight equipment.

(3) Evaluation of EUT provided for FLVT by FCAT

EUT provided for FCAT may be used as EUT for FLVT, but in principle, the EUT may not be onboarded as flight equipment after the FLVT of the relevant equipment (see **section 4.4.5.1 (3)**).

(4) Diversion of "EUT for evaluation" described in **section 4.4.4** to EUT for FCAT

After compliance has been confirmed in the evaluation up to **section 4.4.5.1** (FLVT) for the relevant commercial equipment, equipment that has been subjected to the **section 4.4.4** test, but has not undergone any configuration changes such as overhaul, repair, etc. and is only exposed to environmental or input-output loads within the range encompassed by the FLVT conditions in **section 4.4.5.1** Equipment that has been exposed to the environment and input/output loads may be allowed to be used for flight, provided that its conformance may be verified by FCAT.

(5) Determination of FCAT results

a. Determination of compliance based on FCAT results

When the EUT in paragraph (2) above is confirmed to comply with technical requirements by FCAT, the relevant equipment is determined to be compliant to space applications and may be used onboard spacecraft as flight equipment.

b. Accidental malfunctions in FCAT

When an accidental malfunction occurs in the FCAT of a flight lot due to parts failure, etc. (noncompliance with functions and performance that were confirmed to be compliant in the evaluation up to FLVT), other test specimens from the same flight lot whose compliance has been confirmed by FCAT may be used as flight equipment.

The same applies when the cause of the malfunction is not in the relevant EUT (e.g., equipment failure).

However, when a noncompliance that is assumed to be an accidental failure is found in the FLVT as well (**section 4.4.5.1(5)c**), the relevant flight EUT basically may not be used because there is a possibility that the failure was not an accidental failure. (another lot should be used as the flight EUT and re-evaluated in **section 4.4.5**)

c. Review of technical requirements (FCAT requirement conditions) based on FCAT results

When noncompliance is found in FCAT and review of the technical requirements to ensure compliance is required, compliance with the review policy should be evaluated by FLVT

according to **section 4.4.5.1(5)b)**. The review should be conducted as a review of "Technical requirements document (tentative name)".

d. Noncompliance by FCAT

When noncompliance is found in FCAT and the paragraph (3) above does not ensure compliance, the relevant commercial equipment should be determined as noncompliance to space application.

4.4.6 Considerations in conducting space application compliance evaluation test

Sections 4.4.4 and **4.4.5** for technical requirements compliance evaluation describe evaluation methods by testing. In this guideline, these tests are collectively referred to as the ‘space application compliance evaluation test’.

Basically, the method of conducting each test and the pass/fail criteria should be considered and set by the ordering party, but common considerations for conducting evaluation tests are described below.

(1) Inspection for acceptance (procurement) of commercial equipment

Since space application compliance evaluation test for commercial equipment may be conducted in an environment or under test conditions that are outside the scope of the warranty for the relevant commercial equipment as ground-based equipment, there is a possibility that a guarantee (repair or replacement) by the supplier will not be provided, even when a defect is discovered during evaluation testing.

Therefore, at the time of procurement (delivery acceptance) of EUT and flight equipment to be used for space application compliance evaluation tests, the qualitative evidence of the products and, when necessary, acceptance tests and inspections should be conducted to eliminate defective products.

(2) Implementation of modification, etc. (When necessary)

When modification, etc. of equipment is required for space application of commercial equipment (described in **section 4.1.1.1(3)b and c** in principle, the same modification should be performed on all EUT for evaluation and flight equipment before they are provided for evaluation tests.

When equipment retrofitting becomes necessary due to noncompliance or malfunctions during the evaluation test (when compliance with technical requirements may be ensured by retrofitting), the FLVT according to the modification specifications should be conducted and the technical requirement compliance should be re-evaluated.

(3) Conducting tests to confirm the integrity of commercial equipment

For all EUT and flight equipment for evaluation procured for the purpose of space application compliance evaluation should be subjected to the "Integrity Confirmation Test for Commercial Equipment" to confirm the integrity of the equipment, and to eliminate initial and potential failure factors of the equipment to be used for space applications compliance evaluation, thereby ensuring its effectiveness as EUT for evaluation.

However, depending on the test environment and test conditions, there may be cases in which a malfunction of the relevant commercial equipment may not be considered to a supplier's defect even when such malfunction is discovered during this verification test.
In this test, items that may be confirmed by reliable qualitative evidence (inspection report, test data, etc.) available from the supplier may be omitted.
Equipment that has failed in this test may not be used as EUT for space application compliance evaluation or as flight equipment.
The results of this test may also be made a part of the test results in **section 4.4.4** or **4.4.5**.
In particular, when functional and performance tests by applying power to the equipment as a vacuum thermal cycle test or vacuum exposure test is conducted at the same time (equivalent to a thermal vacuum test) and a favorable result is obtained, the results may be evaluated as part of the thermal vacuum test results in **sections 4.4.4** and **4.4.5**.

The basic integrity verification test flow for commercial equipment is shown below.

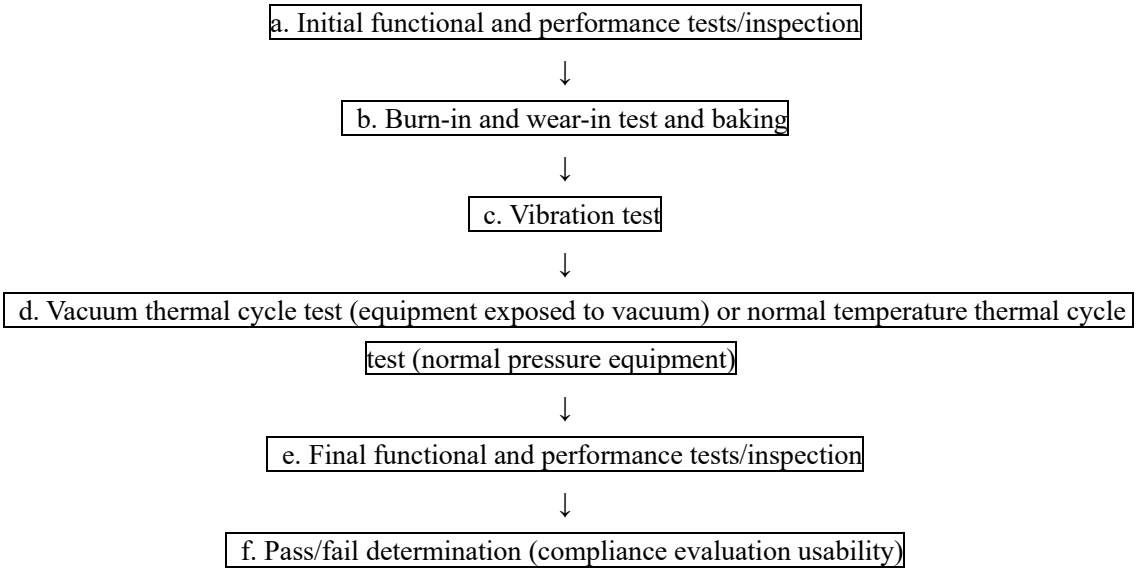

Figure 4.4.6-1: Integrity verification test flow for commercial equipment

a. Initial functional and performance tests/inspection
   Functional and performance tests and inspection in the operating environment specified in the instruction manual, etc. for the relevant commercial equipment.
   Normally, tests are expected to be conducted at normal temperature and pressure.
   When reliable qualitative evidence may be obtained from the supplier, it may be omitted. (Diversion of qualitative evidence at the time of procurement)
b. Burn-in and wear-in test and/or baking

Burn-in and wear-in tests are to eliminate initial failures of the relevant commercial equipment by continuously applying power go (burn-in) or operating (wear-in) the equipment under high temperature environment.

Baking is conducted to remove molecular contamination and volatile substances from the relevant equipment.

The temperature and operating time depend on the required functional characteristics and equipment characteristics. When there are no special considerations, it is desirable to conduct the test for 24 hours or more at the maximum temperature that the relevant equipment normally encounters while onboard spacecraft as a serving of burn-in and wear-in test and baking.

The burn-in and wear-in test may be omitted when it is confirmed that the supplier has already conducted the test prior to delivery.

In the baking, when there are concerns about harmful effects by outgassing, and vacuum discharge (due to degradation of vacuum level caused by outgassing), etc. as a component of the relevant equipment, outgassing evaluation before and after baking should be taken into consideration.

c. Vibration test

The purpose of this test is to detect initial failures and potential defects, but it may also be used to evaluate resistance to vibration environment at the time of launch.

