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Nationales Vorwort

Dieses Dokument (EN 16603-20:2023) wurde Technischen Komitee CEN/CLC/JTC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat von DIN (Deutschland) gehalten wird.

Für Deutschland hat hieran der Arbeitsausschuss NA 131-06-02 AA „Interoperabilität von Informations-, Kommunikations- und Navigationssystemen“ im DIN-Normenausschuss Luft- und Raumfahrt (NL) mitgearbeitet.

Dieses Dokument enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die Englische Fassung von EN 16603-20:2023.

Aktuelle Informationen zu diesem Dokument können über die Internetseiten von DIN (www.din.de) durch eine Suche nach der Dokumentennummer aufgerufen werden.

Änderungen

Gegenüber DIN EN 16603-20:2021-02 wurden folgende Änderungen vorgenommen:

- a) Abschnitt 2 „Normative Verweisungen“ aktualisiert;
- b) Unterabschnitt 4.2.1.1 hinzugefügt aufgrund der Hinzufügung des neuen Unterabschnitts 4.2.1.2;
- c) Hinzufügung von Anforderungen im neuen Unterabschnitt 4.2.1.2 „Reliable insulation“;
- d) Die Hinzufügung des neuen Unterabschnitts 4.2.1.2 machte es erforderlich, die neue Überschrift 4.2.1.1 „General requirements“ hinzuzufügen, um die Anforderung aus dem früheren Unterabschnitt 4.2.1 „Failure containment and redundancy“ von den neuen Anforderungen an „Reliable insulation“ zu trennen;
- e) Aktualisierung, um die Aspekte der „reliable insulation“, auch bekannt als „double insulation“, abzudecken;
- f) Hinzufügung mehrerer Begriffe in Unterabschnitt 3.2 im Zusammenhang mit dem zusätzlichen Thema „Reliable insulation“;
- g) Norm redaktionell überarbeitet.

Frühere Ausgaben

DIN EN 16603-20: 2021-02

Nationaler Anhang NA (informativ)

Begriffe und Abkürzungen

Reihenfolge und Inhalt der folgenden Begriffe sind identisch mit denen im Abschnitt Begriffe der Englischen Fassung.

NA.1 Begriffe und Abkürzungen

NA.1.1 Begriffe aus anderen Normen

- a) Für die Anwendung dieser Norm gelten die Begriffe nach ECSS-S-ST-00-01.
- b) Für die Anwendung dieser Norm gelten die folgenden Begriffe nach ECSS-E-ST-20-20:
 - 1) Sperrstrombegrenzer [(LCL), en: latching current limiter];
 - 2) nachtriggerbarer Sperrstrombegrenzer [(RLCL), en: retriggerable latching current limiter].

NA.1.2 Für diese Norm spezifische Begriffe

3.2.1

Antennenfarm

Gesamtheit aller am Raumfahrzeug angebrachten Antennen, mit denen sämtliche Funksignale gesendet und empfangen werden

3.2.2

Antennenanschluss

Abstraktion der physikalischen Verbindung zwischen der Antenne und deren Zuleitungen, die mithilfe von Steckverbindern oder Hohlleiterflanschen erhalten wird

3.2.3

Antennenfunktette

Folge von Mikrowellenkomponenten, die zwischen einem Eingangsanschluss der Antenne oder einem Ausgangsanschluss des BFN und einem entsprechenden einzelnen abstrahlenden Bauteil eingefügt sind

ANMERKUNG Beispiele für Mikrowellenkomponenten sind: Orthomodenkoppler, Polarisatoren, Transformatoren sowie Filter.

3.2.4

Antennentragstruktur

Teil einer Antenne ohne elektrische Funktion, der jedoch seine elektrischen Leistungen entweder direkt durch Streuung oder indirekt beeinflussen kann

ANMERKUNG Ein Beispiel für eine indirekte Wirkung sind induzierte thermoelastische Verformungen.

