
**Space systems — Electrical, electronic
and electromechanical (EEE) parts —**

**Part 1:
Parts management**

*Systèmes spatiaux — Composants électriques, électroniques et
électromécaniques (EEE) —*

Partie 1: Gestion des composants

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Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms, definitions, and abbreviated terms	1
3.1 Terms and definitions.....	1
3.2 Abbreviated terms.....	3
4 EEE parts management programme	4
4.1 EEE parts management process.....	4
4.1.1 General.....	4
4.1.2 Design process.....	4
4.1.3 Design margin.....	5
4.1.4 Life cycle cost.....	7
4.1.5 Technology insertion strategy.....	8
4.1.6 Technical support.....	8
4.1.7 System engineering support.....	10
4.1.8 Parts selection.....	11
4.1.9 Obsolescence management.....	12
4.2 Supplier management.....	12
4.2.1 General.....	12
4.2.2 Management processes.....	12
4.2.3 Information management.....	14
4.2.4 Internal controls.....	15
4.3 Shared data guidance.....	15
Annex A (informative) Radiation effects	17
Annex B (informative) Parts selection checklist	20
Annex C (informative) Subcontractor/supplier management checklist	21
Annex D (informative) Shared database	35
Bibliography	40

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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

This edition cancels and replaces the first edition (ISO 14621-1:2003), which has been technically revised. The main changes compared to the previous edition are as follows:

- Introduction and definitions have been revised,
- consistency has been checked with ISO 14621-2, and
- the document has been aligned with the ISO/IEC Directives Part 2, 2018 edition.

A list of all parts in the ISO 14621 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

ISO 14621-1 and ISO 14621-2 are designed to jointly assist the user and supplier communities in developing and executing an effective process for the design, selection and application of electrical, electronic, and electromechanical (EEE) space parts throughout the life cycle of the programme.

NOTE In both ISO 14621-1 and ISO 14621-2, the family of EEE parts includes electro-optical parts.

The strategy represented in the ISO 14621 series is:

- for ISO 14621-1 a system approach to managing risk throughout the life cycle of the programme, by developing, selecting and properly applying the right EEE part for its intended application;
- for ISO 14621-2 a framework for developing and documenting an EEE parts control programme to assure that the parts used in space flight hardware have acceptable risk, i.e. possess adequate functional, radiation and reliability characteristics to meet the system requirements.

Both ISO 14621-1 and ISO 14621-2 should be tailored to meet the specific needs of each individual programme, i.e. to address the applicable system performance requirements, risk tolerance, budget, mission duration, operating environment, and schedule. Tailoring should result in a set of planned activities that are not only capable of achieving all contractual EEE parts related requirements, but also commensurate with the space system's unit-value/mission-criticality and life cycle technical data product requirements.

NOTE This type of planning is sometimes referred to as capability-based Safety, Dependability, and Quality Assurance (SD&QA) programme tailoring; and the guidance for performing it is provided in ISO/TS 18667.

ISO 14621-1 and ISO 14621-2 are relevant to all users and customers of space systems, and the suppliers and vendors that furnish space flight hardware. However, to utilize these documents to their fullest potential, it is necessary to understand the commercial space business environment which has unique cost and schedule constraint challenges.

This document discusses the following key elements that support an effective EEE parts management programme:

- Part obsolescence management — perform early assessment of part availability risk for the entire space system, develop and implement risk mitigation activities that will prevent or minimize programme disruption due to part shortages, and ensure long-term supportability throughout the programme life cycle.
- Supplier management — plan and execute techniques for verifying that the practices and products of suppliers and vendors comply with:
 - contractual requirements;
 - their documented internal business practices (also known as command media), which should be consistent with the commercial consensus on technical best practices.
- Cost management — minimize the costs, including verifying parts suppliers and vendors can provide the rationale why they set different costs for parts that are functionally identical, e.g. identify the cost of special processing applied to parts that are designed for a specific space environment or mission.
- Technology insertion — focus on creating a technology road map, which minimizes risk of obsolescence and develops a strategy for technology insertion during the entire system life cycle.
- Space parts community alert exchange — have a forum focused on managing peer to peer communication among space industry participants seeking to reduce or eliminate expenditures of resources on common problems, by sharing EEE parts related problem information collected during research, design, development, production, and operational phases of the programme.

- Process control — ensure the user’s and supplier’s approaches for controlling EEE parts risks, and risks of other critical items and processes, are documented, formally approved, and validated.
- Systems engineering — encourage parts engineering participation in all phases of the product life cycle.
- Training — provide effectively trained resources on the various processes required to develop, select, and properly apply the right EEE part for the its intended application, as well as to establish awareness of the parts management programme throughout all levels of the user and supplier communities.

Those specific elements or opportunities are presented in descriptive terms and illustrated in graphic flow charts. There is no intent to provide detailed descriptions of “how to” in this document. It may be cited as a basic guideline within a statement of work and/or for assessing proposals and contractor performance. All levels of contractual relationships (acquiring activities, primes, subcontractors and suppliers) may use this document. It is the responsibility of the user community to establish, define, and administer those tasks based on the programme goals and objectives and thus provide the “what” elements envisioned and establish their appropriate criteria for their programme.

Although this document was written with the intent of covering EEE parts, the concept established is a system approach for developing an EEE parts programme with reference to specific material and mechanical processes that make up EEE parts.

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Space systems — Electrical, electronic and electromechanical (EEE) parts —

Part 1: Parts management

1 Scope

This document addresses the key elements for an EEE parts management programme for space systems and is written in general terms as a baseline for developing, implementing, validating, and evaluating a space parts management programme. The family of EEE parts includes electro-optical parts.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 14621-2, *Space systems — Electrical, electronic and electromechanical (EEE) parts — Part 2: Control Programme Requirements*

ISO 17666, *Space systems — Risk management*

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1.1

best practice

documented process or product developed by the user community, consisting of suppliers and customers, teaming for the purpose of establishing industry guidelines

3.1.2

electronic, electrical, or electromechanical part

EEE part

device that performs an electronic, electrical, or electromechanical (EEE) function, including electro-optical devices, and consists of one or more elements so joined together that they cannot normally be disassembled without destroying the functionality of the device

3.1.3

integrated product team

IPT

integrated product team consisting of members selected from the appropriate disciplines

EXAMPLE Engineering, manufacturing, quality, suppliers or customers, as appropriate.

3.1.4

manufacturer

company or organization that transfers raw material into a product

3.1.5

performance specification

document that defines what the customer desires as a product, its operational environments and all required performance characteristics

3.1.6

product specification

document that defines the end item(s) the supplier intends to provide to satisfy all the *performance specification* (3.1.5) requirements

3.1.7

reliability engineering

integral part of the system engineering requirements definition and analysis function

Note 1 to entry: The tasks are to conduct cost/benefit trade-offs and to analyse and determine alternative design and procurement solutions.

3.1.8

systems engineering

interdisciplinary approach governing the total technical and managerial effort required to transform a set of stakeholder needs, expectations, and constraints into a solution and to support that solution throughout its life

[SOURCE: ISO/IEC/IEEE 24748-1:2018, 3.57]

3.1.9

technology insertion strategy

decision making process to assess current and future part availability and trends, which leads to a decision regarding emerging or new technology insertion

Note 1 to entry: This process is used in the concept development phase, but also impacts the production and field support phases.

3.1.10

validation

confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled

[SOURCE: ISO 9000:2015, 3.8.13, modified — Notes 1, 2, and 3 to entry have been deleted.]

3.1.11

vendor

seller of parts, products, or commodities

Note 1 to entry: This term can be interchangeable with *manufacturer* (3.1.4), depending on the application

3.1.12

verification

confirmation, through the provision of objective evidence, that specified requirements have been fulfilled

[SOURCE: ISO 9000:2015, 3.8.12, modified — Notes 1, 2, and 3 to entry have been deleted.]

3.2 Abbreviated terms

ARN	anticipated reliability number
ASIC	application specific integrated circuit
BOM	bill of materials
CAM	computer-aided manufacturing
Cpk	process capability
DEMP	discharge electromagnetic pulse
DIC	digital integrated circuit
DM	design margin
DMSMS	diminishing manufacturing sources and material shortages
DoE	design of experiments
DPA	destructive physical analysis
EEE	electronic, electrical and electromechanical
EMC	electro-magnetic compatibility
EMP	electromagnetic pulse
EPI	epitaxial
ESD	electrostatic discharge
FMECA	failure modes and effects criticality analysis
F ³ I	form, fit, function interfaces
FRACAS	failure reporting, analysis, and corrective action system
HAST	highly accelerated stress test
HEMP	high altitude electromagnetic pulse
IPD	integrated product design
MPU	micro processing unit
NDI	non-developmental item
OEM	original equipment manufacturer
PEM	plastic encapsulated microcircuit
PWB	printed wiring board
QML	qualified manufacturers list
QPL	qualified parts list
RH	relative humidity

SEB	single event burnout
SEE	single event effects
SEGR	single event gate rupture
SEL	single event latchup
SEU	single event upset
SGEMP	system-generated electromagnetic pulse
SPC	statistical process control

4 EEE parts management programme

4.1 EEE parts management process

4.1.1 General

The EEE parts management process defined in this document is designed to assist in dealing more proactively with critical parts management issues and to provide guidance for developing comprehensive strategies to manage EEE parts related performance, cost, and schedule risk via an integrated product team (IPT) process (Figure 1). The main aspects of the EEE parts management process are design process, supplier management, and shared data. The design process includes, but is not limited to, design margins, life cycle cost, technology insertion, technical support, system engineering support, parts selection, obsolescence management and validation/verification. The emphasis should be on concurrent rather than sequential consideration of these factors in design. Space systems users shall systematically select and proactively monitor their parts supplier base, while information collected from the EEE parts manufacturing and supplier communities shall be organized in a database and shared with IPT members.