When the purpose is to detect initial failures or potential defects, the test may be omitted when it is confirmed that an equivalent evaluation has already been conducted by the supplier prior to delivery. When the evaluation test is also used to evaluate the resistance to vibration environment test at launch, etc., the results of the evaluation test may be diverted by considering the technical requirement conditions specified in the technical requirements document (**section 4.1.4.1**).

d. Vacuum thermal cycle test or atmospheric pressure thermal cycle test

The purpose of this test is to detect initial failures, but it may also be served as a space application compliance evaluation test.

When the purpose is only to detect initial failures, it is basically unnecessary to apply power to the equipment during the thermal cycle load and may be omitted when it is confirmed that an equivalent evaluation has already been conducted by the supplier prior to equipment delivery.

In case where the test serves as a part of technical requirement compliance evaluation test (e.g., thermal cycle test, etc. under thermal vacuum requirements), functional and performance test by applying power to the equipment should be conducted in consideration of the technical requirements specified in the Technical Requirements (**section 4.1.4.1**).

e. Final functional and performance tests/inspection

Functional and performance tests and physical characteristic inspections of the relevant

equipment, generally at normal temperature and pressure.

The test/inspection items are the same as those for the initial functional and performance tests/inspection.

f. Determination of pass/fail (Usability as EUT for compliance evaluation)

When it may be confirmed that the integrity of the commercial equipment is maintained in the various tests described above in (1) to (5), and when it is determined that there is no significant difference between the results of (1) and (5), the equipment may be used as a EUT (including flight equipment) for space application compliance evaluation.

Equipment for which there are concerns about integrity or significant differences between the results of (1) and (5) may not be used for subsequent compliance evaluation (including flight) and therefore may not be used as EUT or flight equipment.

(4) Considerations for environmental resistance and functional/performance evaluation tests

Basically, the functional and performance evaluation for commercial equipment should be verified under its operating environment (vibration, vacuum, thermal, cosmic radiation, etc.).

However, due to the limitations of evaluation test methods on the ground, when no special consideration is required as an evaluation of the operating characteristics of the relevant commercial equipment, the following concepts generally adopted in the evaluation of spacecraft are used.

When the effects due to a weightless environment or a space complex environment (weightless/microgravity, thermal vacuum, cosmic radiation, etc.) are considered to be significant, the on-orbit evaluation test in **section 4.4.7** should also be taken into account.

a. When environmental load during operation (vibration, radiation, etc.) and operational test may not be conducted simultaneously, functional and performance requirements compliance evaluation should be conducted after the environmental load.

b. For heat-generating equipment that operates in a weightless or microgravity space, evaluation tests should always be conducted under a thermal vacuum environment to eliminate the effects of air convection, regardless of whether the equipment is in a pressurized environment or not.

(5) Purpose of reliability evaluation test

The purpose of the reliability evaluation test in space applications compliance evaluation of commercial equipment is to confirm that the technical requirements for the space application of the relevant commercial equipment have a sufficient margin (safety margin) with respect to the inherent functional and performance tests of the relevant equipment.

The reliability evaluation tests include limit performance tests, overload tests, and worst-case tests for evaluating the limit capabilities of the functional and performance of the relevant equipment, as well as disassembly and inspection for the purpose of evaluating the reliability/quality compliance of the relevant commercial equipment.

Basically, equipment under test submitted to reliability evaluation test may not be used for flights even when it is a flight lot, because there is a possibility that an excessive load has been applied

to the relevant commercial equipment or the configuration has been changed during manufacturing.

(6) Life test

Tests to be conducted when there are operation life requirements, etc. for the relevant commercial equipment for space application.

For electrical equipment, etc., when the equipment has a guaranteed service life (e.g., 2 MDC or more) that is sufficient for space application as ground-based commercial equipment, tests may be omitted by evaluating the effects of differences in the operating environment, etc.

For devices that involve mechanisms or mechanical operations, etc. there are many factors that depend on the product manufacturing quality, such as differences in loading conditions due to the gravity environment and the effects of differences in sliding part properties in air and in a thermal vacuum. Therefore, when using flight lot EUT, it is desirable to conduct a life evaluation that exceeds the required life (MDC) at the number of operations or period, and when using EUT from a lot other than the flight lot, it is desirable to conduct a life evaluation of 1.5 MDC or more.

EUT provided to life test may not be used for flight even when it is a flight lot unless the qualitative evidence, etc. presented by the supplier clearly shows that the life test period (number of operations) is sufficient margin against wear degradation of the equipment.

(7) Test level of space application compliance evaluation test

Space applications compliance test consists of the tests described in **section 4.4.4** "EET using EUT for evaluation", **section 4.4.5.1** "FLVT", and **section 4.4.5.2** "FCAT", and the test conditions are different for each test purpose.

The relationship between each test condition is shown in **Table 4.4.6-1**.

Table 4.4.6-1 Test conditions for space application compliance evaluation test

Test objective	Environmental load conditions	Input condition tolerance	Output range requirements	Remarks
Section 4.1.4.1. Technical requirements document (tentative name)	Predicted environmental range	I/F specified tolerance (expected range of variation)	I/F specified range (Required functional and performance)	Operational conditions onboard the relevant spacecraft
Section 4.4.5.1 FCAT	Same as above	Same as above	Same as above	Same as above
Section 4.4.5.2 FLVT	Predicted environment +1.5 dB or 20% (load, vibration, etc.) or ±5℃ (temperature)	I/F specified tolerance + EMC conditions or ±10% (input voltage, signal level, synchronization error, etc.)	Same as above	Evaluation level that may encompass dispersions and variations between flight lots.
Section 4.4.4 EET using EUT for evaluation	Same as above (or +3dB or 50% when possible) or load-bearing limit environment	Levels and limit levels encompassing the FLVT level	Same as above and characterization of behavior when limit levels are exceeded	Identification of the FLVT envelope and behavior when deviating from the requirements

(8) Space application of commercial equipment through screening tests

In the case of information availability level 3 in **Appendix Table-1** (evaluation of the reliability/quality, etc. of the relevant commercial equipment and its supplier is difficult or noncompliant) or in the case where it is determined in **Appendix Table-3** that the reliability of the qualitative evidence or the evaluation by the space application conformity evaluation test may not be ensured, since it is not possible to guarantee the effects of dispersions in the functional and performance of the relevant equipment, fluctuations in characteristics, or the reproducibility of the results of ground evaluations in the usage environment (ground and space, etc.) after the equipment is installed on spacecraft, the equipment may not generally be used in space.

However, when the equipment meets the following conditions, it may be selected through the screening test of the relevant commercial equipment (only the equipment that has passed the test among multiple EUT is considered as the flight equipment).

a. EEE parts should not be used.
b. FCAT of the functional and performance characteristics under all environmental conditions that the relevant commercial equipment will encounter onboard spacecraft should be possible.
c. The operating mechanism of the relevant commercial equipment should be understood, and various tests, inspections, analyses, etc. of the used parts and materials, etc. should be possible as necessary.
d. There is no risk of external contamination or safety issues.
e. Equipment that has been identified by JAXA in advance as a mechanism/structure equipment capable of screening test evaluation (however, no equipment has been identified at this stage.)

4.4.7 On-orbit evaluation test

On-orbit evaluation test is a method of testing and evaluation in a space environment that may not be realized on the ground, and requires separate consideration of launch, etc. However, it has the following advantages.

(1) Design technical evaluation of the relevant commercial equipment in the space environment is possible.
(2) For jointly developed equipment, etc., it is possible to evaluate the effectiveness of design/manufacturing/inspection processes in the space environment.

The on-orbit evaluation test has a strong meaning as a "demonstration," and although evaluation under a complex environment that may not be realized on the ground is possible, it is only an evaluation for the number of flights (number of pieces).

It is also necessary to fully consider the possibility that the on-orbit test environment and the actual target operational environment may differ.

On-orbit evaluation test plans and evaluation criteria are out of the scope of this guideline.

4.4.8 Diversion of flight-proven commercial equipment (heritage equipment)

In principle, heritage equipment should be conducted space application compliance evaluation in accordance with this guideline for each space application of the relevant commercial equipment, regardless of whether the equipment is "repeat equipment" (see **section 3**, "Terms and definitions") or not.

However, evaluation may be omitted for items for which the evaluation results (EET data, etc.) of the heritage equipment may be used as qualitative evidence without modification.

In this case, when the qualitative evidence is reliable and it has been agreed through coordination with the supplier that the information may be verified, when necessary, the act of verifying the relevant qualitative evidence may be omitted.

When it is difficult to obtain information or when there is noncompliance with the requirement objectives in **section 4.2** (**Table 4.2-1**), the compliance evaluation test in accordance with **Appendix Table-3** may not be omitted in principle.

