INTERNATIONAL STANDARD

ISO 21350

First edition
2007-09-01

Space systems — Off-the-shelf item utilization

Systèmes spatiaux — Utilisation d'équipement prêt à l'emploi

Reference number
ISO 21350:2007(E)

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 21350 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

Space projects are more often faced with proposals to use off-the-shelf (OTS) items which can offer opportunities for reduced cycle time, faster insertion of new technology and lower procurement costs.

Space projects have been successful in using OTS items in space systems and products. These projects have found that the use of OTS items required a re-emphasis of some traditional business, management and engineering practices, as well as a number of changes to other practices. Successful projects embraced these changes by building systems that were conceived, acquired and sustained with an understanding of the risk associated with OTS items.

Space systems — Off-the-shelf item utilization

1 Scope

This International Standard contains requirements and guidelines for the utilization of off-the-shelf (OTS) items, their selection, acquisition, integration, qualification and implementation related to a space product or system.

Specifically excluded are piece parts and materials, such as electrical, electronic and electromechanical (EEE) parts, thermocouples, rivets, fasteners, connectors, fittings, adhesives, insulation, wiring and plumbing.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9000, *Quality management systems — Fundamentals and vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9000 and the following apply.

3.1
critical application
any application where a failure could cause loss of life or loss of mission

3.2
product heritage
collection of data supporting adequacy for the intended use by time in service, number of units in service, mean time between failures (MTBF) performance, failure history, number of use cycles and manufacturing characteristics

3.3
characteristic of high product heritage
item from the original supplier that has maintained the great majority of the original service, design, performance and manufacturing characteristics

3.4
characteristic of low product heritage
item that was not build by the original manufacturer, does not have a significant history of successful test and usage, or has had significant aspects of the original service, design performance and manufacturing characteristics altered

3.5
item
piece of hardware or software or combination of hardware and/or software, usually self-contained, which performs a distinctive function

3.6
off-the-shelf
OTS
existing item which has been developed for a specific application and is intended to be used in another application

3.7
expanded specifications
specification of OTS item in which the environment requirements are different from the vendor specification and the design of the OTS item has not been changed

4 Requirements

4.1 Responsibilities

It is the responsibility of the project or engineering organization to provide OTS items in accordance with this International Standard.

4.2 Tailoring

When viewed from the perspective of a specific programme or project context, the requirements defined in this International Standard should be tailored to match the genuine requirements of a particular profile and circumstances of a programme or project.

NOTE Tailoring is a process by which individual requirements or specifications, standards and related documents are evaluated and made applicable to a specific programme or project by selection and, in some exceptional cases, modification and addition of requirements in the standards.

5 Policy

5.1 Evaluation of the OTS item design

5.1.1 General

For projects which have design responsibility, the following practices shall be adhered to in the application of OTS items. These practices shall address the potential impact of an OTS item at any level of functionality.

5.1.2 OTS item requirements

Requirements shall be defined and baselined for each OTS item application.

5.1.3 OTS item evaluation

Early environmental and performance tests on sample OTS items that verify supplier compliance with procurement specifications shall be performed. The extent of this testing will be determined by design based on the criticality of the application and the significance of any modifications performed and approved by the project. For critical applications, product data, inspection data, and test or usage data shall be reviewed prior to final selection of the OTS item.

During the design phase, the OTS item shall be specifically evaluated to see if the proposed application is within the range of environments and operating conditions which are consistent with the OTS use experience and advertised specifications. This will include evaluation of advertised specification data, vendor inspection and test data, if available, or the generation of additional data over the intended operating and environmental range by the project or organization intending to use the flight time testing. For an OTS item to be selected, there shall be data showing the OTS item's conformance to its specification, including the availability of associated documentation.

If the intended operation of an OTS item is outside the specified operating conditions or environments over which the item has demonstrated successful performance, then

a) an appropriate conservative design margin (i.e. margin) shall be applied by the responsible design organization for the intended use conditions, and/or

b) a comprehensive inspection and test programme shall be implemented to prove that the OTS item is acceptable.

Since the OTS item is being operated outside its envelope, these extra measures will provide the confidence in the design that was not available through the empirical body of data that is implicit in repeated successful operations of a common design under specified environments and operating conditions.

