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EUROPEAN COOPERATION
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FOR SPACE STANDARDIZATION

Space product assurance

Components reliability data sources and their use

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Foreword

This Standard is one of the series of ECSS Standards intended to be applied together for the management, engineering and product assurance in space projects and applications. ECSS is a co-operative effort of the European Space Agency, national space agencies and European industry associations for the purpose of developing and maintaining common standards.

Requirements in this Standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standards.

The formulation of this Standard takes into account the existing ISO 9000 family of documents.

This Standard has been prepared by the ECSS-Q-30-08 Working Group, reviewed by the ECSS Product Assurance Panel and approved by the ECSS Steering Board.

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ECSS Secretariat
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Scope

This Standard identifies data sources and respective methods to be applied for reliability prediction of components. It proposes suitable data sources and an application matrix for component families.

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

NOTE Tailoring is a process by which individual requirements or specifications, standards and related documents are evaluated and made applicable to a specific project. This process can result in deletion, addition or modification of requirements.

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2
Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revisions of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references the latest edition of the publication referred to applies.

ECSS-P-001	ECSS — Glossary of terms
ECSS-Q-30	Space product assurance — Dependability
ECSS-Q-40	Space product assurance — Safety
ECSS-Q-60	Space product assurance — Electrical, electronic and electromechanical (EEE) components
IEC 60050-191	International Electrotechnical Vocabulary – Chapter 191: Dependability and quality of service

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3
Terms and definitions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ECSS-P-001 and IEC 60050-191 apply.

3.2 Abbreviated terms

The abbreviated terms given in ECSS-P-001 apply.

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4
Selection of reliability data and methods

4.1 Introduction

This Standard shall be applied whenever EEE and mechanical components reliability data or failure rates are needed to perform quantitative dependability or safety analyses in accordance with ECSS-Q-30 or ECSS-Q-40.

The boundaries of this process are shown in Figure 1. Inputs are project requirements, handbook data and manufacturer or user data. The selection process should consider selection criteria and methods of use of data. Outputs are usually included in equipment reliability assessments. Selection is supported by suitable justification.

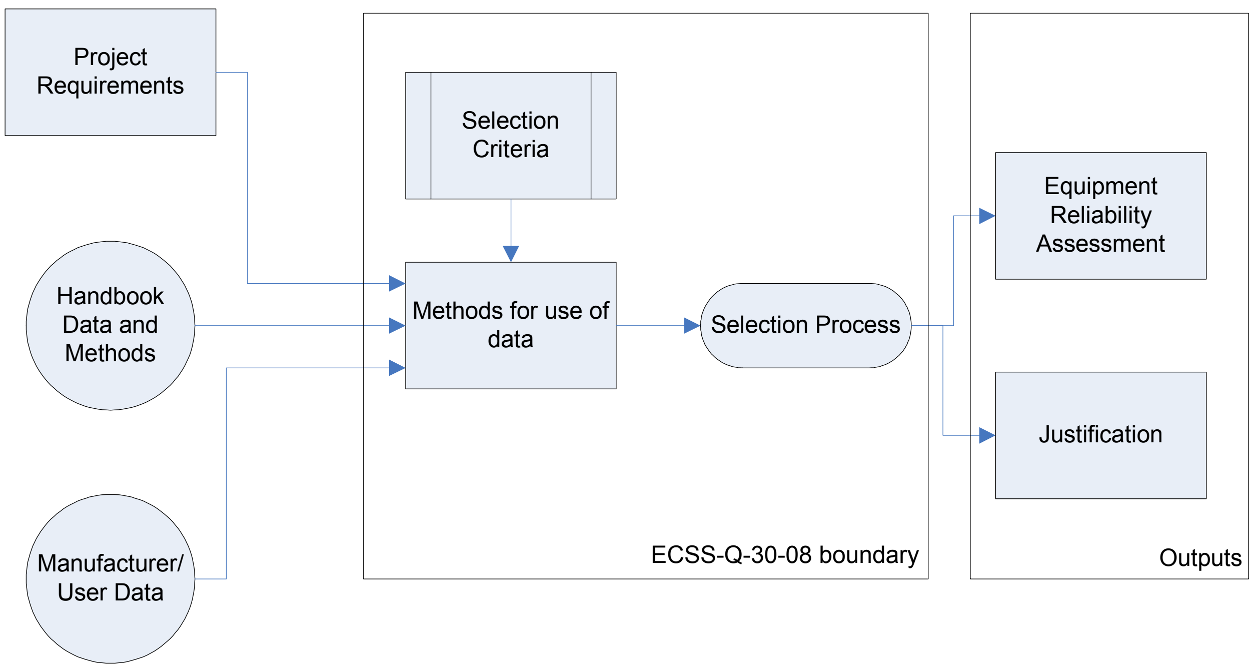

Figure 1: Boundaries of ECSS-Q-30-08 (inputs and outputs)

4.2 Selection process

The selection of a suitable methodology is made according to Figure 2. Where the customer requires that a reliability prediction be computed according to a particular methodology, contractual requirements are applicable.

The term "methodology" includes the process, data and equations as defined in a particular handbook or prediction system.

