INTERNATIONAL STANDARD

ISO 14621-1

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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

Reference number
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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.

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.

ISO 14621-1 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

ISO 14621 consists of the following parts, under the general title *Space systems — Electrical, electronic and electromechanical (EEE) parts*:

— *Part 1: Parts management*

— *Part 2: Control programme requirements*

Introduction

This part of ISO 14621 is a document designed to assist the user community in developing a parts programs by providing a descriptive process for the design, selection and application of space parts. The strategy represented in this document is a system approach to managing risk at the start of the program by selecting the right part for the application. Utilizing this part of ISO 14621 to its fullest potential means understanding the new business environment which embodies some newly accepted business challenges.

This part of ISO 14621 discusses the following 10 key elements that support this new business environment:

— Part obsolescence management — minimize program disruption and ensure long-term supportability throughout the program life cycle.

— Supplier management — establish teaming partnerships with key suppliers to improve delivery and lower cost.

— Standard supplier assessments — eliminate redundant efforts and non-value added evaluations.

— Cost management — realize significant cost reduction on existing and new programs.

— Technology insertion — focus on utilizing technologies with lowest life cycle cost and maximum longevity.

— Communication information exchange — share contractor data via innovative concepts.

— Process control — validate supplier techniques for monitoring critical manufacturing processes.

— Oversight — transition customer oversight to integrated product team (IPT) insight and participation by the customer.

— Concurrent engineering — encourage parts engineering participation in all phases of the product life cycle.

— Training — establish program awareness of reformed acquisition strategy throughout all levels of the user community.

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 part of ISO 14621. It is the responsibility of the user community to establish, define and administer those tasks based on the program goals and objectives and thus provides the “what” elements envisioned and allows users the opportunity to establish their appropriate criteria for their program.

Although this part of ISO 14621 was written with the intent of covering EEE parts, the concept established is a system approach for developing a EEE parts program with reference to specific material and mechanical processes that make up EEE parts.

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

Part 1: Parts management

1 Scope

This part of ISO 14621 addresses the preferred programme elements recommended for EEE parts. This part of ISO 14621 is written in general terms as a baseline for developing and implementing a parts programme.

2 Terms definitions, abbreviated terms and acronyms

2.1 Terms and definitions

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

2.1.1
best practice
documented process or product developed by the user community, consisting of suppliers and customers, teaming for the purpose of establishing industry guidelines

2.1.2
integrated product team
IPT
integrated product team consisting of members selected from the appropriate disciplines

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

2.1.3
IPT product
product conceived through “best practice” design process with respect to the bill of materials and documentation for the hardware as described by the product specification

2.1.4
manufacturer
company or organization that transfers raw material into a product

2.1.5
part
device that performs an electronic, electrical, or electromechanical (EEE) function and consists of one or more elements so joined together that they cannot normally be disassembled without destroying the functionality of the device

2.1.6
performance specification
document that defines what the customer desires as a product, its operational environments and all required performance characteristics

2.1.7
product specification
document that defines the end item(s) the supplier intends to provide to satisfy all the performance specification requirements

2.1.8
reliability engineering
integral part of the system engineering requirements definition and analysis function

NOTE The tasks are to conduct cost/benefit trade-offs and to analyse and determine alternative design and procurement solutions.

2.1.9
sunset
products/parts that have reached shelf-life expectancy

2.1.10
systems engineering
an interdisciplinary, collaborative approach to derive, evolve and verify a life-cycle balanced system solution which satisfies customer expectations and meets public acceptability

2.1.11
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 This process is used in the concept development phase, but also impacts the production and field support phases.

2.1.12
validation
confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled

[ISO 9000:2000]

2.1.13
vendor
seller of parts, products, or commodities; may be interchangeable with manufacturer, depending on the application

2.1.14
verification
confirmation, through the provision of objective evidence that specified requirements have been fulfilled

[ISO 9000:2000]

2.2 Abbreviated terms and acronyms

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^3I	form, fit, function interfaces
HAST	highly accelerated stress test
HEMP	high altitude electromagnetic pulse
IPD	integrated product design
IPT	integrated product team
MPU	microprocessing unit
NDI	nondevolopmental 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
WWW	world wide web

3 Parts management

3.1 Parts management process

3.1.1 General

The process employed within this part of ISO 14621 was developed to assist in dealing more proactively with critical parts management issues and to provide guidance for developing comprehensive strategies to manage cost and schedule risk via an integrated product team (IPT) process (Figure 1). The main aspects of the 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. Supplier management proactively selects and monitors the supplier base, while information generated from the design and supplier management processes are organized in a database to be shared with IPT members in reducing cost and improving schedule performance.