Table 4.4.8-1 summarizes the relationship between heritage equipment and the relevant commercial equipment regarding whether or not the compliance evaluation may be omitted.

Table 4.4.8-1: Possibility of omitting compliance evaluation in diverting heritage equipment

Heritage equipment Common design (common model)			Common design (common model) of the relevant commercial equipment Reduction (omission) of space application evaluation items			
Relationship with the relevant commercial equipment (flight equipment)		Guideline application	Reliability/Quality etc. evaluation (**Section 4.4.2**)	EET (**Section 4.4.4**)	FLVT (**Section 4.4.5**)	FCAT (**Section 4.4.5**)
Repeat equipment (Note 1)	Flight lot equipment	Yes	Not possible (Note 3)	Possible	Possible	Not possible
		No	Not possible (Note 4)	Possible	Possible	Not possible
	Other lot equipment	Yes	Not possible (Note 3)	Possible	Possible (Note 5)	Not possible
		No	Not possible (Note 4)	Possible	Possible (Note 5)	Not possible
Other than repeat equipment (Note 2)	Flight lot equipment	Yes	Not possible (Note 3)	Not possible (Note 6)	Not possible (Note 6)	Not possible
		No	Not possible (Note 4)	Not possible (Note 6)	Not possible (Note 6)	Not possible
	Other lot equipment	Yes	Not possible (Note 3)	Not possible (Note 6)	Not possible (Note 6)	Not possible
		No	Not possible (Note 4)	Not possible (Note 6)	Not possible (Note 6)	Not possible

Note 1) Heritage equipment and the relevant commercial equipment have the same technical requirements.

Note 2) Heritage equipment and the relevant commercial equipment have different technical requirements.

Note 3) May be omitted when it may be judged that there is no change in compliance with reliability/quality, etc. requirements, etc. from the heritage equipment.

Note 4) Omission is not allowed when this guideline is applied for the first time. After that, it is the same as (Note 3).

Note 5) May be omitted when the results of lot-to-lot/individual dispersion evaluation based on past performance data of heritage equipment are reflected in the Acceptance Test conditions.

Note 6) When a compliance evaluation for requirements that are not included in or deviate from the technical requirements for heritage equipment is required.

4.5 Determination of space application compliance, and potential risks

4.5.1 Determination of space application compliance for commercial equipment

When the results of the space application compliance evaluation in accordance with **section 4.4** show that all the requirements are satisfied, the relevant flight equipment should be judged (determined) "compliance for space applications" limited to onboard the relevant spacecraft.

4.5.2 Handling of equipment judged "compliant to space applications

Flight equipment that has been judged "compliance for space applications" as a result of space application compliance evaluation in accordance with this guideline may, in principle, be used limited to onboard the relevant spacecraft.

In the case of repeat use of the relevant commercial equipment onboard series satellites, etc. or diversion of the equipment to other spacecraft, re-evaluation in accordance with **section 4.4.8** should be conducted for each use of onboard spacecraft.

The handling of equipment that has been determined to be "compliance for space applications" is the same as that of space equipment, unless the relevant equipment is disassembled, repaired, etc. and its configuration is changed.

When a malfunction or damage is caused by any reason other than noncompliance of the relevant commercial equipment during assembly into a spacecraft system or system/subsystem test after assembly, etc., the compliance may be maintained by replacing the equipment with spare equipment.

4.5.3 Potential risks of space application of commercial equipment

Equipment that has been determined to be compliance with space application by the evaluation of reliability/quality etc. compliance of the relevant commercial equipment and its supplier as well as the technical requirements compliance evaluation necessary for integration of the relevant commercial equipment into the relevant spacecraft may be installed and used on the relevant spacecraft.

However, since the commercial equipment covered by this guideline is generally designed, developed, and manufactured for ground use, it should be considered that the potential risks

associated with the use of the relevant equipment as space equipment may not be eliminated completely.

Risks defined in compliance evaluation according to this guideline are identified as follows

(1) Risk of noncompliance of space application for the relevant commercial equipment

The possibility that equipment selected as a candidate for space applications in the preliminary study may be found to be non-compliant to space applications during the process (results) of space application compliance evaluation in accordance with this guideline.

The burden of recovery may be minimized by bringing problems to light in the early stages of compliance evaluation.

(2) Risks due to noncompliance with reliability/quality requirements, etc. (**Appendix Table-3**)

The possibility that noncompliance may be discovered during the process of compliance evaluation or during the process of mounting on spacecraft, launch, and operation, which arise in response to noncompliance items for each of the 17 requirements related to the compliance evaluation of reliability/quality, etc., classified in this guideline.

It is possible to reduce risks by thoroughly coordinating with suppliers and gathering information to minimize noncompliance in terms of reliability/quality, etc.

(3) Potential risks in space application of commercial equipment for ground use

The possibility of unexpected malfunctions occurring in the subsequent onboard spacecraft and in various ground tests, launches, and operations after commercial equipment has been determined "compliance with space applications" in accordance with this guideline.

In particular, timers, limiters, synchronous circuits (out of synchronization), etc., of equipment, etc., that have control circuits may be in an unexpected state due to long-term operation or multiple operations that may not be detected during compliance evaluation tests.

Therefore, it is necessary to minimize the risk through life and reliability tests, as well as through adequate coordination with the supplier and information gathering.

Appendix Table-1: Methods of compliance evaluation to reliability/quality etc. requirements according to the level of availability of information on reliability/quality etc.

Level of information availability	Information availability	Availability of correction/improvement of reliability/quality control methods	Example	Example of space applications	Methods of reliability/quality requirements compliance evaluation
Level 0	Necessary information is available	Corrective/improvement actions are possible	It is possible to view various design/manufacturing control documents, be present during manufacturing/inspection processes, and, when necessary, add or change inspection methods according to the ordering party's request. It is also possible to make modifications etc. to the relevant commercial equipment at the supplier's production line, when necessary.	◆Space application of commercial equipment that has been manufactured and sold by a company with an understanding of space development ◆Space application of commercial equipment through joint development, etc. between the supplier of the commercial equipment and JAXA	◆Evaluation implementation by using various information provided by the supplier or by witnessing manufacturing, testing, and inspection processes at the supplier. ◆Implementation of improvement/corrective actions by improvement requirements for noncompliance with reliability/quality, etc. When noncompliance remains after improvement, follow **Appendix Table-3** according to the contents. ◆Technical requirements compliance evaluation according to **Appendix Table-3** after implementing modification to ensure technical requirements compliance with commercial equipment as necessary.
Level 1	Necessary information is available	Improvement/modification are not possible	It is possible to view various design/manufacturing control documents and be present during the manufacturing/inspection process, but it is generally not possible to add or change inspection processes in response to requests from the ordering party, or to modify	◆Space application of commercial equipment, for which design/manufacturing/test/inspection processes have been established as COTS items or made-to-order products, and for which many manufacturing, sales, and operation records have been established.	◆Evaluation implementation by using various information provided by suppliers or by witnessing manufacturing, test, and inspection processes at suppliers. ◆ Noncompliance based on the results of evaluation should be in accordance with **Appendix Table-3** according to the contents.

			the commercial equipment on the supplier's production line.		
Level 2	Part of necessary information is not available	Improvement/modification are not possible	Some information, such as confidential information in the design/manufacturing process, may not be obtained. In addition, additions or changes to the inspection process in response to requests from the ordering party, or modifications to the commercial equipment at the supplier's production line, etc. may not be made.	◆Space application of commercial equipment, for which design/manufacturing/test/inspection processes have been established as COTS items or made-to-order products, and for which many manufacturing, sales, and operation records have been established.	◆Conducting compliance evaluation based on available information. ◆Follow **Appendix Table-3** for items for which information is not available and for which compliance evaluation is difficult or noncompliance evaluation is not possible.
Level 3	Necessary information is not available.	Improvement/modification are not possible	It is not possible to obtain any information other than the qualitative evidence attached to the product and publicly available product information (catalogs, data books, etc.). In addition, the supplier is not allowed to make design changes or modifications to the product. (Items purchased from a catalog with an unknown supplier)	Basically, space application is difficult, but it may be possible in the following cases. ◆Space application for equipment whose structure, materials, and operating mechanism of equipment are simple, does not use EEE parts or electronic control parts, and of which functional and performance characteristics may be guaranteed only by screening of flight equipment.	◆Basically, as "equipment not subject to evaluation test" which basically does not have compliance with reliability/quality etc. requirements are defined separately and follow to **section 4.4.6 (8)** "Screening test".