Qualification assessment should be conducted in accordance with ISO 15865.

5.2 Rules in a critical application of OTS

5.2.1 Operational boundaries

The OTS item shall not operate near the boundaries of its performance or environmental envelopes. To ensure this, specific margins shall be established during the design phase of the project and adhered to during the selection of the OTS.

5.2.2 Design evaluation

Prior to preliminary design review, critical aspects of a design that utilizes OTS items shall be identified and evaluated. This evaluation shall ensure that the intended applicable functions to be performed by the OTS items are addressed and that the previous existing functions of the OTS items are consistent with the new application.

5.2.3 OTS item modifications

Following the configuration management rules applicable to the project, the OTS item modifications shall be developed jointly by the project or organization intending to use the flight item and the vendor, if practical. OTS items shall not be modified for a critical application unless adequate vendor design disclosure is obtained, or the project or engineering organization developing/proving the flight item have an adequate understanding of the OTS item design.

5.2.4 Qualification requirements

The project or organization intending to use the OTS item shall establish a qualification plan on the basis of Annex B. OTS items utilized in critical applications should be reviewed at each scheduled design review and approved as appropriate. For implementation of OTS items in a non-critical application, the selected Annex B requirements, or exceptions thereto, should at a minimum be reviewed and approved by the leader of the project or organization intending to use the OTS item.

6 Precautions and warning notes

6.1 Notes about product heritage of OTS item

6.1.1 OTS product heritage

The “heritage” of an OTS item can be an indicator of the quality or reliability of OTS items in a space application.

"High heritage" does not exist on all OTS items. An OTS item may have a "low heritage" due to limited production because of recent availability, low sales volume, unique application, etc.

6.1.2 Application of OTS design/manufacturing practices

OTS design or manufacturing practices may not be acceptable despite the heritage of mass production. Inspection and/or testing should confirm workmanship acceptability to the degree determined by the project or organization intending to use the OTS item as appropriate for its application.

6.1.3 OTS design margins

OTS design margins should be verified with the vendor, determined by testing, or an additional safety factor included, particularly for critical items.

6.2 Notes about acquisition of OTS

6.2.1 General

When the project or organization intending to use flight items utilizes OTS hardware, unique acquisition issues may be encountered. The following areas should be considered.

6.2.2 Specification

The project should ensure that the OTS item is purchased to work within the expected specification required by the application and should obtain environmental specifications and/or test data from the vendor to confirm compatibility. There shall be data showing the OTS item's conformance to its specification, including the availability of associated documentation.

6.2.3 Space environment

OTS vendors (designers or manufacturers) may not be sensitive to space environment issues such as radiation, vacuum, thermal extremes, lack of convection cooling in zero-G, launch vibration, or enriched oxygen atmosphere. Therefore, the project or engineering organization providing/developing the flight item should accept responsibility for assessing space environment compatibility.

6.2.4 Configuration control

The vendor configuration control of OTS items may not ensure that all products are manufactured/developed identically. OTS items manufactured/developed at different times may have differences in materials, parts and/or development process. Whenever feasible, all OTS items (including development test units and spares) should be purchased from a single lot to minimize material/part/process differences. If not feasible, OTS items purchased should be traceable to lot, if possible.

6.2.5 Acceptance testing

OTS acceptance testing may need to be more comprehensive than the typical manufacturing defect screening tests, especially when the purchase of a single lot is not feasible. The more comprehensive acceptance testing should include workmanship as well as performance under expected use environments.

6.2.6 Maintenance

If the project or organization intending to use the flight item is to become responsible for maintenance of the OTS item during its service life, this requirement should be addressed during procurement of the hardware to ensure that the total quantity of hardware required for the project is covered, including spares and replacement parts.

6.3 Management of modified OTS

6.3.1 Purchasing

When purchasing a modified OTS item, the modified hardware should be treated as a new design and all appropriate processes associated with the design change should be reviewed.

6.3.2 Qualification

The project or organization intending to use the flight item is not always qualified to work on or modify OTS hardware, so OTS vendor involvement should be considered as appropriate. Depending on the nature and degree of modification, the vendor may be the only one qualified to make the changes.