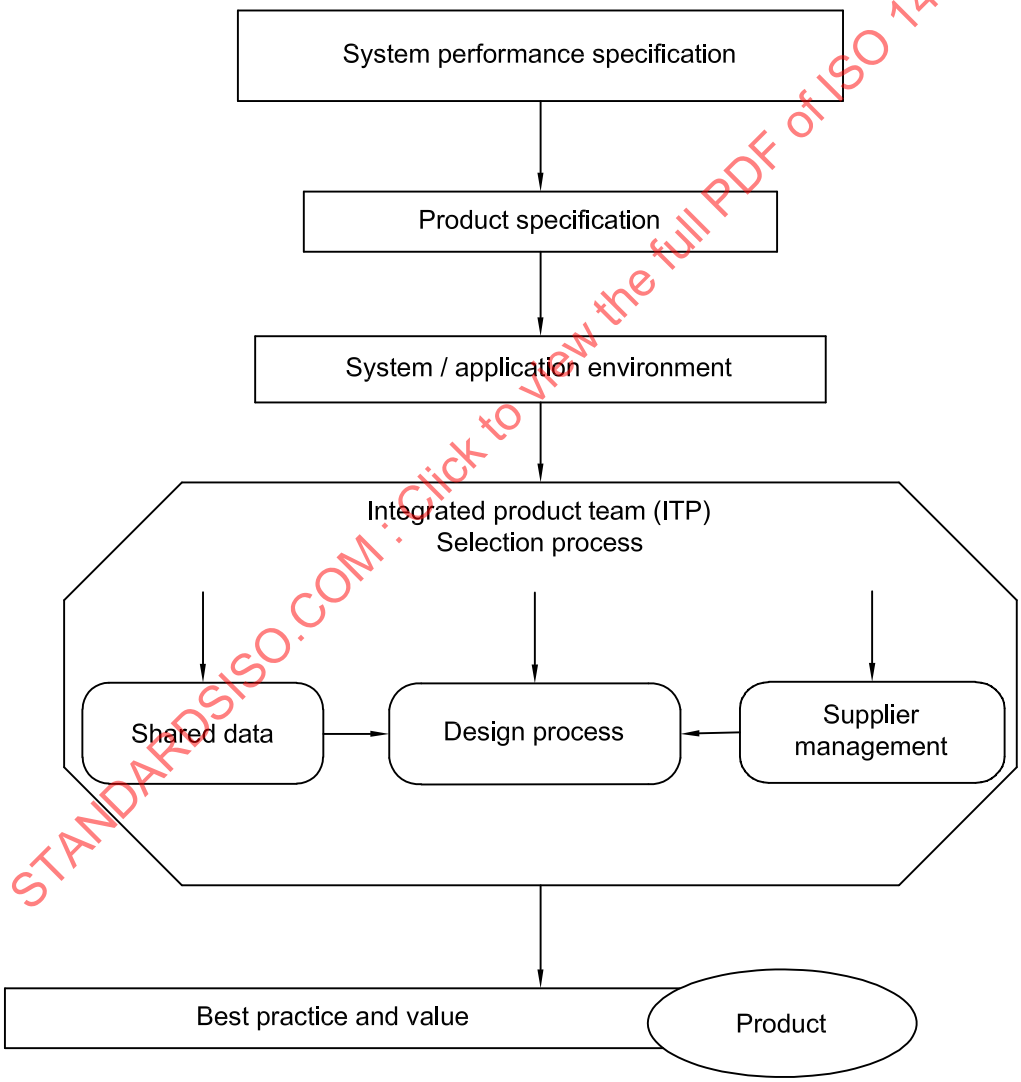

Figure 1 — Parts management IPT overview

3.1.2 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 3.2), 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 3.3. The following paragraphs describe the principles embodying the ten key elements. Refer to the introduction.

3.1.3 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 (3.1.8) and technical support (3.1.6).