Appendix Table-2 Classification with the purpose of compliance with reliability/quality etc. requirements (1/2)

Requirement objective No.	Classification by purpose of compliance with reliability/quality etc. requirements	Evaluation items by the reliability/quality etc. compliance requirements document		
		Reliability/quality etc. control documents (JMR-004,005,006) Corresponding section number		
		JMR-004 (Reliability Program Standard)	JMR-005 (Quality Assurance Program Standard)	JMR-006 (Configuration Management Standard)
1	Review/audit by JAXA (ordering party)	4.1.2, 4.2.3, 4.3.15.2	4.2.1, 4.2.2, 4.3.2.3, 4.3.2.4, 4.3.3.2, 4.3.5, 4.9.5.3, 4.9.7, 4.9.10, 4.9.11	4.1.3, 4.2.2.3, 4.3.3.2, 4.3.2.3
2	Review/audit by independent reliability/quality assurance system at the supplier	4.1.3, 4.2.1, 4.2.2.2, 4.2.2.3, 4.3.3(2), 4.3.14, 4.4.4, 4.5	4.1, 4.3.1, 4.3.2.4, 4.3.6, 4.4.1.3, 4.4.3.1, 4.4.3.2, 4.4.3.3, 4.8.9.1, 4.8.9.2, 4.8.9.3, 4.8.9.4, 4.9.8, 4.9.9	4.2, 4.2.1, 4.2.2.2, 4.3.2, 4.4
3	Design, fabrication based on planning documents and technical requirement documents, preparation and maintenance of the records	4.1.3, 4.2.2, 4.2.2.2, 4.2.2.3, 4.3.3(1), 4.3.4(1), 4.3.4(2), 4.3.4(3)	4.3.2.1, 4.3.2.2, 4.3.2.4, 4.3.3.1, 4.4.1.1, 4.4.1.2	4.2.2.1, 4.2.2.2, 4.2.2.3
4	Configuration management/identification of equipment and implementation of product identification inspections	4.3.3, 4.3.14.3, 4.4.3.2	4.4.2.1, 4.4.2.2, 4.5, 4.5.2, 4.5.3, 4.5.4, 4.5.5, 4.5.6	4.1.1, 4.1.2, 4.3.1, 4.3.1.1, 4.3.1.1, 4.3.1.3, 4.3.3, 4.3.2, 4.3.2, 4.3.2.1, 4.3.2.2, 4.3.2.3, 4.3.2.4, 4.3.3
5	Training and maintaining skills of personnel	4.2.5	4.3.7, 4.6.9	
6	Management of suppliers of procured parts, materials, etc. and implementation of acceptance tests/inspections	4.2.6.1, 4.2.6.2, 4.2.6.3, 4.2.7, 4.2.8	4.6, 4.6.1, 4.6.3.1, 4.6.3.2, 4.6.4, 4.6.5, 4.6.6, 4.6.6.1, 4.6.6.2, 4.6.6.3, 4.6.7, 4.6.8, 4.6.9, 4.6.10, 4.6.11, 4.6.12, 4.8.8.2	
7	Recording results of various works and test/inspection data and maintenance	4.1.3	4.3.7, 4.4.1.3, 4.5.6, 4.6.3.2, 4.7.1, 4.7.5.6, 4.8.5.1, 4.8.8.1, 4.8.9.3, 4.10, 4.11.6.6, 4.11.10	4.1.1, 4.1.2, 4.3.3
8	Corrective actions and continuous improvement for malfunctions and complaints	4.3.13, 4.3.14, 4.3.15	4.9.3, 4.9.4, 4.9.4.1, 4.9.5, 4.9.5.1, 4.9.5.2, 4.9.6, 4.9.6.1, 4.9.6.2, 4.9.6.3, 4.9.10, 4.9.11, 4.9.12, 4.9.13	

Appendix Table-2 Classification with the purpose of compliance with reliability/quality etc. requirements (2/2)

9	Equipment reliability and service life evaluation through the use of reliability engineering	4.3.2,,4.3.2(1), 4.3.2(2), 4.3.2(3), 4.3.2(4), 4.3.2(5), 4.3.5.1, 4.3.5.2, 4.3.5.3, 4.3.6, 4.3.7, 4.3.8, 4.3.9, 4.3.10.1, 4.3.10.2, 4.3.10.3, 4.3. 10.4, 4.3.10.5, 4.4.3.4, 4.4.3.5		
10	Reliability assurance of software	4.3.11		
11	Quality control through statistical methods and collection and analysis of part and material quality information		4.15, 4.15.1, 4.15.2	
12	Manufacturing process control	4.3.17.10, 4.3.17.12	4.3.4, 4.7, 4.7.1, 4.7.1.1, 4.7.6, 4.7.7, 4.7.8, 4.7.9	
13	Marking and handling control of goods		4.7.3, 4.7.3.1, 4.7.3.2, 4.7.3.3, 4.7.4, 4.12, 4.13, 4.14, 4.14.1, 4.14.2, 4.14.3, 4.14.4, 4.14.5, 4.14.6, 4.14.7, 4.14.8, 4.14.8.1, 4.14.8.2, 4.16, 4.16.1, 4.16.2	
14	Ensuring reliability/quality in testing/inspection	4.4, 4.4.1, 4.4.2, 4.4.3, 4.4.3.1, 4.4.3.2, 4.4.3.3, 4.4.3.4, 4.4.3.5, 4.4.3.6	4.8, 4.8.1, 4.8.2, 4.8.3, 4.8.4, 4.8.5, 4.8.5.1, 4.8.5.2, 4.8.5.3、4.8.6, 4.8.6.1, 4.8.6.2, 4.8.6.3, 4.8.7, 4.8.7.1, 4.8.7.2, 4.8.7.3, 4.8.8, 4.8.8.1, 4.11.10	
15	Program management of parts, devices, materials and processes	4.3.17, 4.3.17.1, 4.3.17.2, 4.3.17.3, 4.3.17.4, 4.3.17.5, 4.3.17.6, 4.3.17.7, 4.3.17.8, 4.3.17.9, 4.3.17.10, 4.3.17.11, 4.3.17.12		
16	Identification and control of special processes and critical Items	4.3.16, 4.3.16.2.1, 4.3.16.2.2, 4.3.16.3, 4.3.16.4, 4.3.16.5, 4.3.16.6	4.7.2, 4.7.5, 4.7.5.1, 4.7.5.2, 4.7.5.3, 4.7.5.4, 4.7.5.5, 4.7.5.6, 4.7.5.7	
17	Ensuring maintainability and post-delivery response	4.3.12	4.14	4.3.2.4

Appendix Table-3: Establishment of a policy for technical requirements compliance evaluation considering the status of noncompliance to reliability/quality etc. requirements, etc. (1/10)

Note: In case of noncompliance with multiple required objectives, the common items for each item should be adopted.

EET: Section 4.4.4 "Engineering Evaluation Test", FLVT: **Section 4.4.5.1** "Flight Lot Verification Test", FCAT: **Section 4.4.5.2** "Flight Equipment Acceptance Test".

Requirement objective No.	Required objective	✕Noncompliance with the required objective (Reference) Examples of compliance with other requirements	Combination of compliance evaluation ◎: Valid (No problem) ○: Valid (caution required) ✕: Invalid	Applicable/expected cases	Risks arising from noncompliance to required objectives and measures
0	All requirements (Baseline)	(No noncompliance) All 17 required objectives are met, and when necessary, improvements, etc. may be requested from the supplier.	◎ **Section 4.4.3** "Qualitative evidence" ◎ **Section 4.4.4** "EET" ◎ **Section 4.4.5.1** "FLVT" ◎ **Section 4.4.5.2** "FCAT"	Commercial products developed/manufactured by the suppliers who implement the same reliability/quality, etc. control as those used in the development of space equipment, etc. And modification or improvement may be done through joint research and development with JAXA (the supplier), etc., as necessary.	**<Risk>** None. **<Measures>** Not required
1	Review/audit by JAXA (ordering party)	✕ JAXA (ordering party) is not allowed to conduct review or audit during the design/manufacturing/inspection process of product inspections, or to give instructions for process changes, etc. (Reference) At the time of product procurement (or prior to that), it is possible to verify the results of reliability/quality, etc. control of the product (after production) and various types of qualitative evidence.	◎ **Section 4.4.3** "Qualitative Evidence" ◎ **Section 4.4.4** "EET" ◎ **Section 4.4.5.1** "FLVT" ◎ **Section 4.4.5.2** "FCAT"	◆Procurement of products that manufacturing has already been completed. ◆Products for which manufacturing begin after an order is placed, but for which the ordering party may not intervene in the design, manufacturing, or inspection processes, or carry out process reviews or audits.	**<Risk>** When human induced design errors or inappropriate actions are involved, product quality (design compliance, lot quality, etc.) will lose its reliability and re-evaluation will be required. **<Measures>** Conduct a thorough review of quality evidence, including the results of reliability/quality etc. control before procurement of the relevant commercial equipment, including EUT for evaluation.