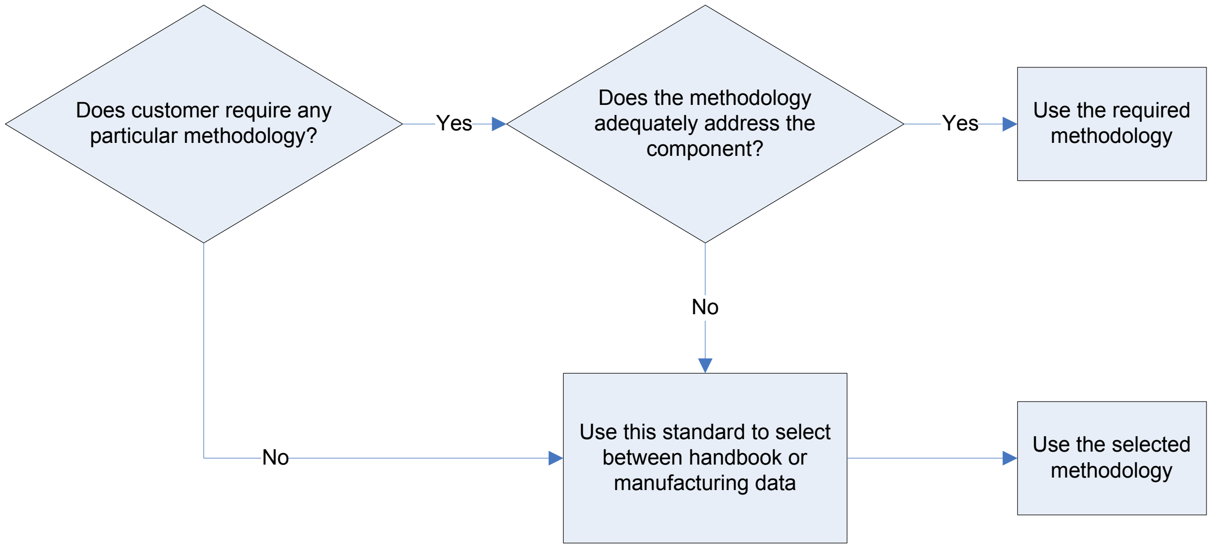

Figure 2: Selection process

In the case where there is no prescribed methodology, this Standard should be applied and a suitable methodology should be selected.

In the case where the prescribed methodology does not adequately address the component under consideration, this Standard should be applied and a suitable methodology should be selected.

In order to perform any reliability predictions, reliability data is needed as an input, and a suitable methodology needs to be applied.

Figure 3 shows the decision logic that should be applied when selecting data sources. Data should be obtained from the following sources, in order of preference:

- Handbook data
- Manufacturer or user data.

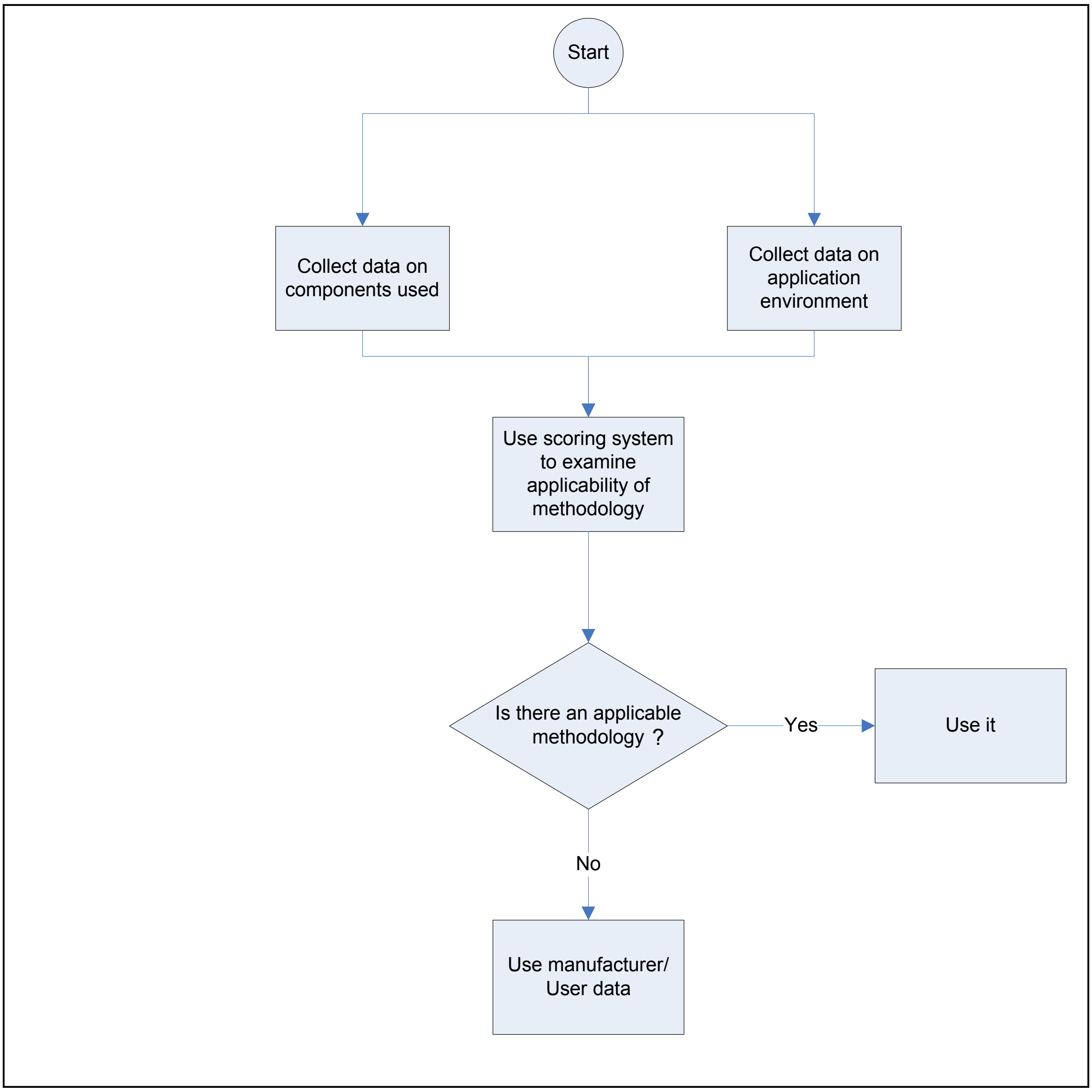

Figure 3: Decision logic

A description of data sources is given in subclause 4.3.

The choice of a given data source is acceptable if it satisfies the criteria listed in subclause 4.4. Data on the handbook methodology, the components, environment and use should be collected. A suitable methodology can be selected by using a weighted score ranking scheme, as described in subclause 4.4.1.

The rationale for selection is justified according to subclause 4.5.

A suitable methodology or instructions for use is described in subclause 4.6.

If a handbook is determined to be not suitable for the component, then manufacturer or user data should be used.

4.3 Description of data

4.3.1 Handbook reliability data

There are a number of reliability handbooks available; these publish reliability metrics on a large number of components. Some examples are provided in Annex A. Care should be taken with such data since it is not always possible to ascertain the actual source of the data. The data can be a mix of field and test data, and even interpolated or extrapolated data can be present.