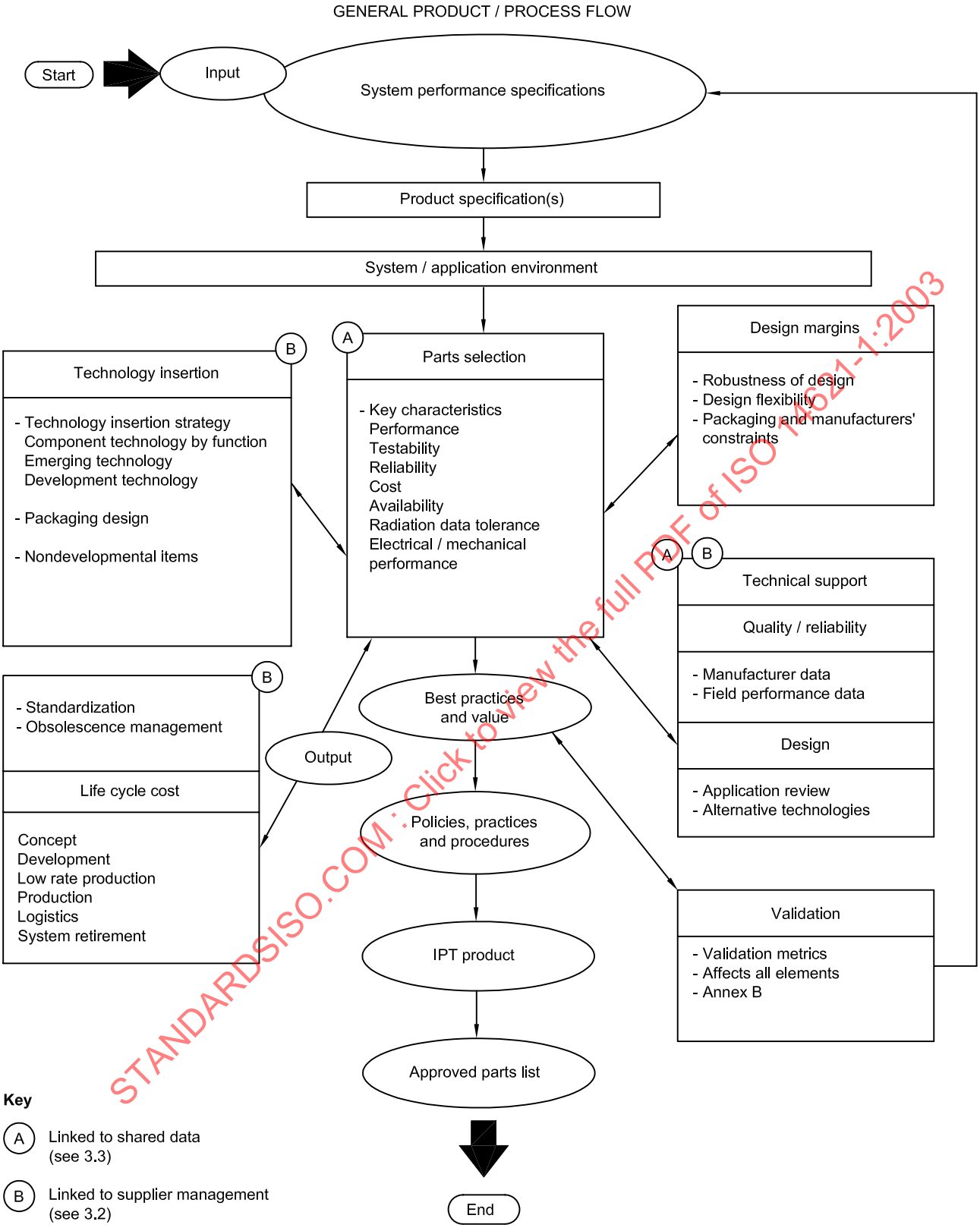

Figure 2 — Concurrent engineering IPT product

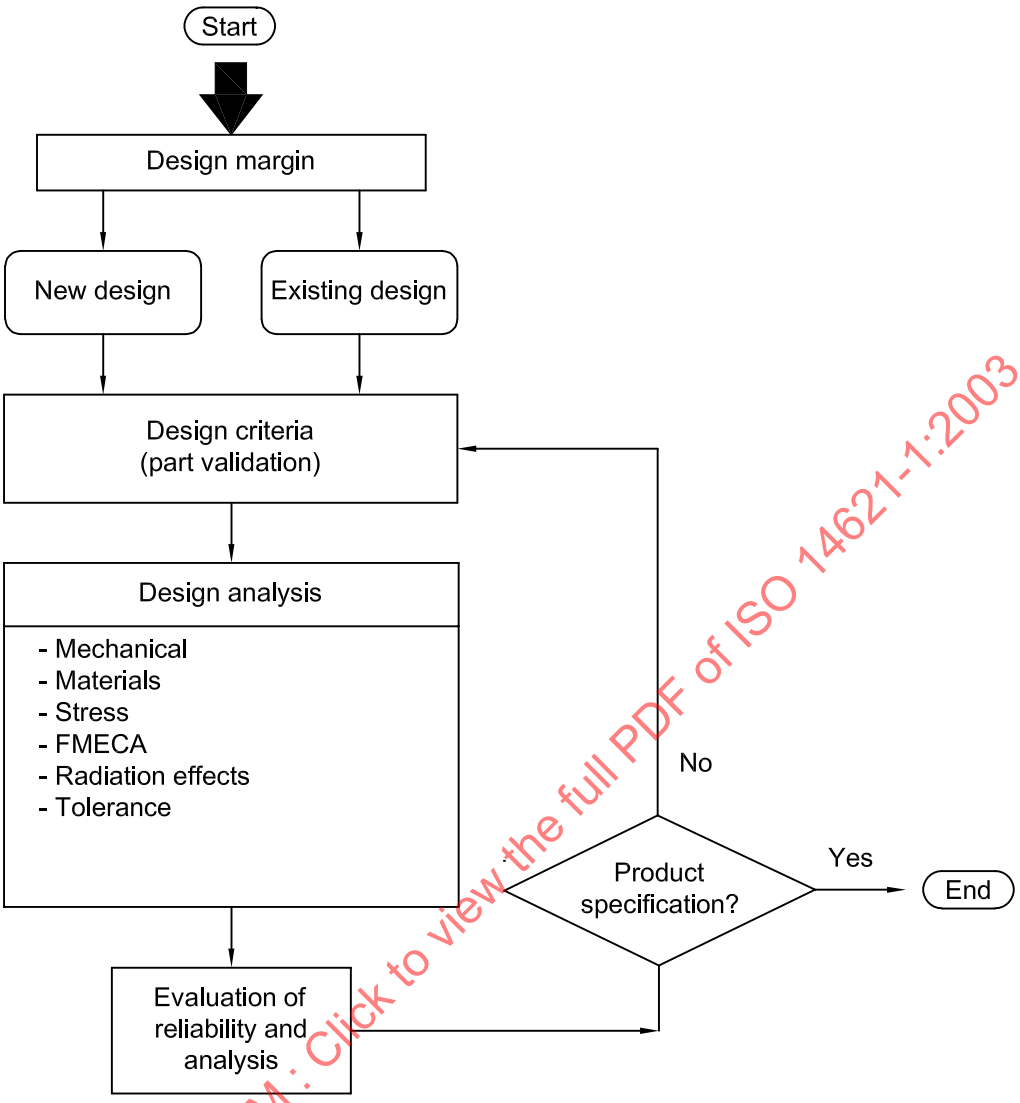

Figure 3 — Design margin process

3.1.4 Life cycle cost

In establishing life cycle cost for EEE parts, the following methods should be employed: identify technology assessment techniques and the risk of part mitigation and utilize procedures that minimize programme disruption (parts obsolescence). This process (analysis) should include as well as define the parts programme baseline and support a methodology to lower cost as well as reduce schedule disruption (programme risk) for the life 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 (F^3I). 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, program 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 (3.1.5),

   2) parts selection (3.1.8),

   3) obsolescence management (3.1.9).

3.1.5 Technology insertion strategy

The objective of the technology insertion strategy is to create a technology road map, which minimizes 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 of their program to validate their effectiveness.

Associated elements are

a) design margin (3.1.3),

b) life cycle costs (3.1.4),

c) parts selection (3.1.8),

d) obsolescence management (3.1.9).

3.1.6 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 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 (3.1.3),

b) parts selection (3.1.8),

c) shared data (3.3).