Appendix Table-3: Establishment of a policy for technical requirements compliance evaluation considering the status of noncompliance to reliability/quality etc. requirements, etc. (2/10)

2	Review/audit by independent reliability/quality assurance system at the supplier	✕ Confirmation or inspection by an organization/responsibility independent from designers or manufacturing personnel is not conducted. (Reference) Since designers and product manufacturing personnel confirm and judge test evaluation/inspection results by themselves based on their own standards, there is a possibility that human induced design errors or errors in judgment caused by inappropriate actions, etc. or error in evaluation result of test/inspection may flow to the next process or even to products after delivery.	✕ **Section 4.4.3** "Qualitative Evidence" **Section 4.4.4** "EET" **Section 4.4.5.1** "FLVT" **Section 4.4.5.2** "FCAT"	◆Qualitative evidence is basically unreliable. ◆Quality control and lot control of the product may also be unreliable, and the uniformity of the results of each test evaluation test should always be questioned before proceeding with the evaluation.	**<Risk>** There is a possibility that functional and performance, which were assumed to be compliant based on qualitative evidence, may fail in design evaluation tests, or that appropriate flight equipment may not be selected due to extreme dispersions in the products. **<Measures>** Understand fully the functional and performance characteristics of the equipment using sufficient EUT, and select the flight equipment that is most stable and has sufficient functional and performance margins from multiple FCLT EUT.
3	Design, fabrication based on planning documents and technical requirement documents, preparation and maintenance of the records	✕ Planning documents for design and manufacturing specifications and manufacturing processes are not prepared, and therefore, there is no record of whether manufactured product is in accordance with the planned specifications after manufacturing. Therefore, qualitative evidence may not be obtained. (Reference) In the case where sloppy control is not used, it is assumed that the product is like a one-of-a-kind product made by craftsmanship, and the quality is judged based on the workmanship of each product by expert technicians.	✕ **Section 4.4.3** "Qualitative evidence" ✕ **Section 4.4.4** "EET" ✕ **4.4.5.1** "FLVT" ✕ **Section 4.4.5.2** "FCAT"	◆Product is assumed to be a one-of-a-kind, artisanal product. There is no qualitative evidence. ◆ Or product manufactured by sloppy design/manufacturing controls.	**<Risks>** Evaluation according to this guideline procedure (**Table 4.4.1-1**) is not possible. **<Measures>** Screening evaluation that is limited to products that meet the conditions of **section 4.4.6 (8)** "Screening test". However, currently applicable equipment is TBD.

Appendix Table-3: Establishment of a policy for technical requirements compliance evaluation considering the status of noncompliance to reliability/quality etc. requirements, etc. (3/10)

4	Configuration management/ identification of equipment and implementation of product identification inspections	✕ Management and recording of changed parts and configuration changes due to design changes, malfunctions, and claim actions are not implemented. ✕ P/N identification of equipment before and after modification and identification (by tags, etc.) of good and defective products are not performed, and only identification by operator's memory, etc. is performed. ✕ Identification management of P/N, L/N, and S/N is not performed. (Reference) Tests and inspections for compliance to design requirements of individual products are appropriately conducted. In addition, claims handling (repair, etc.) for delivered products is performed.	✕ **Section 4.4.3** "Qualitative evidence" ✕ **Section 4.4.4** "EET" ✕ **Section 4.4.5.1** "FLVT" ✕ **Section 4.4.5.2** "FCAT"	◆A product for which there is no qualitative evidence (e.g., inspection report) or for which there is no one-to-one correspondence between the qualitative evidence and the product in question. For example, products that are extracted from products without solid identification on the shelf for passed products and packaged for shipment. ◆Products without individual identification such as P/N, L/N, S/N, etc. to trace the design/manufacturing history of the product.	**<Risk>** In addition to the risk of delivery of defective products, there is a high possibility that noncompliance will be discovered during evaluation tests. Even when compliance is confirmed during evaluation tests, there is a high possibility of unexpected malfunctions or noncompliance occurring after the product is mounted on a spacecraft. **<Measures>** Screening evaluation that is limited to products that meet the conditions of **section 4.4.6 (8)** "Screening test". However, currently applicable equipment is TBD.

Appendix Table-3: Establishment of a policy for technical requirements compliance evaluation considering the status of noncompliance to reliability/quality etc. requirements, etc. (4/10)

5	Education and training of design, manufacturing, test, and inspection personnel, and maintenance and improvement of their skills	✕ Not only for education and training on work procedures and skills based on written regulations necessary to ensure/maintain product quality, designation and verification of operators for designing/manufacturing/testing/inspection, etc. are not conducted. (Reference) There is a quality control organization and structure, and documents related to various designing/manufacturing/inspection and configuration control are in place, and operators are to perform designing/manufacturing/inspection in accordance with those documents/administrative rules (however, operators with lower skill levels are also to perform such work).	✕ **Section 4.4.3** "Qualitative evidence" 〇**Section 4.4.4** "EET" 〇**Section 4.4.5.1** "FLVT" 〇**Section 4.4.5.2** "FCAT	◆Simple assembly of products that do not require any skill or knowledge of the design/manufacturing worker. ◆Even products shipped as qualified, there is a possibility that there is a mixture of products with large dispersions in product functional/performance characteristics or physical characteristics, or products that will be found to be unqualified upon acceptance (re-inspection) inspection (by the ordering party).	**<Risk>** There is a high possibility that noncompliance will be discovered during evaluation tests. Even when compliance is confirmed during evaluation tests, there is a high possibility of unexpected malfunctions or noncompliance occurring after the product is loaded onto a spacecraft. <**Measures>** Sufficiently understand the functional and performance characteristics of the equipment using sufficient EUT and select the flight equipment that is most stable and has sufficient functional and performance margins from multiple FCLT EUT.
6	Control of suppliers of procured parts and materials, and implementation of acceptance tests/inspections	✕ Parts and materials constituting product inspections are used based on catalogs and inspection reports attached to parts, etc., but no stand-alone or sampling tests/inspections or evaluation tests or audits of parts suppliers are conducted. (Reference) Confirmation/evaluation test is conducted by functional test/inspection at the equipment assembly (including sub-assembly) stage.	〇**Section 4.4.3** "Qualitative evidence" ◎ **Section 4.4.4** "EET" 〇**Section 4.4.5.1** "FLVT" 〇**Section 4.4.5.2** "FCAT"	◆Large variation in equipment, etc. due to poor quality of parts or variation in characteristics, etc. ◆High risk of malfunctions due to defective standards of used parts, etc.	**<Risk>** ◆High possibility of noncompliance detection in the initial operation phase of compliance evaluation. ◆Even when noncompliance is not found in design evaluation or FLVT, there is a high possibility that noncompliance will occur in flight equipment (due to accidental failure of used parts, etc.). <**Measures>** ◆Confirm that the products are good at the inspection at the time of receipt of procurement from the supplier. ◆ Confirm the soundness of the relevant commercial equipment by the "Commercial equipment soundness confirmation test" described in **section 4.4.6(3).**

Appendix Table-3: Establishment of a policy for technical requirements compliance evaluation considering the status of noncompliance to reliability/quality etc. requirements, etc. (5/10)