4.3.2 Manufacturer or user data

a. Manufacturer data

Manufacturer's data is that which is supplied by the manufacturer based on tests on a particular component. Data is normally presented according to the methods laid out in IEC 60319.

b. User data

User data is that which is produced by the company performing the prediction for the sole purpose of deriving reliability information about components that can be obtained in no other way. Data can be, for instance, from in house testing, user experience, lessons learned, or expert judgement. This procedure is most often used for unique component types.

4.4 Selection criteria for input sources

The input data should conform to the selection criteria specified below.

4.4.1 Reliability handbooks

Table 1 provides criteria to be considered for the selection of reliability handbooks. The criteria are listed in order of importance. In order to provide an acceptable evaluation, each of the questions mentioned should be addressed by the user.

The user should consider the use of a scoring scheme, which is shown in this table. In this example, if a selection is made between handbooks, that which has the higher score is considered acceptable. If there is only one handbook, the scoring may be used to determine the adequacy of the handbook, by defining a minimum acceptable score.

The scoring factors given in Table 1 are an example. A particular company may wish to change these scoring factors depending upon their experience.

Table 1: Reliability handbook selection criteria

Item	Question	Scoring factor
Validity	1a) Is the considered technology [1] covered by the handbook?	GO / NO GO criteria
	1b) Is information available on the way in which the data was collected?	15 for yes 0 for no
	1c) If yes to 1a and 1b, are data collected and models implemented according to an international standard or handbook (e.g. IEC)?	10 for yes 0 for no
Suitability for space	2a) Does the handbook cover the space environment [2]?	10 for yes 0 for no
	2b) Does the handbook consider the parts stress method?	10 for yes 0 for no
	2c) Does the handbook address the quality levels of the components being used [3]?	10 for yes 0 for no
Maintenance of data	3a) Has the handbook data been updated in the last 5 years?	10 for yes 0 for no
	3b) Are there any expectations to update the handbook data in the next 5 years?	10 for yes 0 for no
International recognition	4a) Is the handbook requested by the customer?	10 for yes 0 for no
	4b) Is the handbook recognized by the reliability community [4]?	5 for yes 0 for no
Usability	5a) Is a commercial software tool available to support the handbook?	5 for yes 0 for no
Suitability for new technologies	6a) Does the handbook provide extrapolation rules (e.g. Moore's law)?	5 for yes 0 for no
Cost	Not considered	-

[1] Technology includes the component type, technology, family and package

[2] Space environment can include launch vibrations, space vacuum, radiation, and temperature extremes.

[3] In space applications, the component quality is in accordance with ECSS-Q-60, its equivalent, or as otherwise specified.

[4] Recognition by the reliability community can include, for example:
- It is an international standard or handbook;
- It is a national standard or handbook (e.g. MIL-HDBK-217);
- It is a recognized industrial or other standard or handbook (e.g. Telcordia SR-332);
- It is otherwise recognized by the reliability community.

4.4.2 Manufacturer or user data

Use of manufacturer or user data is considered if data from a reliability handbook is not suitable. Figure 4 depicts the selection of manufacturer or user data.

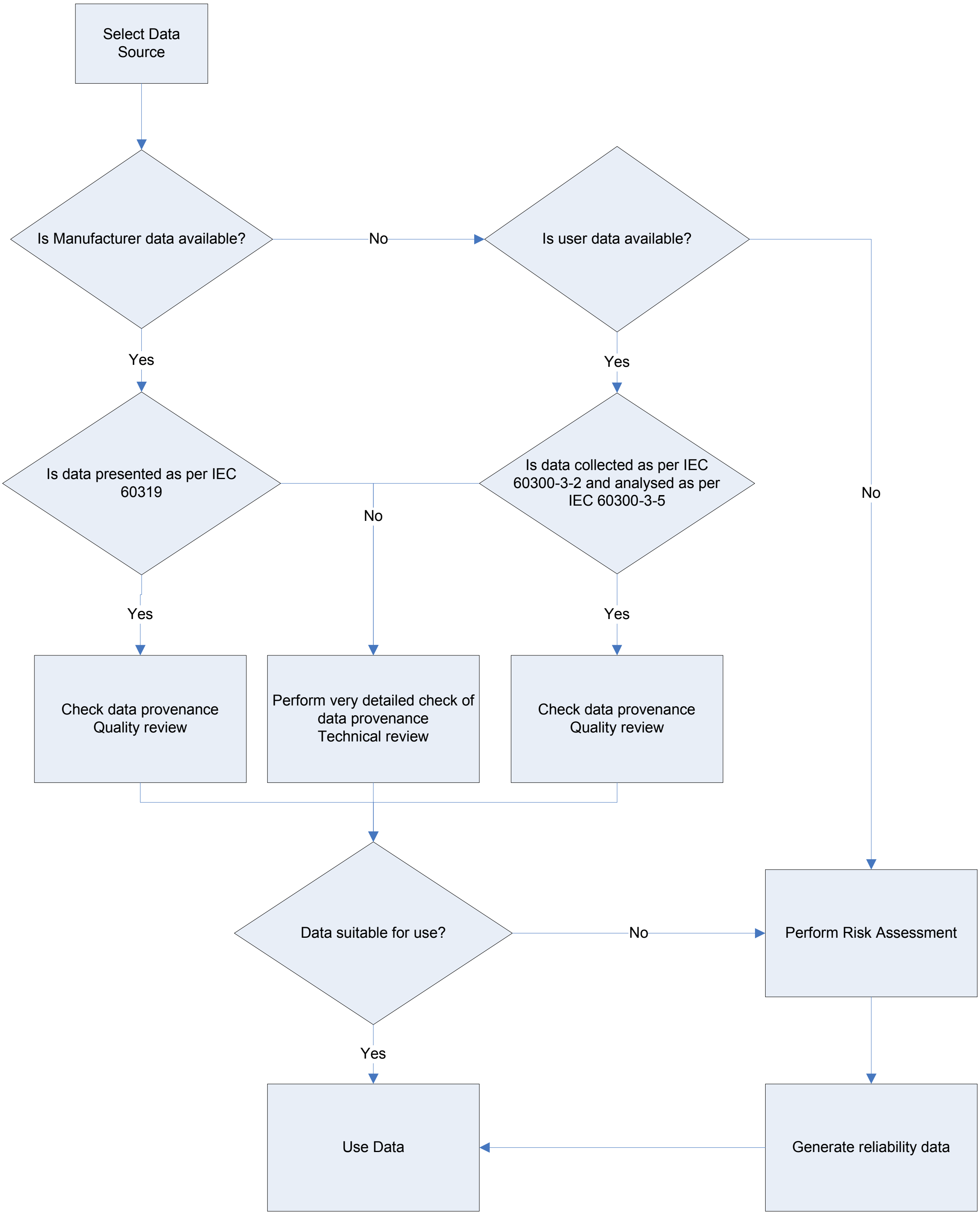

Figure 4: Selection of manufacturer or user data

The steps for selection are as follows:

1. Select the data source.
2. If manufacturer data is available, check whether data is presented in accordance with IEC 60319, in which case it can be considered for use.