6.4 Programmatic decision to use OTS

The decision to use an OTS item by a project or organization intending to use the flight item should be considered based on risk using ISO 17666.

6.4.1 Functional/technical capability

OTS items shall meet the project or organization intending to use the flight item requirements. This is more than functional similarity. The project or organization intending to use the flight items should develop good performance and environmental requirements for a potential OTS application and ensure that the OTS candidate is screened against this comprehensive set of requirements.

6.4.2 Interface definition

When using OTS in a designed system, the interface requirements between the OTS items and other hardware/software items in the system should be defined so that the OTS is operated in accordance with the OTS manufacturer's performance and environmental specifications.

6.4.3 Modification versus heritage

The OTS heritage should be preserved to the maximum extent possible. Even apparently simple modifications often compromise the OTS heritage.

7 Decision logic for OTS item usage

A decision logic for OTS item usage is contained in Annex A. The project or organization intending to use the OTS item should consider this logic when determining whether to use an OTS item or to make the item.

8 Procedure

8.1 Categorizing of available OTS items

A survey of available OTS items should be made. The OTS items identified for consideration during the survey shall be sorted into the following three categories:

a) those which meet all programme requirements;

b) those which meet significant programme requirements; and

c) those which meet few programme requirements and are not normally candidates.

8.2 Considering a good candidate for selection

An OTS item which meets all requirements shall be considered a good candidate for selection.

8.3 Compromise of discrepancies between OTS and project requirements

An OTS item which meets significant programme requirements shall be evaluated in the context of whether the programme requirements can be relaxed to obtain agreement, or whether the OTS item can be modified to meet all relevant programme requirements and still retain a programmatic advantage over a new project or engineering organization developed item.

8.4 Satisfying OTS item requirements

8.4.1 Qualification plan

If the decision to utilize an OTS item in a flight development project is made, the project shall establish a qualification plan on the basis of Annex B and implement the project in accordance with it.

8.4.2 Categorization

8.4.2.1 General

In order to select the appropriate qualification requirement from Annex B, it is necessary to first categorize the application of the OTS item (i.e. how will the OTS item be utilized?). This can be done by considering the three parameters described below.

8.4.2.2 Intended application

The first parameter that affects the selection of OTS “use” requirements is the intended application of the OTS item, e.g. whether the OTS item is intended for a critical or non-critical application alters which “use” requirement from Annex B should be met.

8.4.2.3 Modification

The second parameter that affects the OTS “use” requirements is whether the OTS item can be used as it is, or whether it needs to be modified, and by whom.

8.4.2.4 Similarity of performance and operating environment

The third parameter that affects the OTS “use” requirements is the similarity of the manufacturer’s intended performance and operation environment to those actually encountered in the application.

8.4.3 Combining the parameters

The combination of the three parameters identified above can be used to categorize the anticipated use of an OTS item.

For example, an OTS item selected for a non-critical application, without modification, and within the manufacturer’s specifications defines a category as shown in Annex C. The category identified in this example would require a minimum set of requirements to be applied (i.e. items A and E).

Annex A
(informative)

A decision logic for OTS item utilization

Figure A.1 illustrates in the form of a flowchart a decision logic for OTS item utilization.