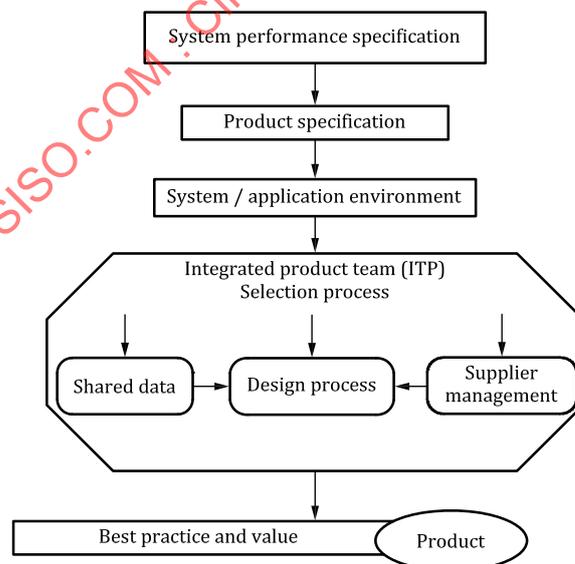


Figure 1 — Parts management IPT overview

4.1.2 Design process

The flow diagram (Figure 2) illustrates the interrelationships of the critical key elements that shall be addressed concurrently by engineering and supplier management (B) (see 4.2), to achieve the “best

practice” selection of EEE parts and documentation required for the initial design. The results obtained from this analysis should be made available as shared data (A) (see [4.3](#)). The following paragraphs describe the principles embodying the ten key elements. Refer to the Introduction.

4.1.3 Design margin

The objective of developing a design margin is to assist integrated product teams with critical analyses resulting in a robust design and minimized life cycle cost. The availability of computer-based analysis and simulation tools presents the opportunity to validate in detail those aspects of design prior to manufacturing/qualification commitment. Creating a design margin analysis based on actual conditions will provide a comprehensive description of EEE part characteristics with simulation results, thereby enhancing system performance. The design margin process ([Figure 3](#)) describes a minimum set of design analyses needed to maximize design robustness and identifies control limits and corrective action procedures. Metrics to validate the process include, but are not limited to, the following:

- a) comparisons of actual design margins to established baselines;
- b) quality of engineering design changes;
- c) qualification test performance (failures);
- d) prediction analysis yield;
- e) manufacturing/production yields.

Associated elements are parts selection ([4.1.8](#)) and technical support ([4.1.6](#)).

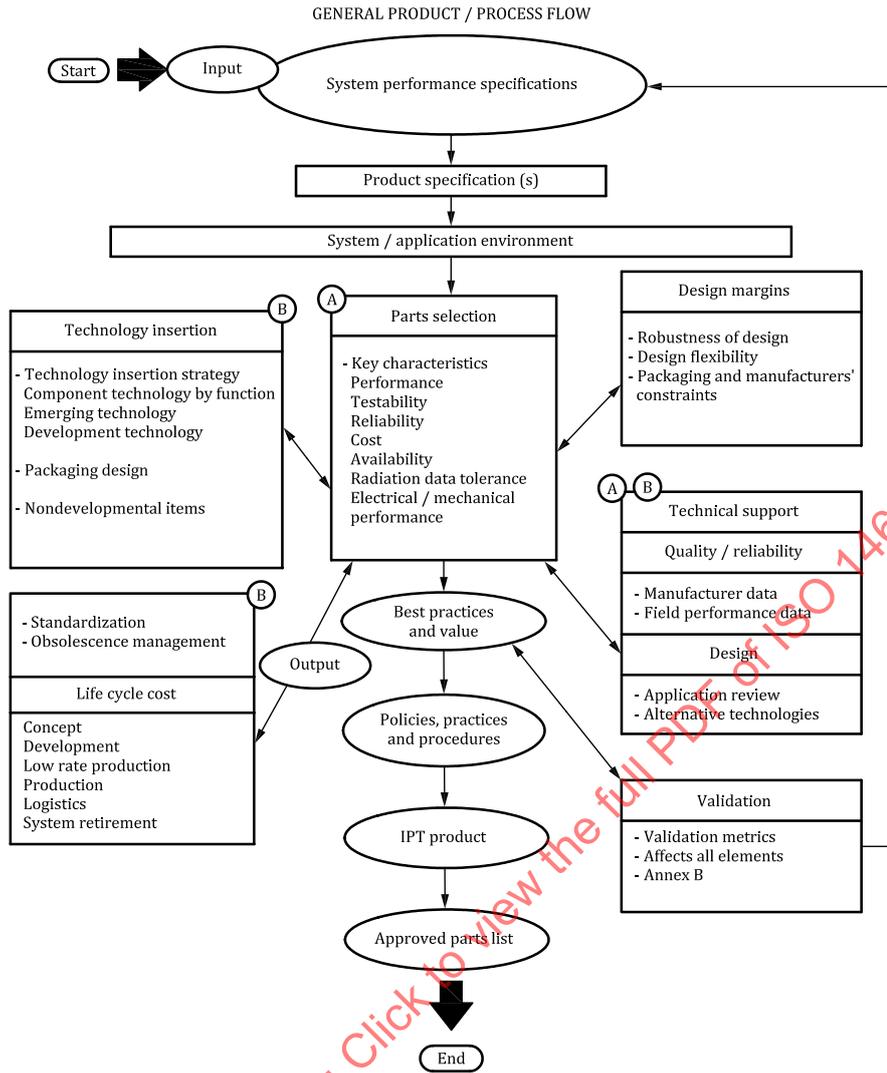


Figure 2 — Systems engineering IPT product

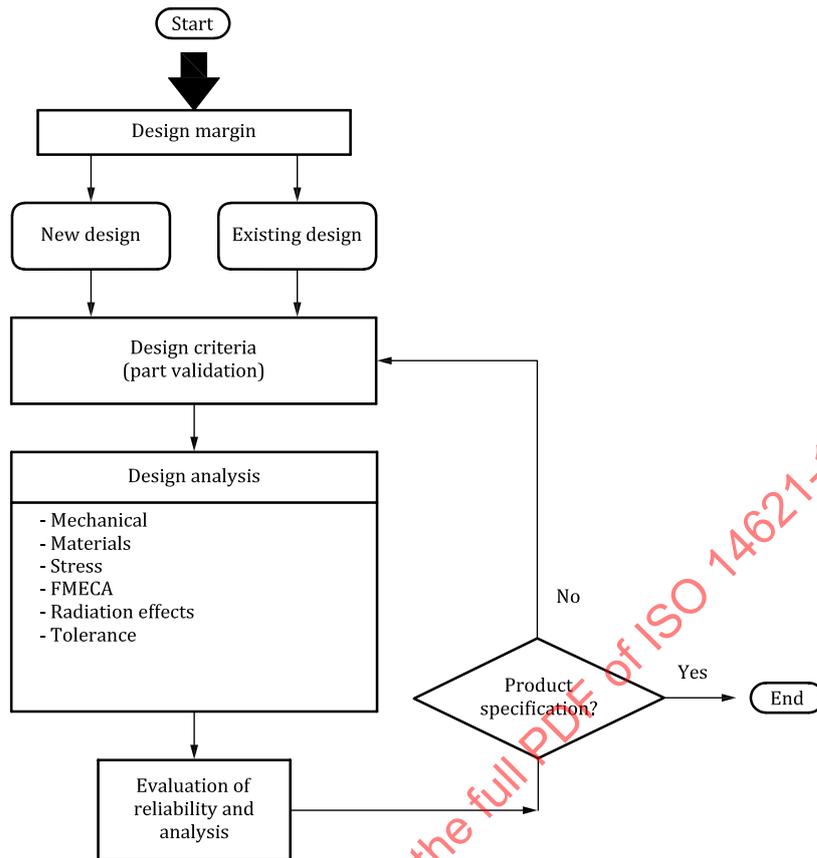


Figure 3 — Design margin process

4.1.4 Life cycle cost

In establishing life cycle cost for EEE parts, the following methods should be employed: identify technology assessment techniques and the mitigation of parts failure risk and utilize procedures that minimize programme disruptions due to parts obsolescence, unavailability, and other unwanted conditions. Life cycle cost analysis should include, as well as define, the EEE parts management programme's baseline and support a programmatic risk management methodology to control cost as well as reduce schedule disruptions throughout the life cycle of the programme (Figure 4).