3.2.5

Gruppenantenne

Antenne, die aus mehreren, möglicherweise unterschiedlichen Elementen besteht, die Funksignale direkt in den freien Raum abstrahlen und in Kombination betrieben werden, so dass alle oder ein Teil davon die gleichen Signale abstrahlen

3.2.6

Reflektorantenne mit Speisearray

Antenne, die aus einem Speisearray, das ein Strahlformungsnetzwerk enthalten kann oder auch nicht, und einem oder mehreren optischen Elementen, z. B. Reflektoren und Linsen besteht

3.2.7

Batteriesammelschiene

Sammelschiene mit Primärversorgung, die direkt an die Batterie angeschlossen ist

ANMERKUNG Die Batteriesammelschiene wird manchmal als unregelte Sammelschiene bezeichnet (obwohl die Batterieladung geregelt ist).

3.2.8

Strahlformungsnetzwerk

BFN, en: beam forming network

Wellenleiterstruktur, die aus einer Kette von Mikrowellenkomponenten und -vorrichtungen besteht, die dafür vorgesehen sind, die an den Eingangsanschlüssen eingespeiste HF-Leistung auf eine Anzahl von Ausgangsanschlüssen zu verteilen; in einer Sendeantenne wird die vom Sender eingespeiste HF-Leistung zu den abstrahlenden Bauteilen geleitet, in einer Empfangsantenne wird die von den abstrahlenden Bauteilen kommende HF-Leistung zu den mit dem Empfänger verbundenen Antennenanschlüssen geleitet

ANMERKUNG Beispiele für Mikrowellenkomponenten und -vorrichtungen sind Leitungen, Phasenschieber, Kupplungen und Verbraucher.

3.2.9

leitungsgeführte Emission

CE, en: conducted emission

erwünschte oder unerwünschte elektromagnetische Energie, die sich entlang eines Leiters ausbreitet

3.2.10

kritische Leitung

[KONTEXT: zuverlässige Isolierung] Leitung, die Teil eines kritischen Netzes ist

ANMERKUNG Als Beispiel, beschränkt auf ein Solarmodul, ist eine kritische Leitung üblicherweise eine Leitung, durch die der Strom eines Abschnitts stromabwärts des elektrischen Knotens geführt und der Strom von den verschiedenen Strängen, die den Abschnitt bilden, gesammelt wird. Falls jedoch ein Kurzschluss zwischen Strängen innerhalb eines Abschnitts zu einer Fehlerfortpflanzung führt, wird entsprechend ein Strang als kritische Leitung betrachtet.

3.2.11

kritisches Netz

[KONTEXT: zuverlässige Isolierung] elektrisches Netz, das bei einem Kurzschluss mit einem anderen elektrischen Netz oder einem anderen Leiter, einschließlich Satelliten- und Trägerraketenstruktur, kritische Auswirkungen verursachen kann

ANMERKUNG Bezüglich „kritischer Auswirkungen“ siehe ECSS-Q-ST-30-02, Tabelle 4-1.

3.2.12

kritischer Druck

Druck, bei dem eine Korona- oder Teilentladung in einem Gerät auftreten kann

3.2.13

Diffusionsvermögen

Fähigkeit eines Körpers, inkohärente diffuse Streuung aufgrund lokaler Rauigkeit, Inhomogenität oder Anisotropie zu erzeugen, wenn er mit Hochfrequenzwellen beleuchtet wird

3.2.14**Entladetiefe****DOD**, en: depth of discharge

einer Batterie entnommene Amperestunde, angegeben als prozentualer Anteil der installierten Ladung

3.2.15**doppelte Isolierung**

siehe „zuverlässige Isolierung“

3.2.16**elektrische Kontaktierung**

Verfahren des Verbindens von leitenden Teilen, so dass ein niederohmiger Pfad für Erdungs- und Schirmungszwecke hergestellt wird

3.2.17**elektromagnetische Verträglichkeit****EMC**, en: electromagnetic compatibility

Fähigkeit eines Gerätes oder eines Elements, in seiner elektromagnetischen Umgebung zufriedenstellend zu funktionieren, ohne dass in dieser Umgebung unerträgliche elektromagnetische Störungen auftreten