7	Recording results of various works and test/inspection data and maintenance	✕ Records of manufacturing process work, records of tests/inspections during the manufacturing process, and test/inspection data on which a pass/fail judgment was made are not kept. (Reference) Assembly/test/inspection based on assembly/test/inspection procedures, etc. are conducted, and pass/fail decisions and identification of good products are made.	✕ **Section 4.4.3** "Qualitative evidence" ◎ **Section 4.4.4** "EET" ◎ **Section 4.4.5.1** "FLVT" ◎ **Section 4.4.5.2** "FCAT"	◆There is a possibility that the delivered products may be mixed up with defective products. ◆There is no qualitative evidence to prove that the relevant products are good products, such as inspection certificates, or the qualitative evidence is unreliable.	**<Risk>** ◆Qualitative evidence of the product is not available or not reliable (e.g., the basis of pass/fail determination). ◆When a noncompliance or malfunction is found during compliance evaluation or onboard spacecraft, the cause may not be traced back. **<Measures>** ◆Conduct sufficient evaluation (especially reliability evaluation test such as marginal performance test, etc.) based on the malfunction mode to understand the characteristics of the relevant equipment in the soundness evaluation and design evaluation tests of the commercial equipment. ◆Prepare a sufficient number of spare equipment for replacement in case of malfunction of flight equipment.
8	Corrective actions and continuous improvement for malfunctions and complaints	○Products with appropriate design/manufacturing/inspection and quality control are shipped. ✕ The policy and corrective actions to deal with product malfunctions and complaints from users of the product are not horizontally expanded or passed on to the next generation. (Design changes and quality control improvements to correct malfunctions are not made.) (Reference) Products are being shipped with appropriate design/manufacturing/inspection. Records of them are also kept.	◎ **Section 4.4.3** "Qualitative Evidence" ◎ **Section 4.4.4** "EET" ◎ **Section 4.4.5.1** "FLVT" ◎ **Section 4.4.5.2** "FCAT"	◆The yield rate of products is low because products are shipped without any improvement even when malfunctions or problems are found. ◆Even for products shipped as passed products, similar failures or malfunctions (from previous defects or complaints) recur/occur frequently during use.	**<Risk>** Regardless of the phase of evaluation test or equipment under test, there is a high possibility of non-compliance or malfunction during test. **<Measures>** Confirmation that the relevant commercial equipment in question is good and identification of malfunction trends should be ensured during the acceptance inspection as commercial equipment (**section 4.4.6(1)**) and the "commercial equipment soundness confirmation test" (**section 4.4.6(3**)).

Appendix Table-3: Establishment of a policy for technical requirements compliance evaluation considering the status of noncompliance to reliability/quality etc. requirements, etc. (6/10)

9	Equipment reliability and service life evaluation through the use of reliability engineering	✕ Evaluation and tests on product durability, robustness, life span, etc. are not conducted. ✕ Burn-in test, etc. to eliminate initial operation phase failures are not conducted at the product shipment stage. (Reference) Functional performance testing/inspection is carried out reliably within product specifications.	○**Section 4.4.3** "Qualitative evidence" ◎ **Section 4.4.4**, "EET" ◎ **Section 4.4.5.1** "FLVT" ◎ **Section 4.4.5.2** "FCAT"	◆There is no qualitative evidence of reliability or life. ◆Tolerance margin to the functional and performance specifications of the relevant commercial product may not be ensured.	**<Risk>** Noncompliance may be found during on-orbit operation (due to life span, degradation over time, changes in onboard environmental conditions, etc.). **<Measures>** Conduct sufficient reliability and life evaluation through design compliance evaluation tests.
10	Reliability assurance of software	✕ Identification of software incorporated in equipment design, design manager, configuration/version management, log management of repairs and modifications, etc., debugging, and other tools are not managed. ✕ No evaluation of software control reliability (time/input/output synchronization, asynchronous responsiveness, runaway, etc.) is performed. (Reference) Reliability/quality, etc. control concerning design/manufacturing/inspection, etc. of H/W is appropriately conducted. In addition, evaluation tests on software functional and performance and control are appropriately conducted.	○**Section 4.4.3** "Qualitative evidence" ◎ **Section 4.4.4** "EET" ◎ **Section 4.4.5.1** "FLVT" ◎ **Section 4.4.5.2** "FCAT"	◆Behaviors other than those specified in the product specifications for commercial equipment may not have been considered or verified in the design. ◆There is a possibility that a different version of S/W from that originally used for the relevant commercial equipment is (mistakenly) used in the product. ◆Different versions of SW may be used for each the relevant commercial equipment, each procurement period, or each lot. ◆There is a possibility that SWs unsuitable for long-term operation or SWs that may cause uncontrollable behavior or runaway may be used.	**<Risk>** ◆Even with the common design (common model) and even between flight lots, there is a possibility that different behaviors may be exhibited during evaluation tests due to differences in the onboard SW versions. ◆ Even when there are no problems during evaluation tests, there is a possibility that unexpected behavior (runaway, etc.) may occur after installation on the spacecraft or in the event of an abnormality during on-orbit operation. <**Measures>** ◆Coordinate sufficiently with suppliers and gather information regarding SW configuration management. ◆ In design evaluation testing, perform sufficient testing and evaluation combining repeated operation tests, worst-case tests, low-voltage tests, and other various conditions.

Appendix Table-3: Establishment of a policy for technical requirements compliance evaluation considering the status of noncompliance to reliability/quality etc. requirements, etc. (7/10)

11	Quality control through statistical methods and collection and analysis of part and material quality information	✕ Appropriate and efficient quality control of parts and materials by statistical methods is not implemented. ✕ Appropriate inspection/selection methods (total inspection, spot checks, etc.) for parts and materials based on statistical process control and information collection, etc. are not implemented. (Reference) Procurement control and acceptance inspection, etc. of component parts are appropriately conducted.	◎ **Section 4.4.3** "Qualitative evidence" ◎ **Section 4.4.4** "EET" ◎ **Section 4.4.5.1** "FLVT" ◎ **Section 4.4.5.2** "FCAT"	◆The yield rate of products is low, and there is a possibility that the delivery date may be delayed due to malfunctions, etc. in the production of the relevant commercial equipment. ◆Even for commercial equipment that are delivered as non-defective products, there is a high risk of malfunctions occurring due to incompatibility between the components and the product, accidental failures, etc.	**<Risk>** ◆Commercial parts and the relevant commercial equipment are not always the best match, which may become the cause of noncompliance discovered during evaluation tests. ◆Even when there is no problem in the acceptance inspection of the relevant commercial parts, there is a possibility to be noncompliance due to accidental failure of the component parts or unidentified cause in the process of subsequent evaluation tests. **<Measures>** ◆Evaluation of parts by obtaining information on parts from suppliers (using JAXA database, etc.) ◆Conduct sufficient reliability evaluation in evaluation tests.
12	Manufacturing process control	✕ Workmanship pass criteria control is not implemented. ✕ Environment of manufacturing inspection facility (temperature, humidity, contamination, static electricity, etc.) is not controlled. ✕ Identification control of temporarily assembled products, etc. is not implemented. ✕ Certification of the manufacturing process or maintenance of manufacturing instructions are not implemented. (Reference) Products based on various manufacturing and inspection instruction documents, etc. are manufactured and inspected, and only products that pass the inspection are shipped.	○**Section 4.4.3** "Qualitative evidence"◎ **Section 4.4.4**, "EET" ◎ **Section 4.4.5.1** "FLVT" ◎ **Section 4.4.5.2** "FCAT"	◆Product yield (in case of post-order production) is low, and there is possibility to delay product delivery. ◆There is a possibility of external contamination being mixed into the product and there may be a large variation in product quality. ◆There is a possibility that potential defects outside the test/inspection items (trends, behavior when standards are deviated, etc.) may occur.	**<Risk>** ◆High possibility of noncompliance being detected in EET due to variation of product quality. ◆Even when compliance is confirmed at EET, there is a high possibility of noncompliance being discovered at subsequent FLVT or FCAT. **<Measures>** Sufficiently identify potential noncompliance in EET and FCVT.

Appendix Table-3: Establishment of a policy for technical requirements compliance evaluation considering the status of noncompliance to reliability/quality etc. requirements, etc. (8/10)

13	Marking and handling control of goods	✕ Appropriate labeling and control to prevent the mix-up of products and parts are not implemented. ✕ Appropriate controls for product handling and working/storage environment are not implemented. ✕ Identification of parts and products requiring prevention of degradation, useful life control items, special process control, etc. are not properly implemented. (Reference) Product tests/inspections are properly conducted.	✕ **Section 4.4.3** "Qualitative evidence" ◎**Section 4.4.4** "EET" ○**Section 4.4.5.1** "FLVT" ◎ **Section 4.4.5.2** "FCAT"	◆There is a possibility that the components of the relevant commercial equipment are incorrect (products containing parts from different lots) or that the delivered products are incorrect.	**<Risk>** ◆There is a high possibility of noncompliance detection due to incorrectly mixed parts, etc. ◆It is not easy to investigate the cause of malfunctions and take measures. <**Measures>** ◆Sufficient evaluation in soundness confirmation test for commercial equipment and in FLVT. ◆Conduct the effectiveness evaluation of lots by comparing the characteristics/trends of FLVT test results and FCAT results
14	Ensuring reliability/ quality in testing/inspection	✕ Test/inspection location and environment (temperature, humidity, cleanliness, etc.) are not controlled. ✕ Test facilities and measuring equipment are not inspected or calibrated according to official standards. ✕ There are no regulations or controls in place regarding the appropriate precision/tolerances that correspond to the functional and performance requirements of the equipment in the test/inspection. (Reference) Tests and inspections according to the planning documents and their records are properly conducted.	✕ **Section 4.4.3** "Qualitative evidence" ◎**Section 4.4.4** "EET" ◎**Section 4.4.5.1** "FLVT" ◎**Section 4.4.5.2** "FCAT"	◆Since the equipment and measuring instruments used for tests and inspections at the supplier are not properly verified, calibrated, etc. the results described in qualitative evidence such as test and inspection records are not reliable. ◆Even when the judgment at the supplier is acceptable, there is a possibility that the functional and performance of the product does not meet the requirements.	**<Risk>** ◆There is a high possibility that a product received as a good product will fail in an evaluation test. There is also a possibility that the expected functional and performance will not be achieved at all. **<Measures>** ◆Evaluation tests should not be entrusted to suppliers, but should be conducted in test/inspection environment and facilities with appropriate reliability/quality control under the responsibility of the ordering party. ◆Conduct sufficient soundness evaluation in the soundness verification test of commercial equipment. ◆Thoroughly understands the functional and performance characteristics of the relevant commercial equipment in design compliance test.