Standardization techniques are becoming increasingly dependent on the available supplier base and market trends. A new and innovative process being implemented moves away from part number standardization to commodity/technology/family standardization. This concept should provide a lower cost/higher benefit approach as the demand for commercial EEE parts increases.

Factors to be considered include technology maturity, market base, material cost, ease of manufacture, performance management, logistics costs, standardization, and form, fit, function interfaces (F³I). Initial nonrecurring costs should be de-emphasized and rationalized with long-term cost savings to provide the best value to the customer.

Through the implementation of technology assessments, strategic supplier relationships, technology leapfrogging, and creative risk mitigation techniques, programme continuity and integrity can be maintained, and life cycle costs can be minimized.

Validation of the life cycle cost objectives can be accomplished through the use of the following methods:

- a) design-to-cost trade studies documenting parts selected during the design phase including all elements of cost;
- b) periodic programme assessment of life cycle ratings, part technology, and part obsolescence;

- c) periodic price trend analyses for “road map” technologies to validate that costs are declining as the technologies move from introduction and growth to production maturity in the market;
- d) associated elements are:
 - 1) technology insertion strategy (4.1.5),
 - 2) parts selection (4.1.8), and
 - 3) obsolescence management (4.1.9).

4.1.5 Technology insertion strategy

The objective of the technology insertion strategy is to create a technology road map, which minimizes the risk of obsolescence and develops a strategy for technology insertion during the entire life cycle (Figure 5). The commercial industry is driving new technology development of EEE parts. The market dynamics of the industry (availability, functionality, performance, characteristics, and packaging) affect the way parts are used in the design. Technology road maps subdivide technologies into functions, which provide the required visibility to resolve future obsolescence and standardization issues. Use of technology road maps is the key element of the parts selection process. Technology road maps shall be assessed over the life cycle of the programme to validate their effectiveness.

Associated elements are:

- a) design margin (4.1.3),
- b) life cycle costs (4.1.4),
- c) parts selection (4.1.8), and
- d) obsolescence management (4.1.9).

4.1.6 Technical support

Technical support is an all-encompassing activity established to provide a method of obtaining data to facilitate reliability analysis, monitor applications, identify risk issues, and suggest mitigation paths associated with the selected parts (Figure 6). Technical support requires a total commitment by all disciplines and levels of management to ensure success. Specifically, the user shall define his/her reliability requirements. The responsibility for reliability engineering activities shall be established early in the programme in order to minimize the cost of unscheduled redesign, rework, or remanufacture, as well as potential safety problems. Accomplishment of the performance objectives will be enhanced through the application of user and field reliability information from shared data. The shared data and supplier management information should be used in support of the IPT for evaluating sourcing, performance, packaging, and availability. Associated elements of reliability models are

- a) design margin (4.1.3),
- b) parts selection (4.1.8), and
- c) shared data (4.3).

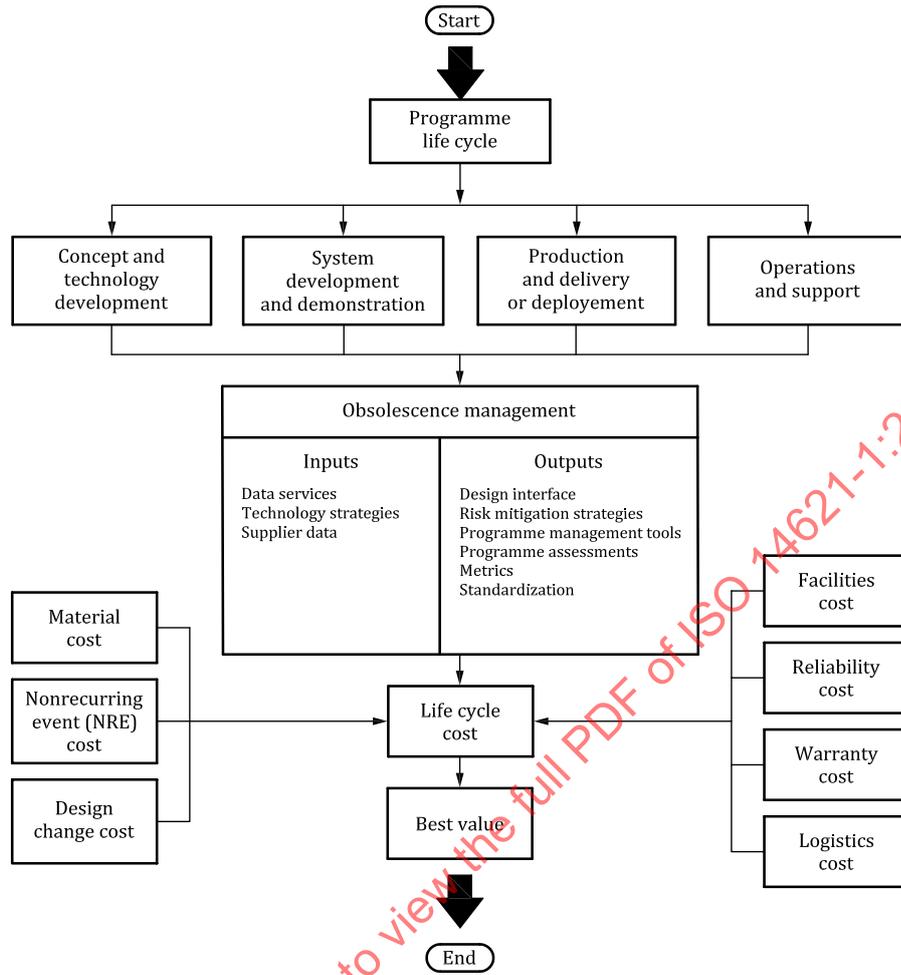


Figure 4 — Life cycle cost process

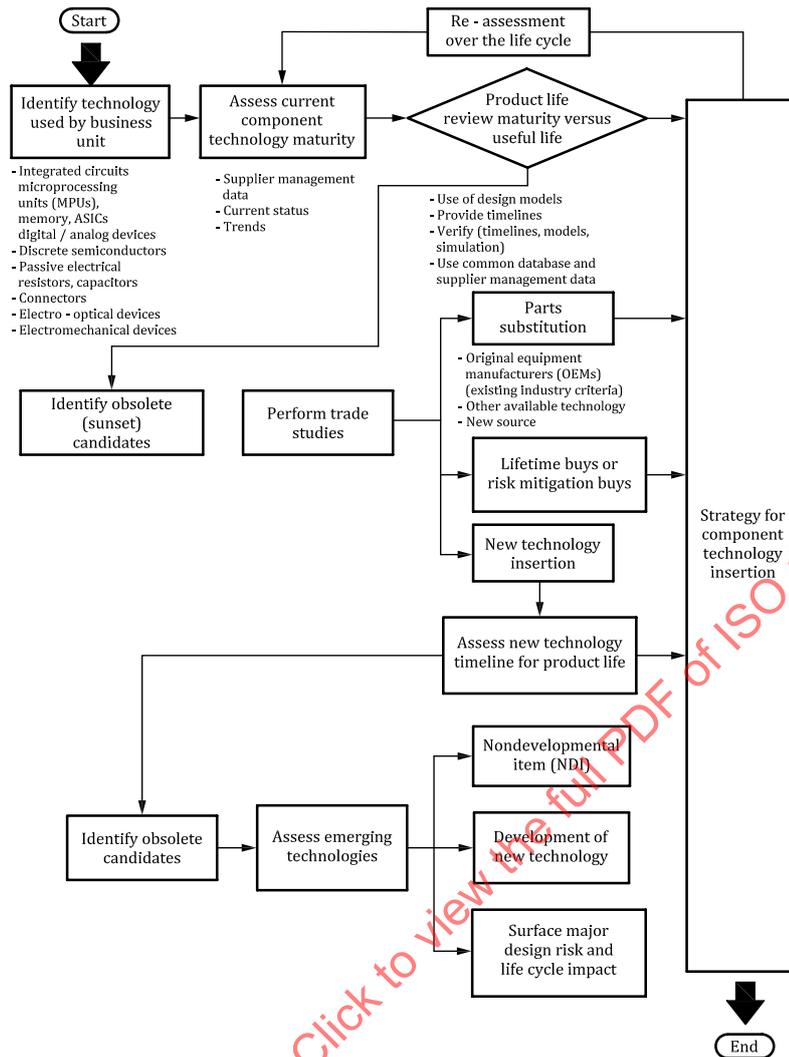


Figure 5 — Technology insertion strategy (road map)

4.1.7 System engineering support

The major engineering disciplines involved in evaluating reliability processes are shown in Table 1. Reliability engineering is just one of the many disciplines required to assess programme development and implementation. Reliability concepts should be developed early in the programme in order to ensure adequate verification techniques are defined. Qualification and verification testing are an integral part of determining system performance characteristics. Failure analysis is a proactive tool for updating reliability models and ensuring system lifetime performance. Reliability growth and pre-qualification testing provide opportunities to reveal design and process deficiencies when they are the least costly to fix or repair or to change the product. Verification testing is equally important in achieving programme reliability goals as well as production processes. Materials and vendors are constantly changing; therefore, the understanding of specific failure modes, fault tree analyses and field performance data should provide a means to identify and correct most reliability problems. During design evaluation, parts manufacturers should identify the use of simulation data [application specific integrated circuits (ASIC's)], interface data, mechanical/thermal robustness, and radiation sensitivity.