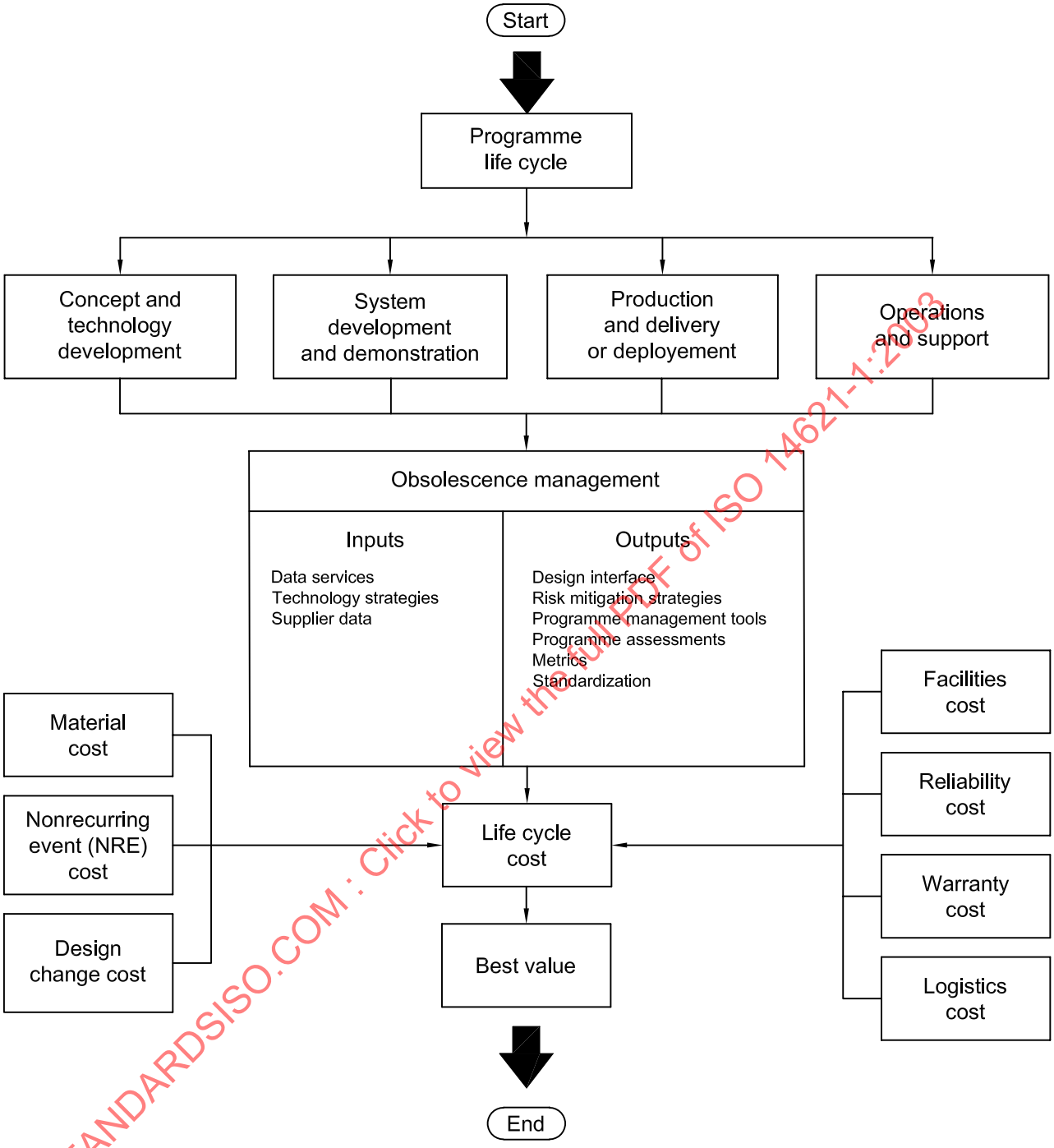

Figure 4 — Life cycle cost process

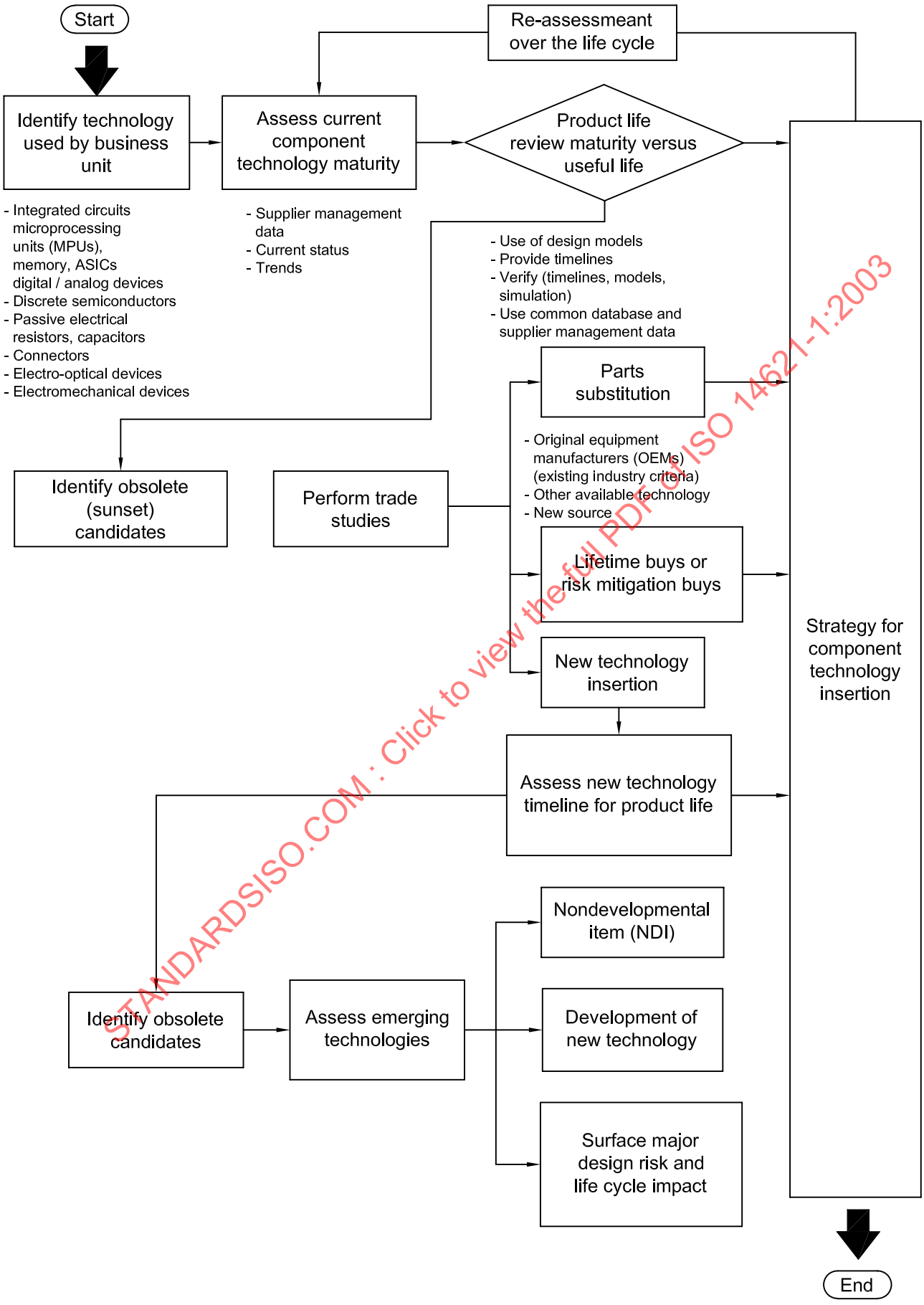

Figure 5 — Technology insertion strategy (road map)

3.1.7 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, and mechanical/thermal robustness and radiation sensitivity.