   If the data is not presented in accordance with IEC 60319, then perform a detailed review of data to ensure the following is available:

   — tests and test conditions applied to the components;
   — lot sampling;
   — number of lots;
   — manufacturing and testing period;
   — technological representativity;
   — failure analysis.

   Once this data is available, assess the effect of any missing data with respect to the expected list above.
3. If user data is available, check whether data is collected and presented in accordance with IEC 60300-3-2 and IEC 60300-3-5, in which case it can be considered for use.

   If data is not presented in accordance with these standards, then a detailed review of data should be made, to ensure the following is available:

   For field return data the following should be reviewed:

   — data collection procedures;
   — relevance of failures;
   — analysis techniques.

   For test data the following should be reviewed:

   — tests and test conditions applied to the components;
   — lot sampling;
   — number of lots;
   — manufacturing and testing period;
   — technological representativity;
   — failure analysis.

   Once this data is available, assess the effect of any missing data with respect to the expected list above.
4. Once these checks have been performed, the analyst can decide on the use of the data.
5. In case suitability is not determined, the above steps are repeated to find an alternative.
6. In case a data source cannot be found, a risk assessment should be performed to determine the necessity for obtaining further data, e.g. via a reliability test programme, whether to use expert judgement or whether to accept the fact that data is not available for the particular component under consideration.

4.5 Justification for choice

In order to ensure that any work performed is technically correct, justification for the choices made shall be presented whilst the work is performed. This allows the argument made for the methodology followed to be understood at some later time. The justification should be included with the reliability assessment report (see subclause 4.7) and may be used as part of any reliability case argued. Annex C provides more details of the justification.

4.6 Instructions for use

4.6.1 Reliability handbooks

The reliability models and methods that are described within the selected reliability handbook should be used. Modifications to the models or methods should be supported with the rationale in accordance with subclause 4.4.

4.6.2 Manufacturer or user data

The selected manufacturer or user data should be used in accordance with IEC 60300–3–5. Test or manufacturing data that conforms to this criterion is suitable for failure rate calculation. The failure rate calculation procedure is described hereafter.

The necessary inputs for failure rate calculation are:

- number and nature of defects, and
- device hours (test duration and number of devices).

The number of devices should be derived using lot sampling procedures in accordance with a recognized sampling plan such as ISO 2859-0 .

The failure rate shall be assessed using the χ^2 (Chi-square) distribution for time truncated and failure truncated tests.

Given the total number of successful part operating hours (*T*) and the number of failures (*f*), the following equations shall be used to calculate failure rate (λ) from test data:

For a time truncated test, where $n = 2f + 2$: $$\lambda = \frac{\chi_n^2 \times 10^9}{2T}$$

For a failure truncated test, where $n = 2f$: $$\lambda = \frac{\chi_n^2 \times 10^9}{2T}$$

where

λ = is the failure rate in 10^{-9}/hour (FIT) at test conditions;

χ^2 = is the percentile of the χ^2 distribution at confidence level (failure rates are provided at 60 % confidence in the commonly used handbooks listed and described in Annex A);

n = is the degree of freedom of the statistics.

The failure rate can be extrapolated to the operating condition by applying the acceleration factor between test conditions and operating conditions. Information on acceleration factors can be found in IEC1709 or IEC 721-3-3

Percentiles of the χ^2 distribution at 60 % and 90% confidence level are given in Table 2 for up to 30 degrees of freedom.

Table 2: Percentiles of the χ^2 Distribution at 60 % and 90 % confidence for n<30.

n	χ^2(60%)	χ^2(90%)
2	1,83	4,61
4	4,04	7,78
6	6,21	10,6
8	8,35	13,4
10	10,5	16,0
12	12,6	18,5
14	14,7	21,1
16	16,8	23,5
18	18,9	26,0
20	21,0	28,4
22	23,0	30,8
24	25,1	33,2
26	27,2	35,6
28	29,2	37,9
30	32,3	40,3

Percentiles of the χ^2 distribution can be found, for instance, in "Practical reliability engineering" by Patrick D.T. O'Connor, 3rd edition, Wiley.

NOTE The calculated failure rate for a given failure mechanism is highly influenced by test conditions and the physics of failure. Whatever the failure mechanism, an acceleration limitation applies. Highly accelerated tests can induce failure mechanisms that are not observed in the actual application. This leads to an overestimation of failure rates. This acceleration limitation applies to all acceleration factors (e.g. temperature, voltage, and current).

4.7 Considerations for reliability prediction for mechanical parts

4.7.1 General

For mechanical reliability prediction, four approaches are available:

- part failure data analysis,
- empirical reliability relationships,
- stress-strength, and
- handbook data.

There are a number of problems that are encountered when performing mechanical predictions and these are summarized below.

- Part failure analysis
  - Data often not available
  - Available data is often grouped (individual times to failure are not available)
  - For a completely new design, expensive testing may be required.
- Empirical reliability techniques
  - Models available for limited number of part types
  - New process/material cannot be accommodated
  - Models are often for life and not hazard rate.
- Stress or strength interference analysis
  - Results are probability of failure not hazard rate
  - Interference often at extremes of distribution tails
  - Standard deviation for stress is difficult to get.
- Handbook data
  - Constant failure rates are assumed
  - Failure rates are not application sensitive
  - Design improvements doubtful.