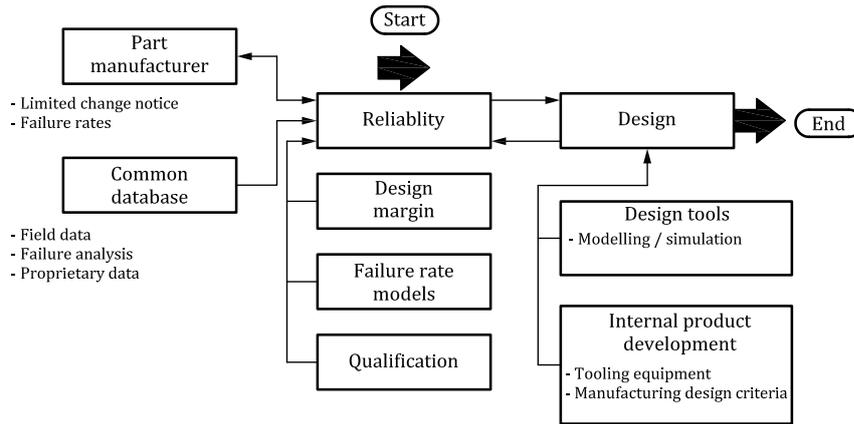


Figure 6 — Technical support

Table 1 — System engineering support functions

Critical processes	Major engineering disciplines										
	System engineering	Configuration management	Quality assurance/reliability engineering	Component engineering	Manufacturing	Process engineering	Designer	Logisticians	Thermal, structural, materials	Test engineering	Safety
Requirements identification and analysis											
System	X	X						X			
Subsystem/configuration items	X	X			X		X	X	X	X	X
Design											
Allocation	X	X					X	X			
Prediction	X		X				X	X	X		
Failure analysis	X		X		X	X	X	X	X		X
Parameter design analysis	X		X	X		X					
Fault tree analysis	X		X	X		X	X	X		X	X
Design reviews	X	X	X	X	X	X	X	X	X	X	X
Part derating	X		X	X	X		X		X		
Process variability	X		X	X		X	X			X	
Risk assessments	X	X	X	X		X	X	X	X	X	X
Verification											
Test	X		X	X	X	X	X	X		X	X
Inspection	X		X	X	X	X	X	X			X
Field data	X		X		X		X	X		X	X

4.1.8 Parts selection

In selecting parts, the objective is to evaluate inputs from all key elements and then select the parts that satisfy the product specification (Figure 7). The selection process is based on determining and assessing the key characteristics of the parts that are under consideration. The process uses existing industry and supplier databases, as established and, where necessary, performs characterization testing.

Parts selected should be assessed for producibility and compatibility with the technology road map. The selection should be made after assessing testability, reliability, radiation tolerance (see Annex A), availability, cost and performance, as appropriate.

Validation of the selection objectives can be accomplished through the use of a checklist (see [Annex B](#)) which ensures completeness of the selection data and results in a best practice product.

4.1.9 Obsolescence management

The primary discipline of obsolescence management is composed of all of the key elements that comprise life cycle cost as shown in [Figure 4](#).

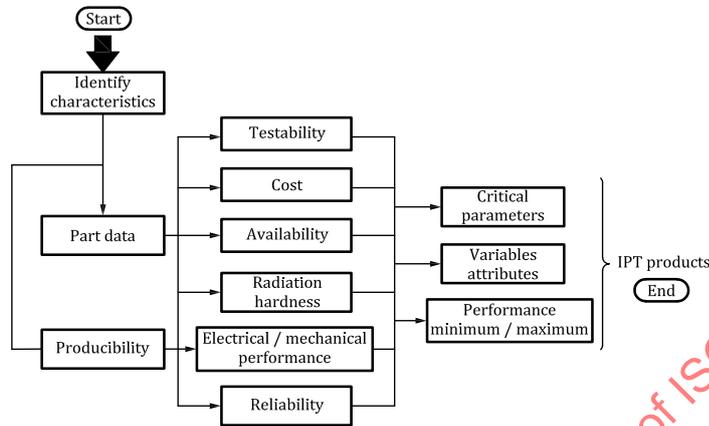


Figure 7 — Parts selection process

4.2 Supplier management

4.2.1 General

Supplier management consists of a supplier selection and monitoring process in which a proactive approach is used to determine the capability and performance of a supplier on a continuing basis ([Figure 8](#)). The attributes of this process are described in [4.2.2](#), [4.2.3](#) and [4.2.4](#). This approach with the suppliers will enable a partnership in the form of IPT's whereby each member will achieve his/her respective business objectives.

4.2.2 Management processes

The objective is to ensure the supplier has documented management practices, which, as a minimum, shall address the following elements.

a) Communications

The supplier shall have a process that facilitates the exchange of information on technical requirements, change notices, contractual issues, and product performance throughout the supply chain.

b) Cost management

The supplier shall have a cost management process that addresses financial resources, life cycle costs, and recurring and nonrecurring costs. The management process should have a cost reduction activity (i.e. a co-ordinated procurement leveraging).

c) Delivery performance

The supplier shall have a process which demonstrates the ability to manage his/her delivery schedules based on history, current and projected resources, capacity and capability.

d) Risk management

The supplier shall have a risk management process, in accordance with ISO 17666, that includes, at a minimum, the ability to identify, assess, mitigate, and track risks related to EEE parts at the mission/system level through the lowest EEE parts level, as applicable. The supplier's risk management process shall be capable of describing the risk in terms of the standard IF-THAN statement, identifying the root causes, and planning and tracking the mitigation/corrective action steps.

Examples of EEE parts risk are obsolescence, health and safety, diminishing sources, process changes, and facility moves.

e) Subcontract management

The supplier shall maintain a process for the development, selection, and ongoing evaluation of subcontract suppliers, consistent with the practices described herein. The selection methodology should be based on evaluation of the subcontract supplier application of this document. The evaluation should assess the subcontract capability to deliver on time, within cost, and in accordance with the specified requirements.

f) Technical requirements management

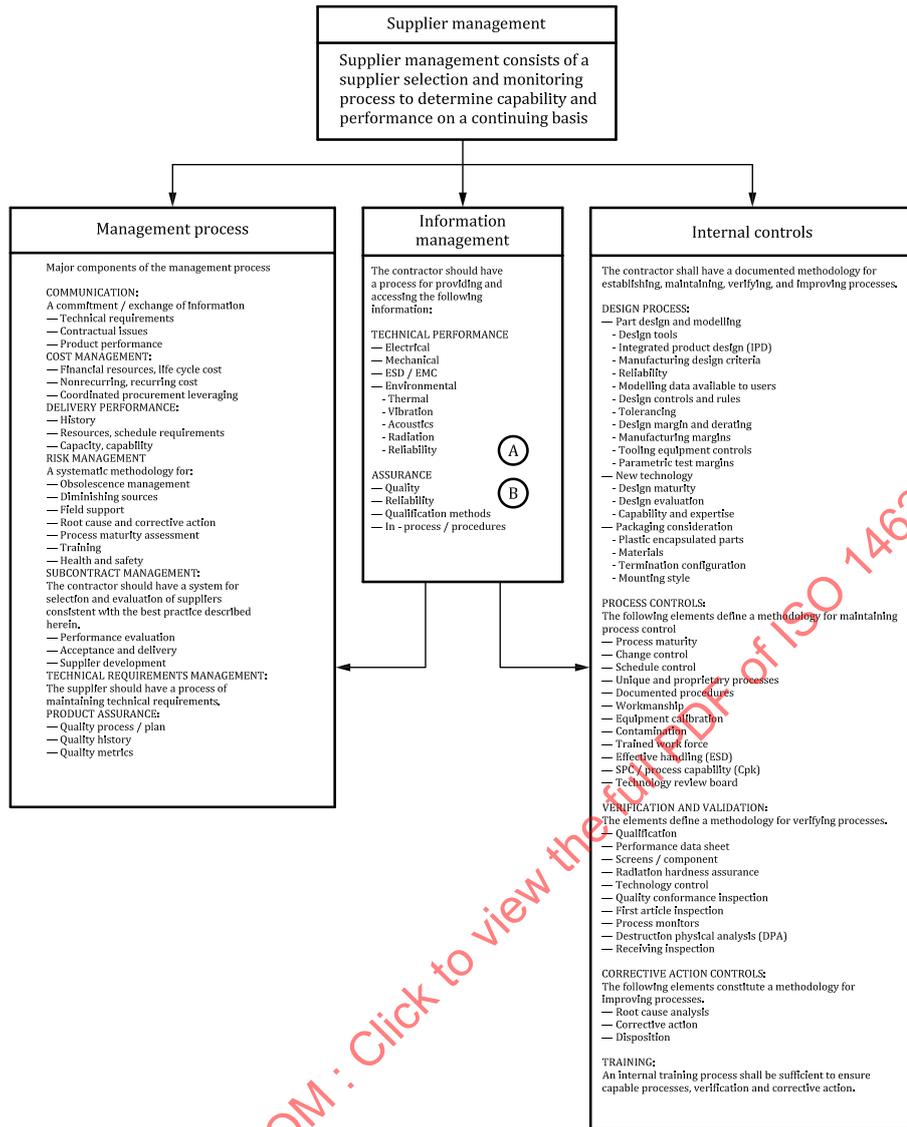
The supplier shall maintain a process for the management of technical requirements. Examples of technical requirements are part design, modelling, design controls, design rules, packaging requirements and life cycle considerations.