3.2.18**Überwachung der elektromagnetischen Verträglichkeit**

Reihe von Techniken zur wirksamen Regulierung der elektromagnetischen Störungsumgebung oder der Empfindlichkeit einzelner Raumfahrtsystemkomponenten oder beidem

ANMERKUNG Sie umfassen u. a. das Design, die Anordnung von Komponenten, die Schirmung und den Einsatz von Sperrfiltern.**3.2.19****elektromagnetische Störung****EMI**, en: electromagnetic interference

unerwünschtes elektrisches Phänomen, das durch jedes Gerät, dessen normale Funktion von der Nutzung elektrischer Phänomene abhängt, erzeugt wird oder dieses nachteilig beeinflusst

ANMERKUNG Es ist durch Anzeichen einer Verschlechterung der Leistung eines Geräts, Übertragungskanal oder Elements gekennzeichnet, die durch eine elektromagnetische Störung verursacht wird.**3.2.20****Sicherheitsfaktor für elektromagnetische Störungen****EMISM**, en: electromagnetic interference safety margin

Verhältnis zwischen der Empfindlichkeitsschwelle und der an einem Prüfpunkt vorhandenen Störung

3.2.21**Emission**

elektromagnetische Energie, die sich durch Strahlung oder Übertragung ausbreitet

3.2.22**Energiebilanz**

Situation, in der der Energiehaushalt des Raumfahrzeugs positiv ist, wenn er über einen bestimmten Zeitraum erarbeitet wird

ANMERKUNG 1 Energiehaushalt ist Erzeugung minus Verbrauch und Verluste.**ANMERKUNG 2** Der betrachtete Zeitraum kann ein Orbit, mehrere Orbits oder ein beliebiger relevanter Missionszeitraum sein.

3.2.23

Energiereserve

Energie, die von der Energiespeicherbaugruppe im ungünstigsten Fall bei maximaler Erschöpfung im Nennbetrieb verfügbar bleibt

ANMERKUNG Es ist wichtig, dass die Energiereserve ausreichend ist, damit beim Auftreten einer Anomalie ein sicherer Betriebsmodus erreicht wird.

3.2.24

wesentliche Funktion

Funktion, ohne die das Raumfahrzeug nach jedem denkbaren Ausfall an Bord oder am Boden nicht wiederhergestellt werden kann

ANMERKUNG Beispiele für irreparable Raumfahrzeuge sind Raumfahrzeuge, bei denen keine Befehle erteilt werden können oder die Einstellung und Kontrolle des Raumfahrzeugs dauerhaft verloren gehen oder die Energiebilanz nicht länger sichergestellt ist oder die Verbrauchsmaterialien des Raumfahrzeugs (z. B. Hydrazin oder Xenon) in einem Ausmaß erschöpft sind, dass mehr als 10 % von dessen Lebensdauer beeinträchtigt oder die Sicherheit der Besatzung gefährdet ist.

3.2.25

fehlerhaftes Signal

von einem Stromkreis erzeugtes Signal, das an seiner Schnittstelle zu einem anderen Stromkreis auftritt und aufgrund eines Fehlers seinen Nennbereich verlässt

3.2.26

Foldback-Strombegrenzer

FCL, en: foldback current limiter

nicht sperrstrombegrenzende Funktion, bei der sich die Strombegrenzung mit der Ausgangsspannung verringert

ANMERKUNG Diese Funktion wird für die Energieverteilung und den Schutz angewendet, üblicherweise für wichtige Verbraucher.

3.2.27

vollständig regulierte Sammelschiene

Sammelschiene, die bei Sonnenlicht und Finsternis mit einer geregelten Spannung Strom liefert

3.2.28

Erdung

Verfahren zum Herstellen von absichtlichen elektrischen Leiterbahnen zwischen einem Referenzstromkreis oder einem leitenden Teil und einem Gerätegehäuse oder einer Raumfahrzeugstruktur

ANMERKUNG Die Erdung erfolgt üblicherweise zu Sicherheits-, Funktions-, Signalintegritäts-, EMI-Kontroll- oder Ladungsableitungszwecken.