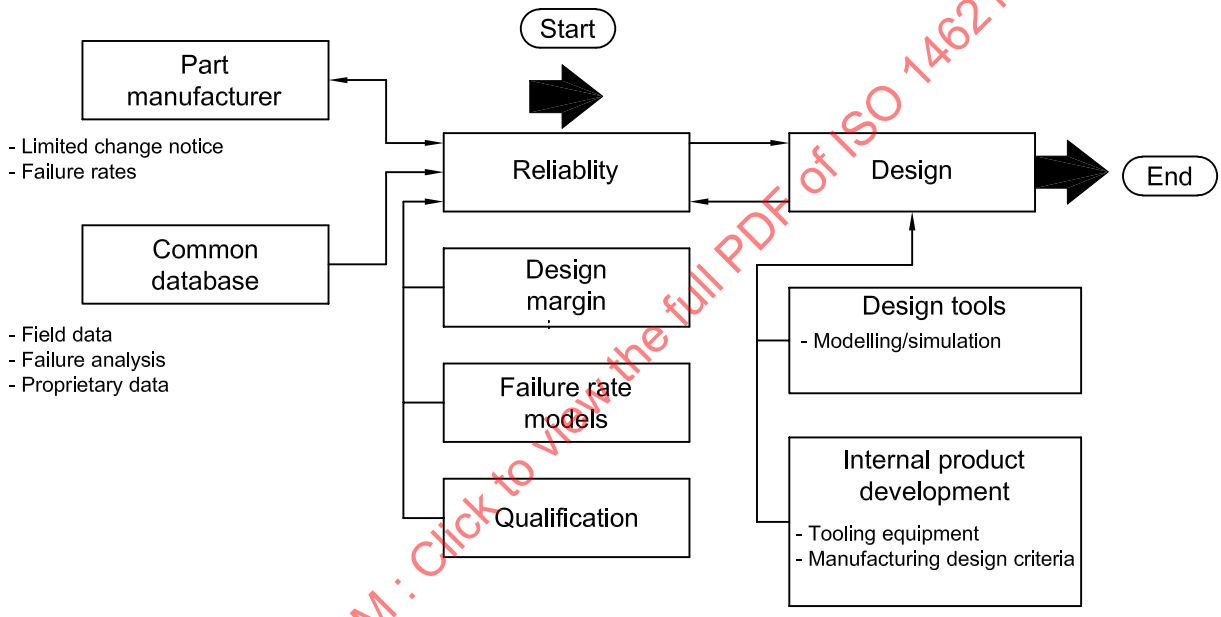

Figure 6 — Technical support

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

3.1.8 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.

3.1.9 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.

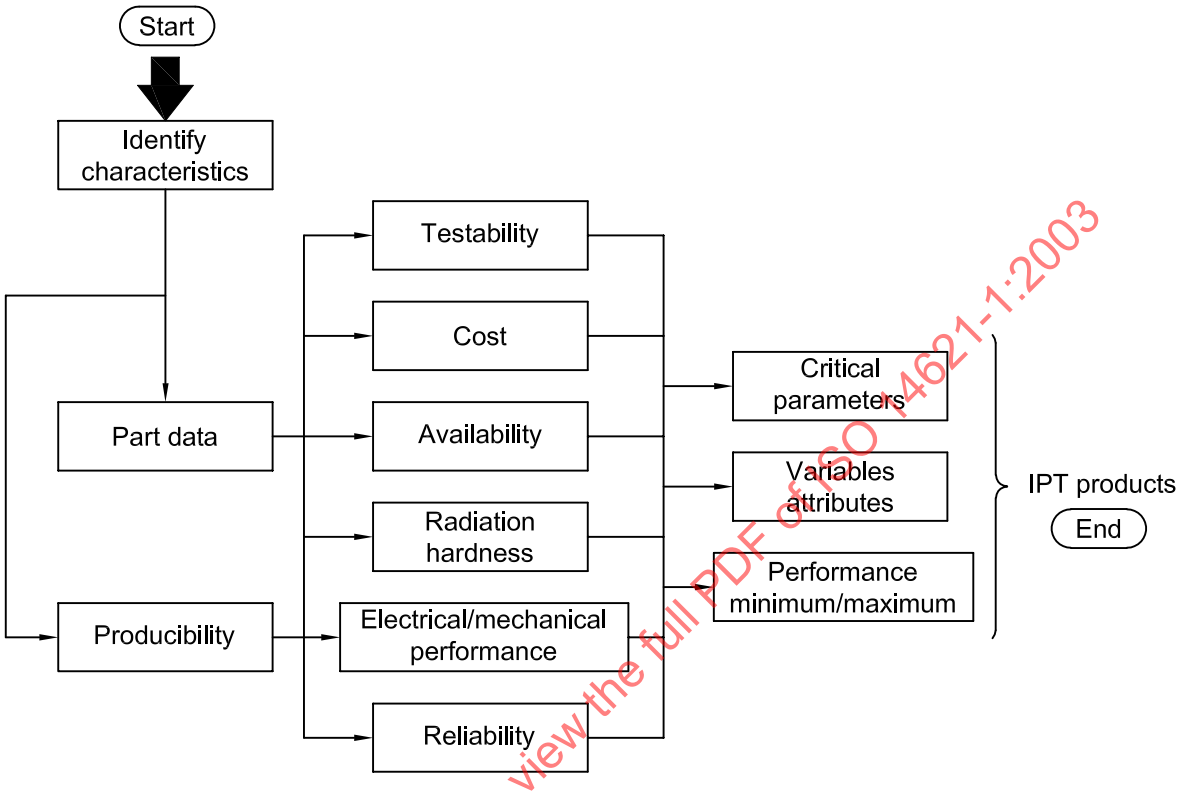

Figure 7 — Parts selection process

3.2 Supplier management

3.2.1 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 3.2.2, 3.2.3 and 3.2.4. 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.

3.2.2 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 should 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

This process should include, as a minimum, the ability to assess risk at the mission/system level through the lowest EEE parts level, as applicable. The supplier should have a risk management system capable of performing root cause analysis, process maturity analysis and corrective action implementation.

EXAMPLES Obsolescence, health and safety, diminishing sources, process changes and facility moves.

e) Subcontract management

The supplier should 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 part of ISO 14621. 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 management process/plan, which ensures that the product assurance requirements are achieved throughout a programme life cycle. The product assurance process should monitor and provide quality history and quality metrics information.