g) Product assurance

The supplier shall have a documented parts management plan, to ensure that all parts related requirements are achieved and verifiable throughout the programme life cycle. The product assurance process should monitor progress and provide quality history and quality metrics information.

Independent or self-assessments of the supplier's parts management programme (see [Figure 8](#)) shall be performed periodically throughout the programme life cycle. The type and frequency of assessments shall be determined by the assessment results.

Recommended quality assurance steps include process verification and validation (as defined in [3.1.10](#) and [3.1.12](#)), of the supplier's quality management control system. Qualification or registration to a recognized quality management standard, such as ISO 9001 or qualified manufacturers list (QML) or an equivalent management system standard, should be considered as indicative of an acceptable quality system. If deemed necessary, monitoring of suppliers can be accomplished through on-site evaluations utilizing checklists or other appropriate monitoring systems. A checklist for this activity is provided in [Annex C](#).



Key

- Ⓐ linked to shared data (see 4.3)
- Ⓑ linked to supplier management (see 4.2)

Figure 8 — Supplier management

4.2.3 Information management

This process shall provide technical information for distribution to the industry and government (Figure 8). Refer to 4.3. The supplier should have an information management process for distributing and reporting technical and assurance information. The supplier should also provide support for his/her commodities. Product information should contain such items as electrical and mechanical characteristics, environmental capabilities, and unique characteristics such as electrostatic discharge (ESD) susceptibility, radiation hardness (Annex A), reliability and quality data.

This information as a by-product of the design activity is not only shared with the industrial community but also fed back to the supplier to enhance the design. The supplier should have a system for assembling and maintaining technical information as well as a process for accessing the shared data (4.3).

4.2.4 Internal controls

The supplier shall have a documented methodology for establishing, maintaining, verifying, and improving its processes (Figure 8). The application of internal controls and their sub-elements should be based upon the design and product maturity as it varies within the life cycle.

a) Design process

The supplier shall have a systematic design methodology that is capable of meeting the performance, reliability, and quality requirements as delineated in Figure 2 (systems engineering IPT). The components of the methodology may include part design and modelling, design controls and rules, performance requirements, F³I, and new technology, as well as providing for new packaging considerations, as appropriate.

b) Process controls

The supplier shall have process controls in place in accordance with ISO 14621-2, to ensure consistency in performance, quality and reliability of the product. Specific process controls will depend on the type of product. Examples of the process controls include, but are not limited to, process maturity, change control, schedule control, unique and proprietary processes, documented procedures, workmanship, equipment calibration, contamination, trained work force, effective handling, statistical process control, and technology review board.

c) Validation and verification

The supplier shall have a methodology to verify and validate that the product meets the requirements. These methods may include, but are not limited to, qualification testing, performance data sheet, screens/components, radiation hardness assurance, technology control, quality conformance inspection, first article inspection, process monitors, destructive physical analysis (DPA) and receiving inspection. Special testing (radiation hardness assurance, Annex A) may also be required.

d) Failure reporting, analysis, and corrective action system (FRACAS)

The supplier shall have a closed-loop FRACAS in place to identify the root cause as well as implementing the corrective actions and disposition the resolutions, and to track/monitor the results.

e) Training

The supplier shall have a continuous improvement process in place to provide effectively trained resources on the various processes required to produce a quality product as well as a method to verify the integrity of the product.

4.3 Shared data guidance

A key to improvements in the design, development, and operation of space systems is the ability to share EEE parts information between the various IPTs at the prime contractor, subcontractor, supplier, and customer/user. The sharing of this information will significantly enhance the ability of a programme to manage its risks, in terms of technical performance, cost, and schedule impacts associated with the implementation of this document.

The design and cost benefits of emerging technology and commercial parts can be fully realized only if the data required for their potential use in all environments is developed, documented, and made available for other users.

The establishment and utilization of a space industry-wide EEE parts community alert exchange that focuses on managing peer to peer communication among space industry participants seeking to reduce or eliminate common expenditures of resources, by sharing EEE parts related problem information collected during research, design, development, production, and operational phases of the programme

life cycle, will reduce the life cycle cost associated with redundant testing and qualification and lead to higher levels of EEE parts standardization, reliability, and safety over the life cycle of the programme.

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Annex A (informative)

Radiation effects

A.1 General

This annex provides radiation-hardening guidance to the design process IPT by addressing the concerns and issues necessary to survive radiation environments (see [Figure A.1](#)). Some of these issues include, but are not limited to, total ionizing dose, dose rate, neutrons, electrons, protons, heavy ions, etc.

A.2 System/analysis/environmental

Radiation effects are application-dependent. The precise level of each type of radiation environmental effects typically flows down from the system performance specification. The flow-down may involve some analysis. Definitions of the radiation environmental effects are presented below.

a) Displacement damage

Displacement damage is a semiconductor and material failure mechanism caused by neutron fluence and/or proton fluence. The neutron fluence is usually a manmade radiation source generated by nuclear weapons. The proton fluence is a naturally occurring phenomenon that is observed during solar flares or in orbit through the Van Allen belt.

b) Dose rate

Dose rate is an ionization dose delivered as a function of time such as high-dose rate resulting from a manmade nuclear event or low-dose rate resulting from a natural ionizing radiation environment. The major contributors for high-dose rates are gamma rays and x-rays. The major contributors for low-dose rates are protons and electrons.

c) Electromagnetic pulse (EMP)

EMP is the electromagnetic radiation generated by the interaction of gamma radiation produced by a nuclear explosion with the atmosphere or conductive material in space. Some of the types of EMP are:

- system-generated electromagnetic pulse (SGEMP),
- discharge electromagnetic pulse (DEMP), and
- high-altitude electromagnetic pulse (HEMP).

d) Single event effects (SEE)

SEE are combinations of single event upset (SEU), single event latch up (SEL), single event burnout (SEB), and single event gate rupture (SEGR). These effects result from a heavy ion or other charged particle travelling through an active area of a semi-conducting device depositing sufficient charge to cause one or more of the effects previously described to occur.

e) Spacecraft charging

Typically, spacecraft charging is a naturally occurring build-up of electrons between two types of material or physical structure in space that may exhibit ESD.

f) Total dose (also called total ionizing dose)

Total dose is the cumulative ionizing radiation which the part experiences during its mission life. Examples of contributing sources, from either natural causes or manmade events, are gamma rays, x-rays, protons, electrons, neutrons, and heavy ions (cosmic rays).

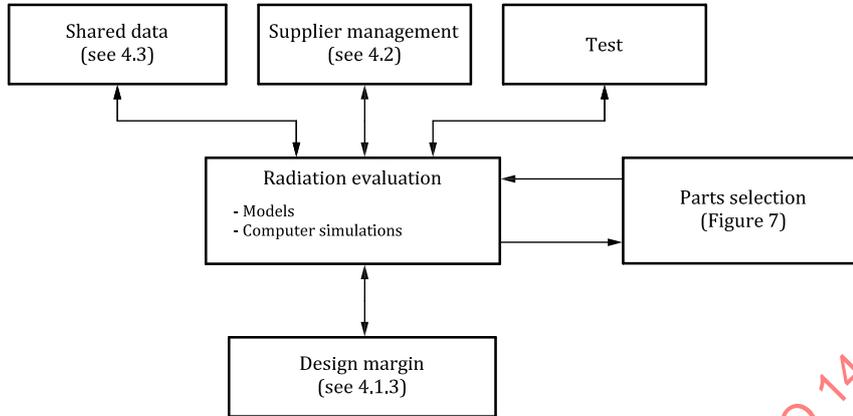


Figure A.1 — Part selection and evaluation process for radiation hardened parts

A.3 Design margin

The design margin process often determines the robustness of the design. Technical support and design information (e.g. critical design parameters, tolerances, and allocations) aid in this process. Some types of analysis used to determine a design margin are:

- circuit analysis,
- shielding analysis,
- system analysis,
- part radiation data analysis, and
- SEU analysis.