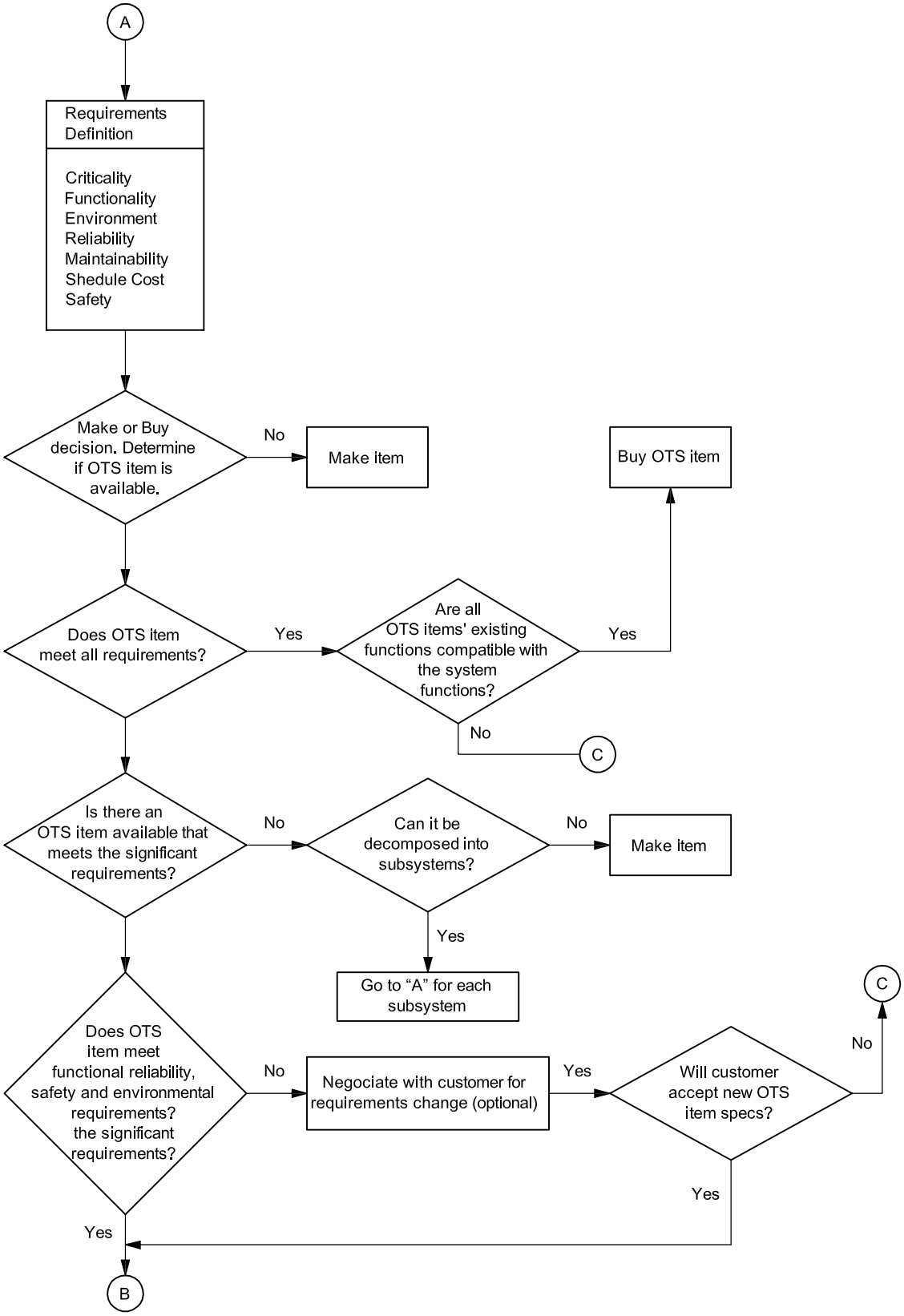

Figure A.1 — Decision logic for OTS item utilization (continued)