3.2.29

Telekommando mit hoher Priorität

HPC, en: high Priority telecommand

Befehl, der von der Bodenstation abgegeben und vom Fernsteuer-Decoder für wesentliche Raumfahrzeugfunktionen ohne Eingriff der bordseitigen Software ausgegeben wird

3.2.30

Hochspannung

Wechsel- oder Gleichspannung, bei der Teilentladungen, Korona-, Lichtbogen- oder hohe elektrische Felder auftreten können

3.2.31**Isolierung**

Trennung von Elementen entweder durch Material oder durch einen Abstand

ANMERKUNG Etymologisch betrachtet ist Isolierung der Vorgang, etwas mit einem Material zu schützen, das den Durchgang von Wärme, Schall, Elektrizität usw. verhindert. Isolieren entspricht dann der Maßnahme, durch Hinzufügen eines Materials, eine Isolierung (Materialien oder Vorrichtungen, die für diesen Schutz verwendet werden) zu schützen.

3.2.32**unveränderlicher Spalt**

physischer Abstand zwischen elektrisch leitenden Elementen, der die festgelegten Mindestgrenzen einhält, unabhängig von den Belastungen, die auf das Gerät oder einen Teil des Geräts ausgeübt werden

ANMERKUNG 1 Änderungen des Spalts können durch mechanische, thermomechanische oder andere Einflüsse auf die Einheit oder einen Teil der Einheit entstehen.

ANMERKUNG 2 Zu den Belastungen zählen die Auswirkungen von MIT-Abläufen, Umweltprüfungen, Alterung und die Verwendung von Isolierstoffen.

3.2.33**Isolierung**

Trennung von weit voneinander entfernten Elementen mit dem Begriff des Abstands

ANMERKUNG Isolieren ist die Maßnahme, durch Hinzufügen eines Abstands zu trennen und isoliert zu sein bedeutet, durch einen Abstand geschützt zu sein.

3.2.34**Linsenantenne**

Antenne, die aus mehreren Hochfrequenzlinsen und reflektierenden Oberflächen besteht und durch diese beleuchtet wird, die von einer Primärquelle, dem Speisearray, versorgt werden

3.2.35**indirekte Auswirkungen von Blitzen**

aufgrund der Kopplung elektromagnetischer Felder durch Blitzeinschlag in Stromkreisen hervorgerufene elektrische Transienten

3.2.36**wesentliche Rekonfigurationsfunktion**

Funktion zur Behebung von Systemausfällen der Kritikalität 1, 2 oder 3

ANMERKUNG Kritikalitätskategorien sind in ECSS-Q-ST-30 und ECSS-Q-ST-40 definiert.

3.2.37**installierte Ladung**

vom Hersteller einer Energiespeicherzelle oder Batterie angegebene Kapazität

ANMERKUNG Sie wird in Amperestunden angegeben. Sie entspricht nicht notwendigerweise jeder messbaren Kapazität.

3.2.38**weniger wichtige Verbraucher**

auf Einheiten bezogene Verbraucher, durch die keine für das Raumfahrzeug wesentlichen Funktionen ausgeführt werden

3.2.39

passive Intermodulationsprodukte

PIM, en: passive intermodulation products

Störsignale, die durch nichtlineare Strom-Spannungs-Eigenschaften in Materialien und Übergängen erzeugt werden, die einer ausreichend hohen Hochfrequenz-Leistung ausgesetzt sind, die von geführten oder abgestrahlten Feldern und Strömen getragen wird, möglicherweise ausgelöst durch mikroskopisch kleine mechanische Bewegung

3.2.40

fotovoltaische Baugruppe

PVA, en: photovoltaic assembly

Stromerzeugungsnetz, das die verbundenen Solarzellenbaugruppen, die Nebenschluss- und Sperrdioden, die Sammelschienen- und Kollektoremulverdrahtung, die Strang-, Abschnitts- und Modulverdrahtung, den Flügeltransferkabelbaum, Steckverbinder, Ableitwiderstände und Thermistoren umfasst