Examples of design margin validation criteria are:

- a) high design margin = acceptable, and
- b) low design margin = hardness assurance.

A.4 Parts selection

The following are tools and methods to mitigate the risk of radiation effects. EEE parts and materials can be selected for radiation hardness in the following ways:

- radiation hardened parts;
- design baselines;
- programme-tailored parts;
- part type de-ratings;
- radiation data available;
- low SEU rates;

- part testing;
- radiation analysis;
- exhibit high design margin;
- lifetime buys.

Integrated circuits require more attention during the selection process than most semiconductor devices ([Figure 2](#)). Sensitive technologies can be used but will depend on the circuit as well as the system application. There are handbooks and databases available in the industry that can help in the selection process.

A.5 Technical support

Successful implementation of radiation hardened parts analysis will require a significant amount of support data from various sources. The sources to obtain radiation information can be derived from the common database and supplier management information. Design information required can be obtained from the design engineers and the test data will be critical and can be costly to obtain.

A.6 Technology insertion

Any new technology used in a radiation environment should be assessed for its radiation hardness capability. Some ways to assess the radiation hardness are:

- parts selection ([4.1.8](#)), and
- supplier management ([4.2](#)).

A.7 Life cycle cost

The semiconductor technologies are moving, e.g. from higher operating voltages (currently 5 V) to lower operating voltages. This evolution, coupled with future changes in the design or technology of the part, could have considerable impact on the radiation characteristics. This growth of semiconductor technology has the potential to compromise future design applications, as well as existing designs, and to impact costs over the life cycle of the product. Other changes significant to the life cycle of these parts include scaling down to smaller feature size and die topology reductions.

A.8 Validation/traceability

Radiation performance can be validated by testing and/or analysis.

Traceability of radiation performance may be accomplished in the following manner:

- engineering documentation;
- production control documentation;
- process control documentation and shared data.

Annex B (informative)

Parts selection checklist

The parts selection checklist informs the reader of the subjects that should be assessed or evaluated when developing a parts plan. The elements listed below represent a general checklist, which when combined with [Annex C](#) can form a basis to audit or review internal or external supplier/subcontractor or contractor capabilities.

- a) Review performance specification
- b) Product specification
 - Provide parts requirement
 - All levels of application (environments)
 - Maintain traceable documentation from performance specification to part level
- c) Generate parts control plan
- d) Technology insertion strategy decision process
- e) Assess current technology
 - Highlight part issues/risks
- f) Obsolescence risk mitigation plan
 - Life of type buys
 - Assess alternatives
- g) Provide decision for new technology
 - Assess technology/road map
 - Can require emerging technology
- h) Highlight technology strategy and obsolescence
 - Impact on life cycle cost
- i) Evaluate design process/design margin
- j) Initiate parts selection process
- k) Identify the bill of material (BOM), risk issues
 - Redesign
 - Emerging technology
 - Availability

Annex C (informative)

Subcontractor/supplier management checklist

This checklist is provided for information only and is typical of checklists used with ISO 9001 and other industry-accepted standards. It may be used individually or in conjunction with [Annex D](#), in which case some duplication may exist.

[Table C.1](#) (Part I) focuses on company quality assurance system provisions, while [Table C.2](#) (Part II) is typical of hardware elements, such as EEE parts.

Table C.1 — Part I: Subcontractor assessment checklist

Number	Subcontractor assessment	Yes	No	N/A
I.1	Process controls			
I.1.1	Quality management plan for subcontractor/contractor			
I.1.1.1	Does the subcontractor have a quality management plan?			
I.1.1.2	Does the subcontractor have support and involvement of management in implementing and maintaining the quality management plan?			
I.1.1.3	Does the subcontractor have a documented and implemented plan to select “world class” suppliers?			
I.1.1.4	Does the subcontractor review the supplier's quality management plan?			
I.1.1.5	Does the subcontractor verify that the supplier's quality management plan has the support and involvement of the supplier's management in implementing and maintaining the plan?			
I.1.1.6	Does the subcontractor verify that communication exists at the supplier between design, fabrication, test, and field regarding performance, quality, reliability and failure analysis using statistical techniques?			
I.1.1.7	Does the subcontractor determine if the supplier's quality management plan charts an internal control board or procedure that maintains communication between groups, evaluates data [statistical process control (SPC), reliability, screening, failure analysis, etc.], determines corrective action and maintains records?			
I.1.1.8	Does the subcontractor have the name of a key contact in the internal control board?			
I.1.1.9	Does the subcontractor verify that the supplier's quality plan establishes clear lines of authority and responsibility?			
I.1.1.10	Does the subcontractor verify that the supplier's quality plan provides for periodic internal audits?			
I.1.1.11	Does the subcontractor review the supplier's quality documentation procedures?			
I.1.1.12	Does the subcontractor determine if the supplier has completed a self-assessment of his/her quality management plan			
I.1.1.13	Does the subcontractor evaluate the supplier's self-assessment			
I.1.1.14	Does the subcontractor determine if the supplier is certified for ISO 9001 or equivalent ISO standards?			
I.1.1.15	Does the subcontractor evaluate the supplier's preventive maintenance procedure?			

Table C.1 (continued)

Number	Subcontractor assessment	Yes	No	N/A
I.1.2	Statistical process control (SPC)			
I.1.2.1	Does the subcontractor select suppliers with wafer fabrication and assembly lines in continuous, high-volume production?			
I.1.2.2	Does the subcontractor determine if the supplier has documented and implemented a plan of SPC for wafer and assembly process steps?			
I.1.2.3	Does the subcontractor evaluate the supplier's SPC to determine if sufficient control exists for at least the following wafer fabrication steps?			
	Wafer			
	EPI layers			
	Wafer backside preparation			
	Masks			
	Photolithography			
	Diffusion			
	Ion implantation			
	Annealing			
	Oxide deposition/growth			
	Nitride deposition			
	Polydeposition			
	Metal deposition			
	Dielectric etch			
	Polyetch			
	Metal etch			
	Rework			
	Wafer parametric data			
	Lot acceptance results			
	Reliability test results			
I.1.2.4	Does the subcontractor evaluate the supplier's SPC to determine if sufficient control exists for at least the following assembly steps?			
	Materials			
	Thick film deposition			
	Wafer mount			
	Wafer saw			
	Visual			
	Die attach			
	Wirebond			
	Die encapsulation			
	Visual			
	Moulding compound process			
	Plastic encapsulated microcircuit (PEM)			
	Lid attachment (hermetic)			
	Lead trim and form			
	Lead finish			
	Hermeticity			
	Internal water vapour			
	Electrical test			

Table C.1 (continued)

Number	Subcontractor assessment	Yes	No	N/A
	Mark			
	Dimensions			
I.1.2.5	Does the subcontractor's supplier evaluation criteria recognize the effectiveness of paperless manufacturing lines with computer-aided manufacturing (CAM) systems?			
I.1.2.6	Does the subcontractor's supplier evaluation criteria recognize the effectiveness of computer- automated SPC chart generation?			
I.1.2.7	Does the subcontractor request copies of current SPC control charts?			
I.1.2.8	Does the subcontractor review the supplier's documented SPC goals and metrics?			
I.1.2.9	Does the subcontractor review the supplier's periodic progress reports on SPC goals?			
I.1.2.10	Does the subcontractor review the supplier's procedures for determining target values at critical process nodes?			
I.1.2.11	Does the subcontractor review the supplier's procedures for responding to deficiencies?			
I.1.3	Continuous improvement			
I.1.3.1	Does the subcontractor verify that the supplier has a documented and implemented plan for continuous improvement?			
I.1.3.2	Does the subcontractor verify that a continuous improvement feedback loop exists from test and field operations to design and fabrication regarding yield, performance, and reliability?			
I.1.3.3	Does the subcontractor review the supplier's process/product improvement projects?			
I.1.3.4	Does the subcontractor review process/product improvement metrics?			
I.1.3.5	Does the subcontractor request data on specific process/product improvements and the resulting feedback from field data?			
I.1.3.6	Does the subcontractor's supplier evaluation criteria recognize the effectiveness design of experiments (DoE)?			
I.1.3.7	Does the subcontractor have expertise to review and evaluate the supplier's use of wafer fabrication and assembly yield models (such as Moore, Murphy, Poisson, Seeds, or supplier developed)?			
I.1.4	New product development			
I.1.4.1	Does the subcontractor review the supplier's systems engineering teams that are used to develop new parts?			
I.1.4.2	Does the subcontractor review the supplier's use of proven design rules and standard cells that incorporate process variation statistics?			
I.1.4.3	Does the subcontractor review the supplier's methodology of incorporating reliability data from testing, production, and field into design rules or standard cells?			
I.1.4.4	Does the subcontractor determine if it is supplier policy to qualify all new parts through reliability testing			
I.1.4.5	Does the subcontractor have an acceptable procedure to qualify industrial grade ceramic parts (in particular, regarding the following)?			
	Does supplier produce equivalent military grade part?			
	Is industrial grade part fabricated on same wafer fabrication line as military grade part?			
	Is industrial grade part assembled on same line as military grade part?			
	Is the industrial grade part a downgraded military grade part?			
	Pre-cap visual check performed on 100 % parts			