4.7.2 Part failure data analysis

Statistical data analysis is the preferred approach to prediction when accurate failure data exist as part of a manufacturer's historical database. This data can also exist as a result of a dedicated reliability test programme. When such data exist, the underlying time to failure distribution can be identified using statistical techniques such as the Weibull analysis. In every case a detailed analysis of failed parts and their data should be performed to identify trends and failure mechanisms.

4.7.3 Empirical reliability relationships

Empirical reliability relationships are based on extensive testing for different combinations of, for instance, loading, materials, and dimensions. The tools required to use these models include some measures of part life and the ability to determine Weibull characteristic life.

4.7.4 Analysis of the stress-strength

An analysis of the stress-strength relationship involves characterization of statistical distributions for stresses acting on a mechanical part and material strength. The most positive benefit is the understanding that stress and strength are subject to variability, and if an incorrect underlying distribution is selected or variability is not accurately characterized, estimated probability of failure can be significantly in error. In order to perform a stress-strength analysis, the stress distribution and strength distribution shall be determined using best engineering practices.

If stress is greater than strength, failure occurs. This failure generally occurs in the area under the intersection of the strength and stress distribution. Hence it is important to understand the shape and location of these distributions.

More information on stress-strength analysis can be found in IEC 60300-3-1.

4.7.5 Handbook data

Handbook data exists for mechanical parts and contain generic failure rate data, for example the RAC publication NPRD. Care shall be taken since the data can be quoted in, for instance, Failures/h, Failures/Cycle, or Failures/Mile and cannot be directly compared with data available on other component types.

4.8 Documentation

Reliability assessment documentation shall be prepared in accordance with ECSS-Q-30 and ECSS-Q-40. The documentation includes:

- the selection process for the data sources,
- the description of calculation methods,
- the derived failure rates, and
- the justification for the methodology and data source choices made.

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Annex A (informative) Potential data sources

A.1 Introduction

This Annex provides information to the user concerning data sources for component failure rate determination. This list is not comprehensive, and is not intended to give a preference for sources. It remains up to the user to determine which data source is relevant for the application.

A.2 EEE parts

AT&T reliability manual

The AT&T reliability manual is more than just a prediction methodology. Although it outlines prediction models and contains component failure data the book also describes the AT&T approach to reliability and covers many diverse reliability topics, albeit with a bias towards reliability prediction. The main prediction models are based on a decreasing hazard rate model, which is modelled using Weibull data. In this respect the handbook is unique. It is available from most good book stores: Klinger, David J., Yoshinao Nakada, and Maria A. Menendez, Editors, l, AT&T Reliability Manual, Van Nostrand Reinhold, 1990, ISBN:0442318480.

FIDES

FIDES is a new reliability data handbook (available since January 2004) developed by a consortium of French industry under the supervision of the French DoD (DGA).

The FIDES methodology is based on physics of failures and is supported by the analysis of test data, field returns and existing modelling. It aims to enable a realistic assessment of electronic equipment reliability, including systems operating in severe environments (e.g. defense systems, aeronautics, industrial electronics, and transport).

The FIDES guide is divided in two parts : a reliability prediction guide and a reliability process control and audit guide. By identifying the factors contributing to reliability, whether technological, physical or process-based, FIDES allows the revision of product definition and intervention throughout the product lifecycle, to improve and control reliability. FIDES is available on request at fides@innovation.net.

HRD5

The British Telecom Handbook of reliability data, HRD5 is a reliability standard developed by British Telecommunications plc that also provides models for a wide range of components. In general, HRD5 is similar to CNET 93, but provides simpler models and requires fewer data parameters for analysis. The HRD5 method is available in a number of commercially available reliability software packages but the original handbook is no longer on sale

IEEE Gold Book

The IEEE Gold book IEEE recommended practice for the design of reliable, industrial and commercial power systems provides data concerning equipment reliability used in industrial and commercial power distribution systems. Reliability data for different types of equipment are provided along with other aspects of reliability analysis for power distribution systems, such as basic concepts of reliability analysis, probability methods, fundamentals of power system reliability evaluation, economic evaluation of reliability, and cost of power outage data. The handbook was updated in 1997; however, the most recent reliability data reflected in the document is from 1989. The IEEE Gold Book is available from:

IEEE Customer Service, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331, U.S.A.

Phone:	+1 800 678 IEEE (in the US and Canada)
	+1 732 981 0060 (outside of the US and Canada)
Fax:	+1 732 981 9667
E-mail:	customer.service@ieee.org

IRPH

IRPH ITALTEL Reliability Prediction Handbook is the Italian telecommunication companies version of CNET RDF. The standards are based on the same data sets with only some of the procedures and factors changed.

The Italtel IRPH handbook is available on request from:

Dr. G Turconi, Direzione Qualita, Italtel Sit, CC1/2 Cascina Castelletto, 20019 Settimo Milanese Mi., Italy.

MIL-HDBK-217

MIL-HDBK-217, Reliability Prediction of Electronic Equipment, has been the mainstay of reliability predictions for about 40 years, but it has not been updated since 1995, and there are no plans by the military to update it in the future. It is therefore becoming obsolete and does not adequately cover newer technologies.

The handbook is available from the following address:-

MIL-HDBK-217F Reliability prediction of electronic equipment,

Department of Defense, Washington DC 20301, Rome Laborato@ERSR, Attn. Seymour F. Morris, 525 Brooks Rd., Griffiss AFB, NY 13441-4505, U.S.A.

The handbook is incorporated within several commercially available reliability software packages.

PRISM (RAC / EPRD)

The RAC (EPRD) Electronic Parts Reliability Data Handbook database is the same as that previously used to support the MIL-HDBK-217, and is supported by a software tool marketed under the name of PRISM, which is also available as a module of several commercial reliability software packages. The models provided differ from those within MIL-HDBK-217.

The PRISM software is available from the address below, or is incorporated within several commercially available reliability software packages:

The Reliability Analysis Center, 201 Mill Street, Rome, NY 13440-6916, U.S.A.

RDF 2000 (UTE C 80-810, IEC-62380-TR Edition 1)

RDF 2000 is the latest version of the CNET handbook which was previously published as RDF93. This handbook has been adopted by UTEC and is known as the UTEC80810 Reliability Data Handbook. Recently this handbook has been adopted by IEC under the name IEC-62380-TR - Reliability Data Handbook – Universal model for reliability prediction of electronics components, PCBs and equipment.