Assessment of the supplier's management (see Figure 8) process should be performed periodically throughout the entire life cycle. The frequency shall be determined by audit results.

Recommended quality assurance steps include process verification and validation (as defined in 2.1.12 and 2.1.14), of the supplier's quality management control system. Qualification or registration to a recognized quality management standard, such as ISO 9000 or qualified manufacturers list (QML), 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.

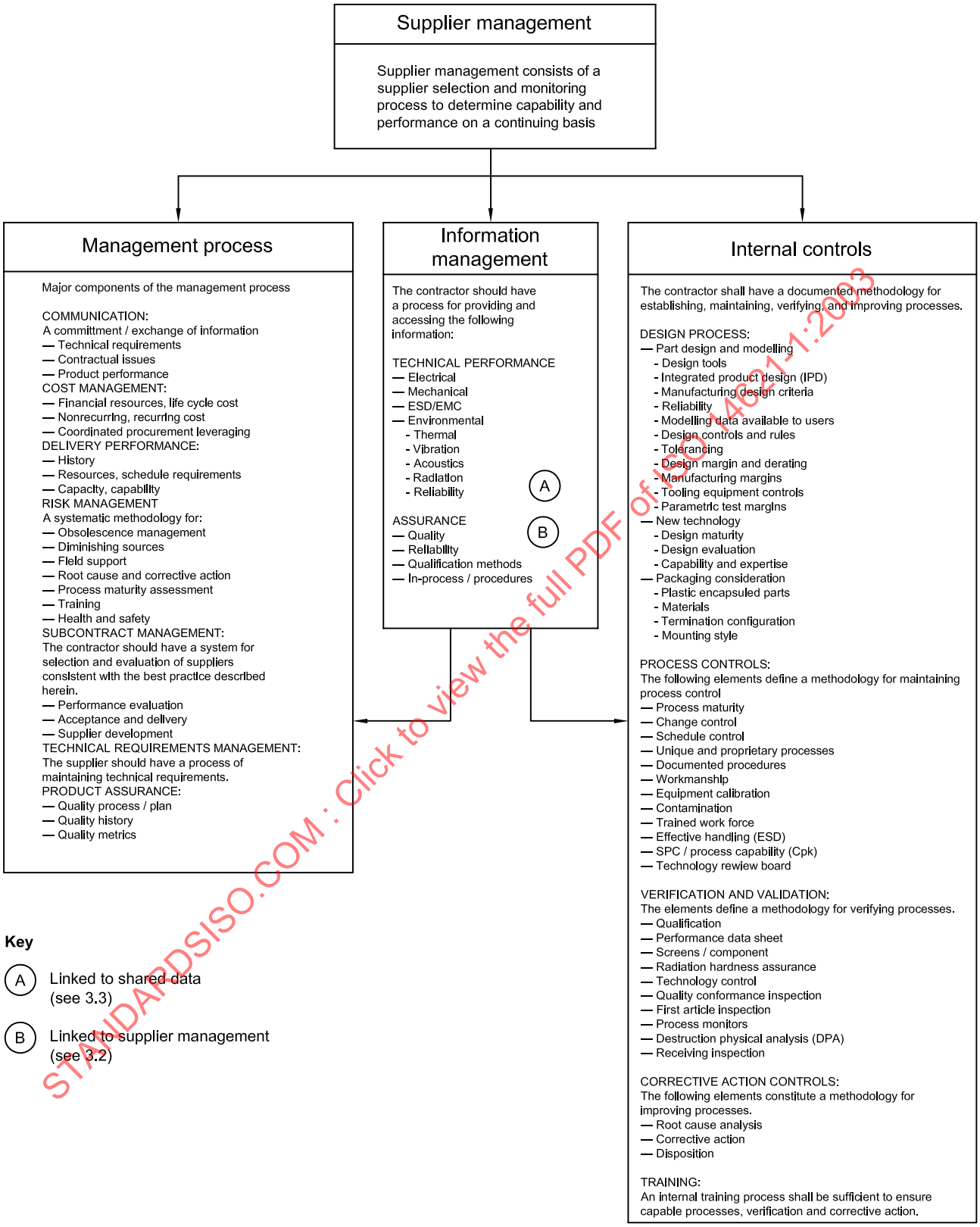

Figure 8 — Supplier management

3.2.3 Information management

This process shall provide technical information for distribution to the industry and government (Figure 8). Refer to 3.3. 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 (3.3).

3.2.4 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 should have a systematic design methodology that is capable of meeting the performance, reliability and quality requirements as delineated in Figure 2 (concurrent engineering IPT). The components of the methodology may include part design and modelling, design controls and rules, performance requirements, F^3I and new technology as well as provide for new packaging considerations, as appropriate.

b) Process controls

The supplier should have process controls in place 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 should 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) Corrective action controls

The supplier shall have a closed-loop corrective action control system sufficient to identify the root cause as well as implement the corrective actions and disposition and to monitor the results.

e) Training

The supplier should have a continuing improvement process 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.

3.3 Shared data

A key to improvement in the design and development process is the ability to share information between the various IPT's at the primes, subcontractor, suppliers and customers. The sharing of data will significantly enhance the programme performance goals in terms of cost savings and schedule improvement associated with implementation of this part of ISO 14621.