Table C.1 (continued)

Number	Subcontractor assessment	Yes	No	N/A
	Fine and gross leak test performed on 100 % parts			
	Final electrical tests performed at -40 °C, room temperature and +85 °C or better			
	High temperature operating life			
	Thermal shock			
	Temperature cycling			
	Vibration			
	Acceleration			
	ESD sensitivity			
	Solvent resistance			
	Bond strength			
	Die shear			
	Solderability			
	Lead integrity			
	Salt atmosphere			
	External visual on 100 % parts			
I.1.4.6	Does the subcontractor have an acceptable procedure to qualify plastic encapsulated parts (in particular, regarding the following)?			
	Electrical test at minimum, room and maximum temperatures			
	Preconditioning procedures			
	High temperature operating life			
	Thermal cycling			
	Bond pull			
	Ball shear			
	Die shear			
	Highly accelerated stress test (HAST)			
	Autoclave			
	ESD sensitivity			
	Solderability			
	Salt atmosphere			
	Lead integrity			
I.1.5	Quality control			
I.1.5.1	Does the subcontractor have an acceptable procedure to screen hermetic ceramic parts (in particular, regarding the following)?			
	Pre-burn-in electrical			
	Burn-in			
	Final burn-in electrical			
	External visual check			
I.1.5.2	Does the subcontractor have an acceptable procedure to screen plastic encapsulated parts (in particular, regarding the following)?			
	Pre-burn-in electrical			
	Preconditioning			
	Burn-in			
	Final burn-in electrical			
	External visual check			

Table C.1 (continued)

Number	Subcontractor assessment	Yes	No	N/A
I.1.5.3	If the subcontractor allows the deletion a qualification or screening step listed above, does the subcontractor have sufficient test data to justify omitting the step?			
I.1.5.4	Does the subcontractor obtain copies of the supplier's qualification test data for new parts?			
I.1.5.5	Does the subcontractor re-qualify a part when processes or materials are changed?			
I.1.5.6	Does the subcontractor have sufficient expertise to review and evaluate the supplier's failure analysis on failed parts to determine the physics of failure?			
I.1.5.7	Does the subcontractor review the supplier's corrective action plan to correct defects or out of control processes?			
I.1.5.8	Does the subcontractor review the supplier's change control programme for designs, processes and materials?			
I.1.5.9	Does the subcontractor receive notification when any changes occur to designs, processes, or materials?			
I.1.5.10	Does the subcontractor receive notification when problems with parts are identified and subsequently resolved?			
I.1.5.11	Does the subcontractor require the supplier to have a quality-monitoring programme that periodically performs reliability tests on samples taken from the production lines?			
I.1.5.12	Does the subcontractor receive copies of the periodic quality monitor reports?			
I.1.5.13	Does the subcontractor use industry standard packages?			
I.1.5.14	Does the subcontractor review problem alerts and responses on the supplier's parts or processes?			
I.1.5.15	Does the subcontractor have a list of recommended replacement parts?			
I.1.5.16	Does the subcontractor perform additional testing when a replacement part is used?			
I.2	Part qualification			
I.2.1	Selection criteria			
I.2.1.1	Did the subcontractor follow the supplier selection criteria described in the subcontractor's parts management plan?			
I.2.1.2	Did the subcontractor follow the part selection criteria described in the subcontractor's parts management plan?			
I.2.1.3	Does the subcontractor's evaluation of part qualification and screening data follow the documented procedures in the subcontractor's parts management plan?			
I.2.1.4	Does the subcontractor have sufficient data to ensure that the subsystem will meet all electrical performance requirements using the selected parts?			
I.2.1.5	Does the subcontractor have sufficient data to ensure that the subsystem will meet all thermal requirements using the selected parts?			
I.2.1.6	Does the subcontractor have sufficient data to ensure that the subsystem will meet all mechanical requirements using the selected parts?			
I.2.1.7	Does the subcontractor have sufficient data to ensure that the subsystem will meet all reliability requirements using the selected parts?			
I.2.1.8	Does the subcontractor have sufficient data to ensure that the subsystem has acceptable compatibility of materials and processes using the selected parts?			

Table C.1 (continued)

Number	Subcontractor assessment	Yes	No	N/A
I.2.1.9	Does the next level assembly require performance of the part that is near the specification limits or is there sufficient margin?			
I.2.1.10	Are there multiple sources for the part?			
I.2.1.11	Does the subcontractor provide adequate assurance that the part will be available for both the short and long term? If not, is there an acceptable obsolescence plan?			

Table C.2 — Part II: Supplier assessment checklist for EEE part

Number	Supplier assessment	Yes	No	N/A
II.1	Process controls			
II.1.1	Quality management plan			
II.1.1.1	Does the supplier have a documented and implemented quality management plan?			
II.1.1.2	Does the supplier have support and involvement of management in implementing and maintaining the quality management plan?			
II.1.1.3	Does the quality management plan require communication between design, fabrication, test, and field regarding performance, quality, reliability, and failure analysis using statistical techniques?			
II.1.1.4	Does the quality management plan charter an internal control board (i.e. similar to a technical review board) that maintains communication between groups, evaluates data (SPC, reliability, screening, failure analysis, etc.), determines corrective action, and maintains records?			
II.1.1.5	Will the supplier supply the name of a key contact in the internal control board?			
II.1.1.6	Does the quality plan establish clear lines of authority and responsibility?			
II.1.1.7	Does the quality plan provide for periodic internal audits?			
II.1.1.8	Does the quality plan require documentation of audits and follow-up actions?			
II.1.1.9	Has the supplier completed a self-assessment of his/her quality management plan?			
II.1.1.10	Are the results of the self-assessment of the quality management plan available for review?			
II.1.1.11	Is the supplier certified for ISO 9001 or equivalent ISO standards?			
II.1.1.12	Does the supplier have an effective preventive maintenance procedure?			
II.1.2	Statistical process control (SPC)			
II.1.2.1	Are the supplier's wafer fabrication and assembly lines in continuous, high-volume production?			
II.1.2.2	Has the supplier documented and implemented a plan of SPC for wafer and assembly process steps?			
II.1.2.3	Does the supplier have sufficient SPC control for at least the following wafer fabrication steps?			
	Wafer			
	EPI layers			
	Wafer backside preparation			
	Masks			
	Photolithography			

Table C.2 (continued)

Number	Supplier assessment	Yes	No	N/A
	Diffusion			
	Ion implantation			
	Annealing			
	Oxide deposition / growth			
	Nitride deposition			
	Poly deposition			
	Metal deposition			
	Dielectric etch			
	Poly etch			
	Metal etch			
	Rework			
	Wafer parametric data			
	Lot acceptance results			
	Reliability test results			
II.1.2.4	Does the supplier have sufficient SPC control for at least the following assembly steps?			
	Materials			
	Thick film deposition			
	Wafer mount			
	Wafer saw			
	Visual			
	Die attach			
	Wirebond			
	Die encapsulation			
	Visual			
	Moulding compound process			
	PEM			
	Lid attachment (hermetic)			
	Lead trim and form			
	Lead finish			
	Hermeticity			
	Internal water vapour			
	Electrical test			
	Mark			
	Dimensions			
II.1.2.5	Does the supplier have a paperless manufacturing line with a computer-aided manufacturing (CAM) system?			
II.1.2.6	Does the supplier use computer-automated SPC chart generation instead of manually plotted SPC charts?			
II.1.2.7	Is the supplier willing to provide copies of current SPC control charts?			
II.1.2.8	Does the supplier have documented SPC goals with metrics?			
II.1.2.9	Does the supplier have periodic progress reports on SPC goals?			
II.1.2.10	Does the supplier have documented procedures for determining target values at critical process nodes?			