This handbook covers most of the same components as MIL-HDBK-217. The models take into account power on/off cycling as well as temperature cycling and are very complex, with predictions for integrated circuits requiring information on equipment outside ambient and print circuit ambient temperatures, type of technology, number of transistors, year of manufacture, junction temperature, working time ratio, storage time ratio, thermal expansion characteristics, number of thermal cycles, thermal amplitude of variation, application of the device, as well as per transistor, technology related and package related base failure rates. As this standard becomes more widely used it can become the international successor to the US MIL-HDBK-217. The standard is available at:

The UTE UNION TECHNIQUE DE L'ÉLECTRICITÉ ET DE LA COMMUNICATION, Immeuble VOLTA, 33, avenue du Général Leclerc - BP 23, 92262 Fontenay-aux-Roses Cedex, France.

Siemens SN29500

The Siemens SN29500 Failure Rates of components and expected values method was developed by Siemens AG for use by Siemens and Siemens associates as a uniform basis for reliability prediction. The standard presented in the document is based on failure rates under specified conditions. The failure rates given were determined from application and testing experience taking external sources (e.g. MIL-HDBK-217) into consideration. Components are categorized into many different groups, each of which has a slightly different reliability model. The π factors used in this model take into account the variations in device operating temperature and electrical stress.

The standard is available on application to Siemens suppliers and customers of Siemens only and can be obtained through your contact person in the company.

Telcordia SR-332

The SR–332, Reliability Prediction Procedure for Electronic Equipment, completely replaces TR-332, Issue 6, and documents the recommended methods for predicting device and unit hardware reliability. The document contains several forms and tables to facilitate the derivation of reliability predictions. It contains instructions for suppliers to follow when providing predictions of their device, unit, or serial system reliability.

Device and unit failure rate predictions generated using this procedure are applicable for commercial electronic products whose physical design, manufacture, installation, and reliability assurance practices meet the appropriate Telcordia (or equivalent) generic and product-specific requirements.

The Telcordia SR–332 is available from the address below:

Telcordia Technologies, Inc., 8 Corporate Place, PYA 3A-184, Piscataway, NJ 08854-4156, U.S.A.

The Telcordia SR–332 is incorporated within several commercially available reliability software packages.

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A.3 Mechanical parts

NPRD-95

NPRD-95 data provides failure rates for a wide variety of items, including mechanical and electro-mechanical parts and assemblies. The document provides detailed failure rate data on over 25000 parts for numerous part categories grouped by environment and quality level. Because the data does not include time-to-failure, the document is forced to report average failure rates to account for both defects and wear-out. Cumulatively, the database represents approximately 2,5 trillion part hours and 387000 failures accumulated from the early 1970's through 1994. The environments addressed include the same ones covered by MIL-HDBK-217; however, data is often very limited for some environments and specific part types. For these cases, it then becomes necessary to use the "rolled up" estimates provided, which make use of all data available for a broader class of parts and environments. Although the data book approach is generally thought to be less desirable, it remains an economical means of estimating "ballpark" reliability for mechanical components. This is available from the Reliability Analysis Center, 201 Mill Street, Rome, NY 13440-6916, U.S.A

NSWC-94/L07 - Handbook of Reliability Prediction Procedures for Mechanical Equipment

This handbook, developed by the Naval Surface Warfare Center – Carderock Division, provides failure rate models for fundamental classes of mechanical components. Examples of the specific mechanical devices addressed by the document include belts, springs, bearings, seals, brakes, slider-crank mechanisms, and clutches. Failure rate models include factors that are known to impact the reliability of the components. For example, the most common failure modes for springs are fracture due to fatigue and excessive load stress relaxation. The reliability of a spring therefore depends on the material, design characteristics and the operating environment. NSWC-94/L07 models attempt to predict spring reliability based on these input characteristics. The drawback of the approach is that, like the physics of failure models for electronics, the models require a significant amount of detailed input data (e.g. material properties, and applied forces) that is often not readily available. They also do not address the issue of manufacturing defects. Data can also be collected from a wide range of applications and stress profiles, and is often grouped based on similar part types and application environments.

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Annex B (informative)
Applicability and limitations of MIL-HDBK-217F

B.1 Introduction

This Annex provides information to the user about MIL-HDBK-217F. Even though it is obsolete, it is still the most commonly used handbook for the space community and is likely to remain so for some time after the publication of this standard

The information here is not comprehensive, and is not intended to express a preference for sources.

B.2 EEE families applicability matrix

The following Table B-1 provides the limitations of the MIL-HDBK-217 when applied to various part types.

Table B-1: EEE families applicability matrix for MIL-HDBK-217

Component class	Component category	Component sub–category	MIL-217 para	MIL-217 para and limits
Active	Integrated circuits	Logic devices	5.1	≤ 60 k gates ≥ 0,8 µm
		Linear devices	5.1	≤ 10 k trans
		Microprocessors	5.1	≤ 32 bits ≥0,8 µm
		Volatile memories	5.2	≤ 1 Mbit ≥0,8 µm
		Non–volatile memories	5.2	≤ 1 Mbit ≥0,8 µm
		Magnetic bubble memories	5.7	
		VHSIC/VLSI devices (> 60 k gates)	5.3	≥0,8 µm and die area limitations
		GaAs devices (MMICs)	5.4	≤ 1 000 elements for MMIC ≤ 10 000 elements for digital
		Hybrids/MCMs	5.5	
		SAW devices	5.6	
	Discrete semiconductor	Diodes (LF and HF)	6.1, 6.2	
		Bipolar transistors	6.3, 6.6, 6.7	
		Field effect transistors (FETs)	6.4, 6.9	
		Unijunction transistors	6.5	
		GaAs transistors	6.8	
		Thyristors/SCRs	6.10	
		Optoelectronics	6.11	
		Meters and displays	6.12, 18.1	
		Laser diodes	6.13	< 3 mW/cm^2 and forward current < 25 A
		Tubes	7.1, 7.2	
		Lasers	8	
Passive	Resistors	Fixed and variable	9.1	
		Thermistors	9.1	
	Capacitors	All except Tantalum	10.1	
		Tantalum	10.1	