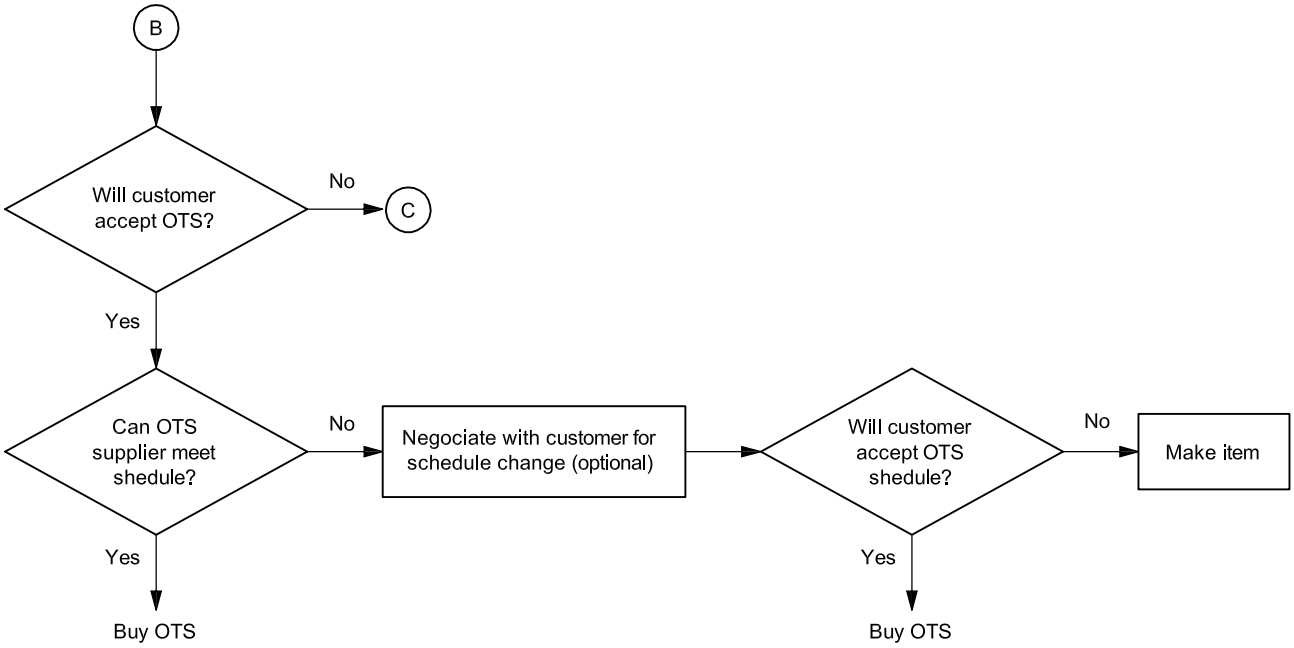

Figure A.1 — Decision logic for OTS item utilization (continued)