Table C.2 (continued)

Number	Supplier assessment	Yes	No	N/A
II.1.2.11	Does the supplier have a documented procedure for responding to deficiencies?			
II.1.3	Continuous improvement			
II.1.3.1	Does the supplier have a documented and implemented plan for continuous improvement?			
II.1.3.2	Does a continuous improvement feedback loop exist from test and field operations to design and fabrication regarding yield, performance and reliability?			
II.1.3.3	Has the supplier identified specific process/product improvement projects?			
II.1.3.4	Does the supplier have process/product improvement metrics that show appropriate improvements over time?			
II.1.3.5	Is the supplier willing to provide data on specific process/product improvements and the resulting feedback?			
II.1.3.6	Does the supplier utilize design of experiments (DoE)?			
II.1.3.7	Does the supplier use a wafer fabrication and assembly yield model developed specifically for his/her processes instead of a standard model (such as Moore, Murphy, Poisson, Seeds, etc.)?			
II.1.4	New product development			
II.1.4.1	Does the supplier utilize systems engineering integrated product teams (IPTs) when developing new parts?			
II.1.4.2	Does the supplier use proven design rules and standard cells that incorporate process variation statistics?			
II.1.4.3	Does the supplier incorporate reliability data from testing, production and field into design rules or standard cells?			
II.1.4.4	Is it supplier policy to qualify all new parts through reliability testing?			
II.1.4.5	Does the supplier have an acceptable procedure to qualify industrial grade ceramic parts (in particular, with regard to the following)?			
	Does the supplier produce equivalent military grade part?			
	Is industrial grade part fabricated on same wafer fabrication line as military grade part?			
	Is industrial grade part assembled on same line as military grade part?			
	Is industrial grade part a downgraded military grade part?			
	Pre-cap visual check performed on 100 % parts			
	Fine and gross leak test performed on 100 % parts			
	Final electrical tests performed at -40 °C, room temperature and +85 °C or better			
	High temperature operating life			
	Thermal shock			
	Temperature cycling			
	Vibration			
	Acceleration			
	ESD sensitivity			
	Solvent resistance			
	Bond strength			
	Die shear			
	Solderability			
	Lead integrity			

Table C.2 (continued)

Number	Supplier assessment	Yes	No	N/A
	Salt atmosphere			
	External visual on 100 % parts			
II.1.4.6	Does the supplier use acceptable procedures to qualify plastic encapsulated parts (in particular, regarding the following)?			
	Electrical tests at minimum, room and maximum temperatures			
	Preconditioning procedures			
	High temperature operating life			
	Thermal cycling			
	Bond pull			
	Ball shear			
	Die shear			
	Highly accelerated stress test (HAST)			
	Autoclave			
	ESD sensitivity			
	Solderability			
	Salt atmosphere			
	Lead integrity			
II.1.5	Quality control			
II.1.5.1	Does the supplier use acceptable procedures to screen hermetic ceramic parts (in particular, regarding the following)?			
	Pre-burn-in electrical			
	Burn-in			
	Final electrical			
	External visual			
II.1.5.2	Does the supplier use acceptable procedures to screen plastic encapsulated parts (in particular, regarding the following)?			
	Pre-burn-in electrical			
	Preconditioning			
	Burn-in			
	Final electrical			
	External visual			
II.1.5.3	If the supplier does not or will not perform a qualification or screening step listed above, does the supplier have sufficient test data to justify omitting the step?			
II.1.5.4	Is the supplier willing to provide qualification test data for new parts?			
II.1.5.5	Is it supplier policy to re-qualify a part when processes or materials are changed?			
II.1.5.6	Does the supplier perform failure analysis on failed parts to determine the physics of failure?			
II.1.5.7	Does the supplier have a corrective action plan to correct defects or out-of-control processes?			
II.1.5.8	Does the supplier have a change control programme for designs, processes, and materials?			
II.1.5.9	Is the supplier willing to notify customers when any changes to designs, processes, or materials occur?			
II.1.5.10	Is the supplier willing to notify customers when problems with parts are identified and subsequently resolved?			

Table C.2 (continued)

Number	Supplier assessment	Yes	No	N/A
II.1.5.11	Does the supplier have a quality-monitoring programme that periodically performs reliability tests on samples taken from the production lines?			
II.1.5.12	Are copies of the periodic quality monitor reports available?			
II.1.5.13	Does the supplier use industry standard packages?			
II.1.5.14	Does the supplier have excessive problem notification/alerts on his/her parts or processes? Are responses to alerts acceptable?			
II.1.5.15	Does the supplier (or subcontractor) have a list of recommended non-MIL replacement parts?			
II.1.5.16	Does the supplier recommend additional testing when a replacement part is used?			
II.2	Part qualification			
II.2.1	Design			
II.2.1.1	Were proven design rules or standard cells used for the design of the part?			
II.2.1.2	Was reliability data from testing, production, and field incorporated into the design rules or standard cells for this part?			
II.2.1.3	Did the supplier exercise sufficient design control, verification, prototyping, and qualification for the part?			
II.2.1.4	Did the supplier include the full operating temperature range in the part design?			
II.2.1.5	Has material compatibility been addressed in part design (in particular, regarding dissimilar metals used in wire bonding)?			
II.2.1.6	Are cleaning materials compatible with part materials, both internal and external? In particular, will cleaning materials corrode part materials? Have long-term effects been considered?			
II.2.1.7	Were coefficients of thermal expansion considered when designing and processing parts?			
II.2.1.8	Are there any potential areas where part reliability may be affected during environmental stress testing due to mismatches in coefficients of thermal expansion?			
II.2.1.9	Does the next level assembly require performance of the part that is near the specification limits or is there sufficient margin?			
II.2.2	Manufacturing			
II.2.2.1	Is the part a high-volume, continuous production, catalogue part?			
II.2.2.2	Does the supplier use statistical techniques to establish, control, and verify fabrication processes and performance characteristics?			
II.2.2.3	Are the processes and equipment used to fabricate the part common to a family of parts?			
II.2.2.4	Are there multiple sources for the part?			
II.2.2.5	Does the supplier provide adequate assurance that the part will be available for both the short and long term? If not, is there an acceptable obsolescence plan?			
II.2.2.6	Does the supplier have documented procedures to inspect and control materials used to fabricate the part?			
II.2.2.7	Does the supplier have documented process instructions, lot travellers, and SPC control points for wafer fabrication? In particular, is there sufficient control for at least the following steps?			
	Wafer			
	EPI layers			

Table C.2 (continued)

Number	Supplier assessment	Yes	No	N/A
	Wafer backside preparation			
	Masks			
	Photolithography			
	Diffusion			
	Ion implantation			
	Annealing			
	Oxide deposition/growth			
	Nitride deposition			
	Polydeposition			
	Metal deposition			
	Dielectric etch			
	Polyetch			
	Metal etch			
	Rework			
	Wafer parametric data			
	Lot acceptance results			
	Reliability test results			
II.2.2.8	Does the supplier have documented process instructions, lot travelers, and SPC control points for hermetic part assembly? In particular, is there sufficient control for at least the following steps?			
	Wafer mount			
	Wafer saw			
	Visual			
	Material composition			
	Die attach			
	Wirebond			
	Die encapsulation			
	Visual			
	Lid attach			
	Lead trim and form			
	Lead finish			
	Electrical test			
	Hermeticity			
	Internal water vapour			
	Mark			
	Dimensions			
II.2.2.9	Does the supplier have documented process instructions, lot travelers, and SPC control points for moulded part assembly? In particular, is there sufficient control for at least the following steps?			
	Wafer mount			
	Wafer saw			
	Visual			
	Lead frame composition			
	Die attach			
	Wire bond			

Table C.2 (continued)

Number	Supplier assessment	Yes	No	N/A
	Visual			
	Epoxy moulding compound composition			
	Moulding process parameters			
	Postmould cure			
	Deflash			
	Lead trim and form			
	Lead finish			
	Electrical test			
	Mark			
	Dimensions			
II.2.3	Test			
II.2.3.1	How does the supplier qualify the part if it is industrial grade hermetic ceramic (in particular, regarding the following)?			
	Does the supplier produce equivalent QML/QPL grade part?			
	Is the industrial grade part fabricated on the same wafer fabrication line as QML/QPL part?			
	Is the industrial grade part assembled on the same line as QML/QPL part?			
	Verify that industrial grade part is not a downgraded QML/qualified parts list (QPL) part			
	Pre-encapsulation visual check performed on 100 % of parts			
	Fine and gross leak test performed on 100 % parts			
	Final electrical tests performed at -40 °C, room temperature and +85 °C or better			
	High temperature operating life			
	Thermal shock			
	Temperature cycling			
	Vibration			
	Acceleration			
	ESD sensitivity			
	Solvent resistance			
	Bond strength			
	Die shear			
	Solderability			
	Lead integrity			
	Salt atmosphere			
	External visual on 100 % parts			
II.2.3.2	How does the supplier qualify the part if it is plastic encapsulated (in particular, regarding the following)?			
	Electrical test at minimum room and maximum temperatures			
	Preconditioning procedures			
	High temperature operating life			
	Thermal cycling			
	Bond pull			
	Ball shear			