Table B-1: EEE families applicability matrix for MIL-HDBK-217

	Inductive devices	Transformers and coils	11.1, 11.2	
	Connectors	General	15.1	≤ 40 A/contact
		Sockets	15.2	≤ 180 contacts
	Electronic filters	Non-tunable	21.1	
	Electromechanical devices	Rotating devices, relays, switches	12.1/2/3, 13.1/2, 14.1/2	
		Disc drive	-	
Miscellaneous	Displays	CRT	-	
	Quartz crystals	Crystal units	19.1	≤ 105 MHz
	Lamps	Incandescent, Neon	20.1, 23.1	≤ 37,5 V (Incan.)
	Fuses		22.1	
	Passive optics	Cables, connectors	23.1	No PI E and PI Q
	Passive microwave devices	Attenuators	23.1	no PI E and PI Q
		Fixed elements	23.1	
		Variable elements	23.1	no PI E and PI Q
		Ferrite devices	23.1	no PI Q
	Batteries		-	
	PCB and connections	PTH	16.1	≤ 18 circuit planes
		SMT	16.2	
		Solder connections	17.1	

MIL-HDBK-217 should not be used (nor extrapolated) beyond its limitations identified in the table above.

When a specific family is not covered by MIL-HDBK-217, the methodology prepared in the present standard should be used to choose the most appropriate alternative standard or handbook. RDF (UTE C 80-810) and Telcordia (SR-332) are the most recently updated handbooks among these commonly accepted in the reliability analysis community.

When no handbook can cover properly the considered family, the manufacturer data can be considered and shall be collected and worked out as described in subclause 4.6 of this present standard.

B.3 EEE packages applicability matrix (based on paragraph 5.6 MIL-HDBK-217)

Table B-2 provides the limitations of the MIL-HDBK-217 when applied to various package types.

Table B-2: EEE package applicability

Package type	Hermetic: DIP w/solder or weld seal, Pin Grid Array, SMT (leaded and non-leaded)	DIPs with glass seal	Flatpacks with axial leads on 50 MIL centres	Cans	Non-hermetic: DIPs, PGA, SMT (leaded and non-leaded)
Maximum number of pins	224	64	24	16	224
DIP: Dual in-line package SMT: Surface mount technology					

MIL-HDBK-217 should not be used (nor extrapolated) beyond its limitations identified in the table above.

When a specific package or technology is not covered by MIL-HDBK-217, the methodology presented in the present standard shall be used to choose the most appropriate alternative standard or handbook. RDF (UTE C 80-810) and Telcordia (SR-332) are the most recently updated handbooks among the commonly accepted in the reliability analysis community.

B.4 EEE part equivalent quality grades

EEE parts quality grades are often needed in order to determine the failure rates. Different handbooks treat part grades in different ways.

When addressing handbooks referring to quality levels (PI Q), Table B-3 provides different quality designations belonging to the same quality grade or level. (based on MIL-HDBK-217):

ECSS-Q-60 defines the quality grades applied in space projects and includes the use of non-standard parts.

Table B-3: Designation of EEE part quality grades

	Class S categories [a]	Class B categories [a]	Class B1 categories [a]	Other
Active parts	MIL[b] JAN Class S MIL[b] QML Class V MIL[b] QML Class K MIL[b] JANS "S" SCD ESA/SCC[c] Level B NASDA[d] QTS Class I	MIL[b] JAN Class B MIL[b] QML Class Q MIL[b] QML Class H MIL[b] JANTXV, JANJ ESA/SCC[c] Level C NASDA[d] QTS Class II	MIL[b] 883 B MIL[b] QML Class M, N, T MIL[b] QML Class D, E MIL[b] JANTX and JAN DSCC[2] Drawing	Level in accordance with manufacturer test flow and additional testing (user requirements)
Passive parts	MIL[b] Class S, T MIL[b] "S" Failure Rate MIL[b] "R" where no "S" QPL MIL[b] Weibull "C" ("D" if available) ESA/SCC[c] Level B NASDA[d] QTS Class I	MIL[b] "P" Failure rate MIL[b] Weibull "B" ESA/SCC[c] Level C NASDA[d] QTS Class II	MIL[b] "M" or "L" Failure rate DSCC[b] drawing	

Note 1 MIL-HDBK-217 contains, as a part of the reliability equations, factors for various parts classes. The factors for microcircuits are:

*Low (= Class S category) = 0,25
**Medium (= Class B category) = 1,0
***High (= Class B1 category) = 2,0
****Unknown (= Other) = 10,0

Therefore failure of medium grade parts is 4 times more likely than that, for instance, low risk parts.

Note 2 Qualification of MIL passive EEE parts to exponential failure rates (S, R, P, M) is granted for the manufacturing process, NOT the individual parts. Therefore, all products produced on an "S" level line are "S" failure rated even though the manufacturer can take orders and mark parts to a "higher" (worse) failure rate, for example "P" level. Therefore, there is generally no advantage to ordering "P" level parts for a Class B programme when the supplier is qualified to "R" or "S" level. Exponential failure rate levels are assigned as follows:

"M"= 1,0 %/1 000 hours
"P" = 0,1 %/1 000 hours
"R" = 0,01 %/1 000 hours
"S" = 0,001 %/1 000 hours

Note 3 Weibull refers to the 100 % accelerated life test performed on solid tantalum capacitors in order to establish lot-specific failure rate levels. Through this, testing failure rate levels are assigned as follows:

Weibull B = 0,1 % failures/1 000 hours
Weibull C = 0,01 % failures/1 000 hours
Weibull D = 0,001 % failures/1 000 hours

Table B-3: Designation of EEE part quality grades

Note 4	For passive EEE parts, Class S refers to specifications that are specifically written for space grade or extremely high reliability applications. Examples include MIL-PRF-123 for ceramic capacitors and MIL-PRF-87217 for metallized film capacitors. Class “T” refers to an established reliability level product that is available with space application relevant testing in addition to the MIL test flow.
Note 5	The requirements defined in MIL-PRF-38535 for Class “T” active EEE parts are sufficiently vague to consider them to be of a generally “high” risk for NASA applications. Per MIL-PRF-38535E Amendment 5 paragraph 3.4.8, “Class “T for active EEE parts is not for use in NASA manned, satellite, or launch vehicle programmes without written permission from the applicable NASA Project Office (i.e. cognizant EEE parts authority).”

a) As specified in MIL-HDBK-217 for microcircuits (see 5-15)

b) American Military quality standard (Defense Supply Center Columbus - DSCC)

c) ESA European quality standard

d) NASDA Japan quality standard

Annex C (informative) Justification

In an audit or similar task, justification for the choice of methodology should be provided, so that the argument for the use of a particular methodology is technically verifiable. In order to provide a complete justification the motives for performing tasks on a number of distinct levels should be considered. The general approach is outlined in Figure C-1, where in the first instance the use of a particular technique and then each step of the methodology chosen should be justified.