Appendix Table-3: Establishment of a policy for technical requirements compliance evaluation considering the status of noncompliance to reliability/quality etc. requirements, etc. (9/10)

15	Program management of parts, devices, materials and processes	✕ Regarding parts, devices, materials and processes constituting equipment, etc., the use of specialized organizations, selection of parts/materials, preparation of specifications, qualification, maintenance of use lists, examination, handling, failure analysis, etc. are not implemented under the program management. (Reference) Design/manufacturing/inspection and record keeping based on the planning documents are properly conducted.	◎ **Section 4.4.3** "Qualitative evidence" ◎ **Section 4.4.4** "EET" ◎ **Section 4.4.5.1** "FLVT" ◎ **Section 4.4.5.2** "FCAT"	Although the product conforms to the delivery conditions (passed the supplier's pre-delivery inspections), there is a possibility that materials, parts, or devices that are not originally intended for use or have inferior characteristics or performance are mixed in the product. There is a possibility that the delivery date will be delayed due to poor product yield.	**<Risk>** ◆There is a high possibility that noncompliance/ malfunction may be found out in the process of evaluation test. ◆Even when noncompliance is not found in the compliance evaluation, there is a possibility that malfunctions may be induced during on-orbit operation due to degradation of materials over time, etc. <**Measures>** ◆Sufficiently remove bugs in the soundness confirmation tests of commercial equipment. ◆Conduct compliance evaluation by reliability and life tests, etc. ◆Conduct lot effectiveness evaluation in FLVT/ AT.
16	Identification and control of special processes and critical Items	✕ (Where defects may not be detected by ground tests or inspections) Identification and control of special processes are not conducted. ✕ Identification and control (operation history management) regarding aging degradation and operation life of parts and materials are not performed. ✕ Reliability critical items are not identified and controlled. (Reference) Appropriate design/manufacturing/testing/inspection, and record based on the planning documents are conducted.	◎ **4.4.3** "Qualitative evidence" ◎ **Section 4.4.4** "EET" ◎ **Section 4.4.5.1** "FLVT" ◎ **Section 4.4.5.2** "FCAT"	◆There may be residual latent malfunctions or defects that may not be detected by the supplier's manufacturing process inspections, pre-delivery inspections, etc. ◆No information on operation life, aging degradation, or accumulated scratches is available, and thus reliability on life and durability may not be obtained. ◆There is a risk of poor product yield and not being able to meet delivery deadlines.	**<Risk>** ◆There is a high possibility that noncompliance will be discovered during evaluation tests due to latent defects that were not detected in the supplier's pre-delivery inspection. ◆ There is a possibility that noncompliance will not be apparent during compliance evaluation, but will be discovered during testing after the spacecraft is installed or during in-orbit operations. **<Measures>** ◆Conduct sufficient screening in the soundness confirmation tests of commercial equipment. ◆Consider conducting not only design evaluation tests but also design life and reliability tests in FLVT.

Appendix Table-3: Establishment of a policy for technical requirements compliance evaluation considering the status of noncompliance to reliability/quality etc. requirements, etc. (10/10)

17	Ensuring maintainability and post-delivery response	✕ Repair or replacement of parts is not possible as a design specification of equipment. ✕ No service to repair equipment, etc. is provided. (Reference) Products are shipped with appropriate design and manufacturing controls and inspections.	◎ **Section 4.4.3** "Qualitative evidence" ◎ **Section 4.4.4** "EET" ◎ **Section 4.4.5.1** "FLVT" ◎ **Section 4.4.5.2** "FCAT"	◆The supplier's support and repair actions are not available even when evaluation test results or noncompliance being discovered.	**<Risk>** ◆Supplier's support is not available for noncompliance or unknown items during evaluation test. ◆Parts for repairing or replacing equipment are not available. **<Measures>** ◆Sufficient evaluation/confirmation should be made during the receiving inspection of procured equipment and the integrity verification test of commercial equipment. ◆When any noncompliance (noncompliance that may not be remedied by relaxing technical requirements, etc.) is found during evaluation test, re-evaluation is conducted using spare parts or spare flight lot as necessary, and when any noncompliance is found again, the equipment should be noncompliance for space application.

FAQ

(About the guideline in general)

Q: May organizations or companies outside of JAXA or JAXA contracts use the guidelines?

A: By replacing the terms "JAXA" and "contractors" in the guidelines with "the organization/organization or manufacturer responsible for the development of the relevant commercial equipment" or "the ordering party," organizations and manufacturers that are not under contract with JAXA may also use the guidelines. The documents (JMR-004, -005, -006, etc.) cited in this guideline are also available outside JAXA and may be searched on the web.

Q: May organizations or companies that are not familiar with the space environment or space development develop spacecraft using commercial equipment that has undergone compliance evaluations under this guideline?

A: This guideline provides guidelines for organizations and companies that are sufficiently familiar with the space environment and space development and wish to use commercial equipment for the purposes specified in **section 4.1.1.1**. When you are not familiar with these knowledge and techniques, we recommend that you use equipment that is well proven for space equipment.

Q: Will these guidelines contribute to expanding the scope of space application of commercial equipment?

A: It is expected to contribute greatly. The reason is that we believe that the evaluation methodology presented in this guideline is the most certain and shortest approach to conducting the space application compliance evaluation of commercial equipment. It is expected to contribute significantly to reducing development time and costs compared to developing new products using space parts. In addition, it is possible to investigate and select space-applicable technologies from among various commercial technologies that have already been established as ground-based technologies. However, potential risks associated with the use of equipment developed/manufactured for terrestrial use should be considered.

Q: May commercial equipment that was determined to be "space-applicable" in accordance with this guideline in one spacecraft project be used as "space equipment" in subsequent spacecraft development?

A: Even when a piece of commercial equipment is judged "space-applicable" in a spacecraft project, when the reliability/quality control level of the equipment or its supplier is not maintained, it may not be able to continue to be used for space application in a subsequent project. However, when equipment that has been judged "space-applicable" obtains flight experience (heritage equipment; see **section 4.4.8**), and the design, reliability/quality control level is maintained afterwards, it may be possible to treat it as space equipment equivalent.

Q: I would like to reduce the cost of spacecraft development by using commercial equipment instead of space equipment. Is this possible?

A: The purpose of your question is one of the major objectives of this guideline (**section 4.1.1(1)** "Objective 2"). However, to confirm the space application of commercial equipment, it is necessary to procure multiple equipment under test and conduct various evaluation tests (including destructive tests when necessary) taking into account the onboard spacecraft conditions.

Therefore, when commercial equipment is sufficiently inexpensive (e.g., 1/5 or less) compared to existing space equipment, there may be an advantage to use commercial equipment. However, when there is no significant price difference between existing space equipment and commercial equipment, the use of commercial equipment may increase both cost and risk. As described in **section 4.4**. "Methods of space application compliance evaluation" for detail, it is important to minimize the burden of test evaluation, etc. by making the best use of qualitative evidence available through sufficient information exchange with suppliers.

Q: In JMR-012 and JERG-0-052, the evaluation/verification requirements differ depending on the quality/reliability level and criticality required for parts, but is there any similar concept for "commercial equipment" covered by this guideline?

A: As indicated in **section 4.1.1.1(1)**, the equipment covered by this guideline is basically limited to "equipment that has benefits even when risks are considered (Objective 1)" or "cost reduction of functional equipment with low criticality (Objective 2)". In addition, it is difficult to follow the same approach for "equipment" as for "parts" because its structure/configuration/functional performance, etc. are more complex than those of "parts" and its suppliers are diverse. For this reason, we do not distinguish evaluation methods based on criticality or reliability level, but rather on "usable or unusable".