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 internet access to the world wide web (WWW) provides an excellent medium for accessing this information. Suppliers and contractors should be encouraged to provide information about their product and business, which will become very useful in future design and development processes.

The development and use of an industry wide shared database will reduce the life cycle cost associated with redundant testing and qualification plus lead to a higher level of standardization and life cycle programme protection.

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 each of the radiation environmental effects are presented below.

a) Displacement damage

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

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)

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),

— high-altitude electromagnetic pulse (HEMP).

d) Single event effects (SEE)

Combinations of single event upset (SEU), single event latchup (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, 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)

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).

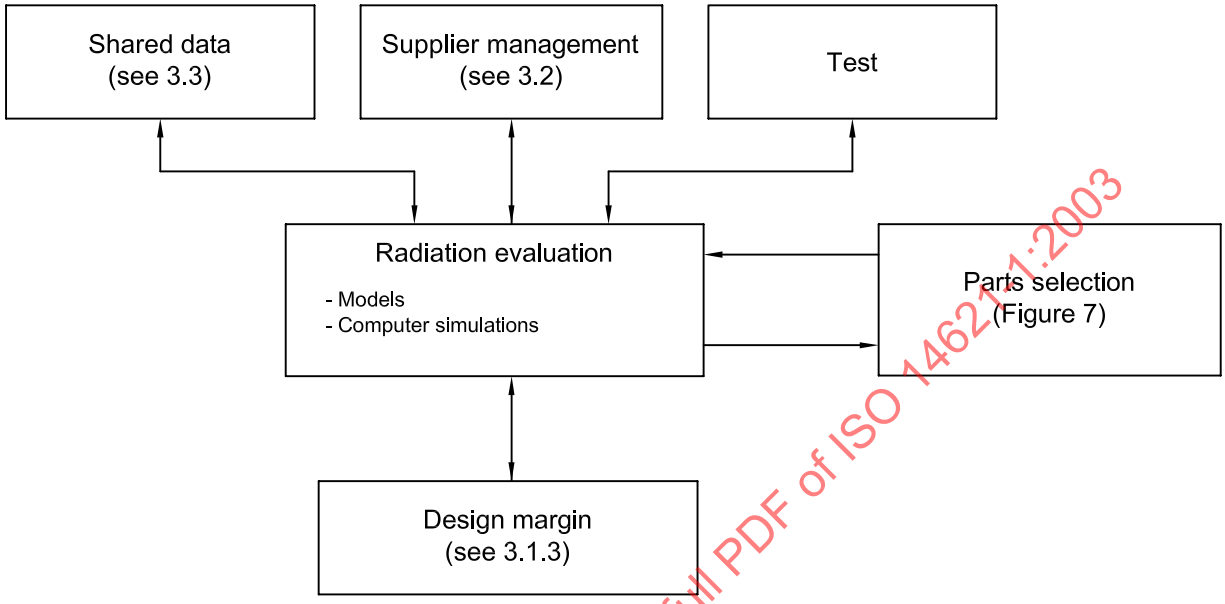

Figure A.1 — Part selection and evaluation process for radiation hardened parts

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, allocations) aid in this process. Some types of analysis used to determined a design margin are

— circuit analysis,

— shielding analysis,

— system analysis,

— part radiation data analysis,

— SEU analysis.

Examples of design margin validation criteria are

a) high design margin = acceptable

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 (3.1.8),

— supplier management (3.2.2).

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 9000 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 charters 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 9000 or equivalent ISO standards?			

Table C.1 (*continued*)

Number	Subcontractor assessment	Yes	No	N/A
I.1.1.15	Does the subcontractor evaluate the supplier's preventive maintenance procedure?			
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			

Table C.1 (*continued*)

Number	Subcontractor assessment	Yes	No	N/A
	Moulding compound process			
	Plastic encapsulated microcircuit (PEM)			
	Lid attachment (hermetic)			
	Lead trim and form			
	Lead finish			
	Hermeticity			
	Internal water vapour			
	Electrical test			
	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)?			

Table C.1 (*continued*)

Number	Subcontractor assessment	Yes	No	N/A
I.1.4	**New product development**			
I.1.4.1	Does the subcontractor review the supplier's concurrent 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			
	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			

Table C.1 (*continued*)

Number	Subcontractor assessment	Yes	No	N/A
	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			
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?			

Table C.1 (*continued*)

Number	Subcontractor assessment	Yes	No	N/A
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?			
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 plant			
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 9000 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			
	Diffusion			
	Ion implantation			
	Annealing			
	Oxide deposition / growth			
	Nitride deposition			

Table C.2 (*continued*)

Number	Supplier assessment	Yes	No	N/A
	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?			
II.1.2.11	Does the supplier have a documented procedure for responding to deficiencies?			

Table C.2 (*continued*)

Number	Supplier assessment	Yes	No	N/A
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 concurrent engineering teams 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			

Table C.2 (*continued*)

Number	Supplier assessment	Yes	No	N/A
	Die shear			
	Solderability			
	Lead integrity			
	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?			

Table C.2 (*continued*)

Number	Supplier assessment	Yes	No	N/A
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?			
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 effected 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?			

Table C.2 (*continued*)

Number	Supplier assessment	Yes	No	N/A
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			
	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 travellers 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 travellers 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			
	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			