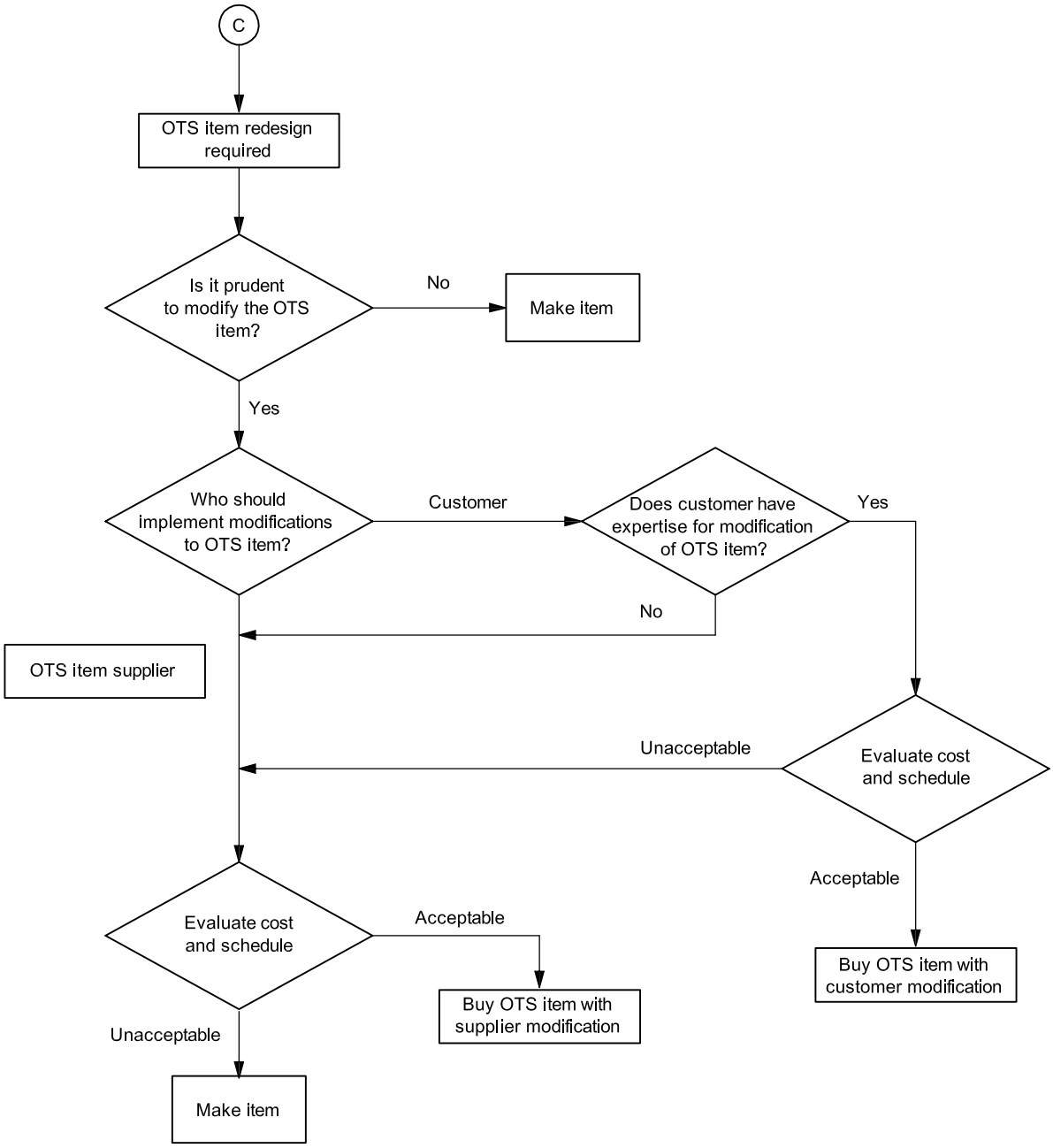

Figure A.1 — Decision logic for OTS item utilization

Annex B
(normative)

Requirement list for OTS item utilization

B.1 Meet the following requirements for all OTS usage:

— Meet safety critical requirements of application (e.g. flammability, toxic offgassing, EMI emissions, touch temperature, sharp edges, etc.).

— Perform environmental testing, if appropriate (e.g. outgassing for vacuum use).

— Perform vibration testing – workmanship.

— Perform thermal testing – workmanship.

— Perform detailed inspection – workmanship/safety audit (including destructive inspection of at least one unit, if required). The decision on the degree of inspection and testing required should be made by the technical lead for the project or organization intending to use the flight item.

B.2 Add the following requirements if OTS is modified or used in a different environment without modification:

— Conduct performance testing – qualification.

— Conduct vibration testing – qualification (if appropriate).

— Conduct thermal testing – qualification (if appropriate).

— Conduct ionizing radiation testing – qualification (if appropriate).

— Conduct testing for vacuum use – qualification (if appropriate).

B.3 Add the following requirements if OTS is in a critical application:

— Add margin to requirements (de-rate the hardware).

— Evaluate redundancy/fault tolerance aspects of the OTS item.

— Acquire or develop reliability or use data to the extent required by the application.

— Qualify the vendor as an acceptable source (ISO certification desirable).

— Buy all units from the same lot if practical, or confirm similarity by inspection and testing.

— Acceptance testing on all OTS items and qualification testing on modified OTS items by the project or organization intending to use the OTS items is required (or surveillance at the vendor).

— Perform validation test of OTS item functionality with respect to system usage.

— Obtain EMI susceptibility data (either test or analysis).

B.4 Perform appropriate analysis of OTS design:

— Take responsibility for technical validity of any applicable vendor analysis with respect to the OTS item.

— Acquire applicable vendor design details with respect to areas to be modified by the project or organization intending to use the OTS item.

NOTE If applicable vendor data is unavailable, the project or engineering organization providing the OTS item is responsible for the necessary testing/characterization.

— Do not modify OTS items for a critical application unless adequate vendor disclosure is obtained, or the project or organization intending to use the flight item has adequate understanding of the OTS design.

B.5 Allow vendor to perform acceptance and/or qualification testing.

B.6 Vendor involvement in the project or organization intending to use the flight item modification is desirable.

B.7 Vendor involvement in the project or organization intending to use the flight item modification is required.

B.8 Design and/or test disclosure from the vendor is desirable.

B.9 Design and/or test disclosure from the vendor is required. Design and test disclosure shall be sufficient to determine that the design approach for the modification to OTS hardware intended for a critical application meets all requirements and workmanship standards.