Q: When EEE parts are included in the components of commercial equipment, are they subject to the restrictions of the EEE parts selection criteria (JMR-012 and JERG standards on the space conversion of EEE parts)?

A: Since when space application compliance evaluation is conducted in accordance with this guideline at the equipment (component) level, basically, the component parts are exempted from the EEE parts selection criteria. In addition, JAXA's satellite development contract manufacturers who are applying JMR-004 are satisfied with the requirements in **section 4.2.6.3** of JMR-004 by conducting space application compliance evaluation of commercial equipment in accordance with this guideline. However, as in the example in section 4.3.2.3, there may be parts that are affected by the unique space environment of which confirmation are difficult through ground tests. Therefore, it is necessary to fully exchange information with suppliers at the candidate equipment selection stage to check whether such equipment is included as a component.

(1. General to 3. Terms and definitions)

Q: Is it possible to tailor the requirements of this guideline when applying this guideline in JAXA's spacecraft development procurement contracts?

A: Tailoring is possible. It is assumed that the technical requirements and evaluation test plans for compliance evaluation may need to be modified as the evaluation work progresses, and consideration is given so that they may be created or modified within the procedures of this guideline.

Q: Does "commercial equipment" covered by this guideline include board-level equipment for example?

A: Yes. Please refer to **section 3.1** "Terms and definition" for the definition of "commercial equipment".

Q: May this guideline be imposed on suppliers of commercial equipment as is?

A: This guideline specifies items to be implemented by the ordering party, including investigation of suppliers, and does not consider imposing such items on suppliers who are designing/manufacturing commercial equipment. This is because it is necessary to consider that it is impossible to conduct the evaluation under the responsibility of the supplier, since the evaluation method will vary depending on information availability of supplier and compliance with reliability/quality etc. requirements. However, when there is no problem with information availability of supplier and compliance with reliability/quality etc. requirements, it may be possible to outsource modifications, improvements, evaluation tests, etc. to the supplier by establishing a positive cooperative and supportive relationship between the ordering party and the supplier. See **section 4.4** "4 Methods of space application compliance evaluation".

Q: COTS items are considered to be of better quality than general commercial equipment, etc. When COTS items are used, are there any items that may be omitted from the evaluation of this guideline?

A: Basically, even when the definition of COTS items is similar to your question, when the specific quality compliance status of the product is not known, the evaluation method in this guideline is the same as for other commercial equipment. However, when, for example, it is clear that NASA, ESA, etc. identifies a certain item identified by the supplier's P/N, etc. as a COTS item, and NASA or ESA's design or quality compliance evaluation documents for the relevant equipment are available, it may be possible to treat the item in the same manner as heritage equipment under **section 4.4.8.**

Q: The concept of lot is often heard of for parts, but not so familiar for equipment.

A: In the case of commercial equipment, even when the common design (common model) is used, the factory, production line, and parts supplier, etc. may be different. For example, a Japanese product may be manufactured in an overseas factory, such as in China or Vietnam. Generally, suppliers that implement appropriate quality control are expected to control identification of factories, production lines, and periods of manufacturing by lot. Even when a product does not have a lot number (L/N) and is only marked with a serial number (S/N), the supplier should be able to provide information on the corresponding lot when you contact them.

(4.2 Compliance with reliability/quality etc. requirements)

Q: What is the relationship between JMR-004 through JMR-006, which are the sources of section 4.2 "Compliance with reliability/quality etc. requirements" of this guideline, and the 17 required objectives (Table 4.2-1)?

A: JMR-004 to JMR-006 are applicable documents when JAXA procures or contracts spacecraft development to spacecraft development manufacturers, and include not only reliability/quality etc. requirements but also rules on how to submit and report various documents for the convenience of supervision and administrative control by JAXA's supervisors, etc. JMR-004 to JMR-006 are also applicable documents when JAXA contracts with spacecraft development manufacturers.

Space equipment development manufacturers under contract with JAXA are familiar with these and have no obstacles, but general commercial equipment suppliers are likely to have their own management methods, and it is expected that it will be difficult for them to directly comply with the requirements of JMR-004 to JMR-006. Therefore, this guideline identifies and classifies the "requirement objectives" of the reliability/quality etc. control of JMR-004 to JMR-006 into 17 items, it is taking account that compliance with reliability/quality etc. compliance may be confirmed by evaluating compliance with control method implemented by the supplier (public standards, internal standards, etc.) and the 17 required objectives.

Q: Are JIS Q 9100, ISO 9001, and other official standards for quality management systems, etc. considered to be in compliance with reliability/quality requirements in section 4.2 for commercial equipment manufactured by suppliers who have obtained certification under these official standards?

A: Supplier s and their commercial equipment certified to official standards such as JIS Q 9100 and ISO 9001 are considered to contribute significantly to conformance to the 17 required objectives in **Table 4.2-1** of this guideline. However, items that may not be covered by these official standards should be checked separately.

Q: We would like to use commercial equipment that has been sold/used in many cases in Japan and abroad by catalog purchases. May we skip the investigation of compliance with reliability/quality etc. requirements to the supplier?

A: **Section 4.4.2.1** "Classification of information availability levels" and **section 4.4.2.2** "Compliance evaluation of reliability/quality etc. requirements according to information availability levels" of this guideline may not basically be omitted. Even when commercial equipment intended for space application is considered to have many histories of sales/use, it is necessary to confirm and evaluate whether that history is based on reliable information and evidence. In addition, whether in Japan or overseas, when the relevant supplier does not respond to inquiries, the information availability level will be 3, and it is necessary to consider that there is no compliance with reliability/quality, etc. On the other hand, when it is confirmed that the necessary information is available, it is not necessarily necessary to conduct a detailed compliance evaluation at an early stage, and it is possible to make arrangements to avoid placing an excessive burden on the supplier, such as by checking each necessary content as the evaluation progresses.

(4.3 General requirements for technical requirements compliance evaluation)

Q: In recent years, the use of "lead-free" soldering and plating, which does not use lead that is harmful to the human body, is becoming more common in ground equipment.
May "lead-free" materials be used in space equipment as is?

A: Conventional solder is eutectic (alloy) of tin and lead, but the high melting point of lead-free solder affects workability and compatibility with parts, whiskers (needle-like metal crystals) are easily generated, and erosion (copper eclipse) occurs easily in ground equipment, etc., necessary measures and studies are underway. Therefore, when the equipment has sufficient reliability and a proven track record as ground use equipment, space application is basically possible by conducting evaluations in accordance with this guideline. Since JAXA has not been able to obtain flight data on lead-free equipment at this time, we are currently considering restricting the use of lead-free parts as space parts. However, it is certain that we will shift to lead-free space parts as well.

Q: The use of aluminum electrolytic capacitors as space parts is prohibited by JMR-012, but may they be used as they are when they are incorporated as component parts in commercial-use parts?

A: What should be taken into consideration for space application of commercial equipment is "consideration of special space environment conditions that do not depend on onboard spacecraft I/F" as exemplified in **section 4.3.2.3**. Aluminum electrolytic capacitors that use liquid dielectrics behave differently from those on the ground as shown in Example 3, and there is a possibility that their operating characteristics may change and they may not function. Therefore, it may be necessary to replace the capacitor with an appropriate part or to test it in an environment that simulates a weightless environment.

(4.4 Methods for compliance with space applications evaluation)

Q: May equipment that is used as equipment under evaluation test be used as equipment for flight?

A: When the equipment has not been subjected to excessive loads or accumulated damage that would interfere with its use as flight equipment during a flight lot, it may be used as flight equipment when its compliance may be confirmed by FCAT (Flight Component Acceptance Test (AT)). For details, please refer to **section 4.4** "Evaluation Procedures".

Q: Is compliance evaluation to reliability/quality requirements necessary for repeat equipment (continuously use for the common model of launch vehicle, etc.)?

A: Basically, yes, it is necessary. **Section 4.4.8** (and **Table 4.4.8-1**) show the evaluation items that may be omitted in the case of diversion of heritage equipment including repeat equipment. Even when the equipment is continuously incorporated into the common model of launch vehicle, the minimum required evaluation should be considered necessary for each new procurement of equipment that differs from the past flight lot. However, there are cases where the results of past evaluations may be used as is and may be treated as

equivalent to evaluations. For example, when the results of a space application compliance evaluation equivalent to this guideline for repeat equipment may be confirmed as reliable information from the supplier (including reliable memorandums such as contacting only when changes occur), the reliable information (without notification of changes) may be used instead of the evaluation results.