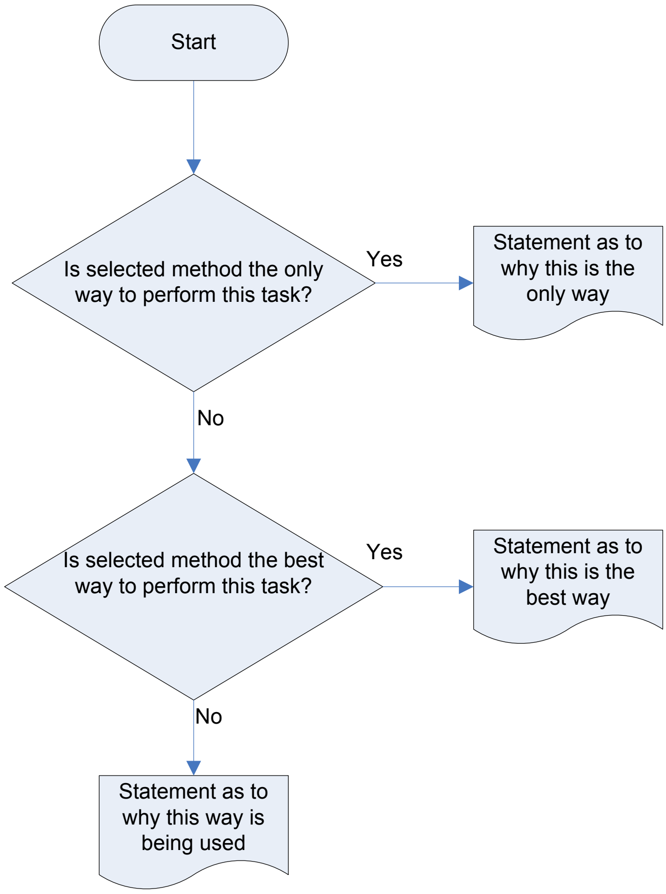

Figure C-1: Justification process

In order to justify the use of the technique, in this case reliability prediction, there are a number of considerations that should be applied:

- If reliability prediction is the only way to perform the task in hand or generate information, then the justification should specify why this is the only way.
- If reliability prediction is not the only way, but is the best way, then the justification should specify why this is the best way.
- If reliability prediction is not the only way and is not the best way, then the justification should specify why it is being used (perhaps because it is specified by a customer).
- Once reliability prediction is justified, then the actual prediction methodology should be justified. This is done in the same manner as the justification for prediction.
- If method "X" is the only way to perform the prediction, then the justification should specify why this is the only way.
- If method "X" is not the only way to perform the prediction, but is the best way, then the justification should specify why this is the best way.
- If method "X" is not the only way and is not the best way, then the justification should specify why it is being used (perhaps because it is specified by a customer).

Once the methodology is justified, any deviations from the methodology, for instance the use of different failure rates, PI-factors or equivalents, should be justified in the same manner.

The same approach should be followed when working with manufacturer's data or other data sources.

The justifications should be recorded so that the decisions made during the process can be defended. The justification information can be used along with the results of a prediction as part of any reliability case (as defined for example, by DEF00-42 (Part 3) Reliability and Maintainability (R&M) Assurance Guidance Part 3: R&M Case.

Bibliography

DEF00-42 (Part 3), Reliability and Maintainability (R&M) Assurance Guidance Part 3: R&M Case

FIDES Guide 2004, Reliability Methodology for Electronic Systems, DGA-DM/STTC/CO/477

GEIA SSB-1C, GEIA Engineering Bulletin: Guidelines for using plastic encapsulated microcircuits and semiconductors in military, aerospace and other rugged applications

HRD5, British Telecom Handbook of reliability data

IEEE Gold Book, IEEE recommended practice for the design of reliable, industrial and commercial power systems

IEC 60319, Presentation and specification of reliability data on electronic components

IEC 60300-3-1, Dependability management - Part 3-1: Application guide - Analysis techniques for dependability - Guide on methodology

IEC 60300-3-2, Dependability management - Part 3-2: Application guide - Collection of dependability data from the field

IEC 60300-3-5, Dependability management - Part 3-5: Application guide - Reliability test conditions and statistical test principles

IEC 61709, Electronic components - Reliability - Reference conditions for failure rates and stress models for conversion

IEC 60721-1, Classification of environmental conditions - Part 1: Environmental parameters and their severities

IEC TR 62380 Ed.1, Reliability Data Handbook-Universal model for reliability prediction of Electronics components, PCBs and equipment or UTE C80-810, Reliability Data Handbook – A universal model for reliability prediction of Electronic components, PCSs and equipment

IRPH ITALTEL Reliability Prediction Handbook

ISO 2859-0, Sampling procedures for inspection by attributes - Part 0: Introduction to the ISO 2859 attribute sampling system

MIL-HDBK-217F, Reliability prediction of electronic equipment

Siemens SN29500 Failure Rates of components and expected values

SR-332, Reliability Prediction for Electronic Equipment (Telcordia Technologies)

UTE RDF 2000 (UTE C 80-810)

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1. Originator's name: Organization: e-mail:				2. ECSS Document number: 3. Date:	
4. Number.	5. Location of deficiency clause page (e.g. 3.1 14)		6. Changes	7. Justification	8. Disposition

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6. **Changes -** Identify any improvement proposed, giving as much detail as possible
7. **Justification -** Describe the purpose, reasons and benefits of the proposed change
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