Annex C
(informative)

OTS item application categories

Figure C.1 illustrates OTS item application categories.

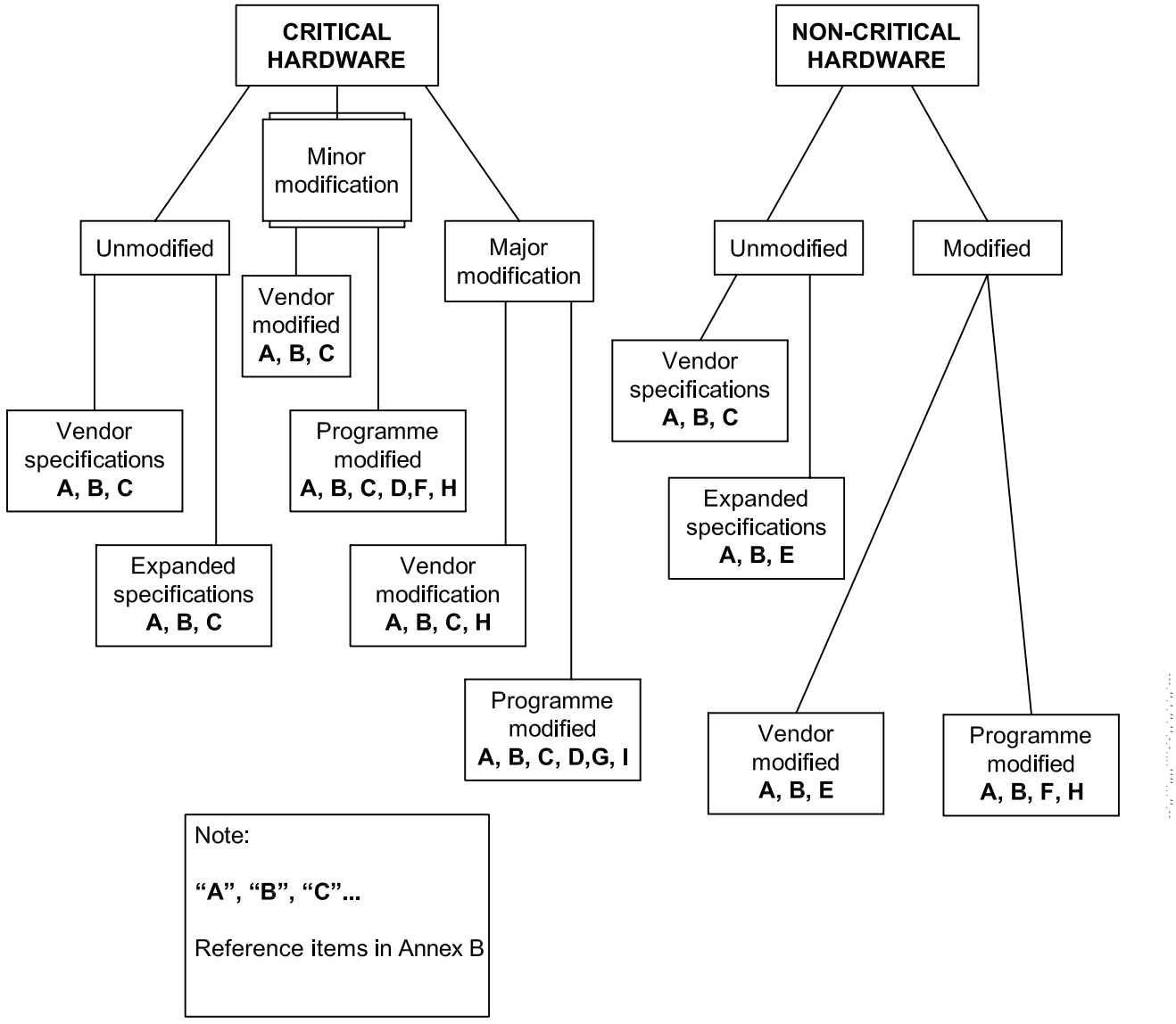

Figure C.1 — OTS item application categories

Bibliography

[1] ISO 15865, *Space systems — Qualification assessment*

[2] ISO 17666, *Space systems — Risk management*

ICS 49.140

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