3.2.41

Primärzelle oder -batterie

Batterie oder Zelle, die so ausgelegt ist, dass sie einmal entladen und niemals aufgeladen wird

3.2.42

Sammelschiene mit Primärversorgung

elektrischer Knoten des Raumfahrzeugs, der den Energiequellen am nächsten liegt, in der die Energie gesteuert und den Benutzergeräten zur Verfügung gestellt wird

3.2.43

Hochfrequenz

RF, en: radiofrequency

für die Übertragung elektromagnetischer Wellen verwendetes Frequenzband

3.2.44

gestrahlte Störaussendung

RE, en: radiated emission

Strahlungs- und Induktionsfeldkomponenten in der Raumfahrt

3.2.45

Wiederaufladungsverhältnis

k

aufgeladene Amperestunden geteilt durch die zuvor entladenen Amperestunden, Beginn und Ende im gleichen Ladezustand

ANMERKUNG Es ist auch als k-Faktor bekannt.

3.2.46

Reflektorantenne

Antenne, die aus mehreren reflektierenden Oberflächen und Hochfrequenzreflektoren besteht und durch diese beleuchtet wird, die von einer Primärquelle, dem Speisearray, versorgt werden

3.2.47

zuverlässige Isolierung

Barriere zwischen Leitern oder Elementen einer elektrischen Schaltung, so dass nach einem anzunehmenden Einzelausfall Leiter oder Elemente einer elektrischen Schaltung immer noch voneinander isoliert sind

ANMERKUNG Der Begriff „**zuverlässige Isolierung**“ wird dem Begriff „**doppelte Isolierung**“ vorgezogen, der in der Vorgängerversion angewendet wurde.

3.2.48**Funkkette**

Folge von Mikrowellenkomponenten, die zwischen dem Hochfrequenzleistungsverstärker und dem Eingangsanschluss der Antenne eingefügt sind

3.2.49**Hochfrequenzlinse**

Kunststoff-, Verbund- oder Metallstruktur, die auf gesendete Hochfrequenzwellen einwirkt, um das Antennenmuster zu steuern

ANMERKUNG Beispiele für Metallstrukturen sind Linsen für Hohlleiter-Arrays.

3.2.50**Hochfrequenzreflektor**

Metall- oder Verbundstruktur, möglicherweise metallisiert oder mit aufgedruckten oder eingebetteten Metallelementen, die auf reflektierte Hochfrequenzwellen einwirken, um das Antennenmuster zu steuern

ANMERKUNG Als Reflektoren gelten Frequenz- und Polarisationsflächen sowie andere voll- oder teilreflektierende und transmittierende Strukturen, die auch ein ungleichmäßiges oder anisotropes Streuverhalten aufweisen.

3.2.51**Sekundärzelle oder -batterie**

Batterie oder Zelle, die so ausgelegt ist, dass sie mehrfach aufgeladen und entladen wird

3.2.52**solarer Aspektwinkel**

SAA, en: solar aspect angle

Winkel zwischen der Normalen zu einem Solarmodul und dem Sonnenvektor

3.2.53**Solarzellen-Baugruppe, Solarzellenanordnung**

SCA, en: solar cell assembly

Solarzelle zusammen mit Verbindungsleitung, Deckglas und, wenn angewendet, auch einer Bypass-Diode

3.2.54**Empfindlichkeit**

Störung, Leistungsabfall oder Abweichung von den festgelegten Angaben zu den in den Spezifikationen des einzelnen Gerätes oder des Teilsystemes über die angegebenen Toleranzen hinaus als Reaktion auf andere als die beabsichtigten Reize

3.2.55**Empfindlichkeitsschwelle**

Störpegel an einem Prüfpunkt, der gerade eine Störung in dem Gerät, dem Teilsystem oder dem System verursacht

3.2.56**Vakuum**

Umgebung mit einem Druck von höchstens 10 Pa

3.2.57**veränderlicher Spalt**

physischer Abstand zwischen elektrisch leitenden Elementen, der aufgrund unterschiedlicher Effekte Änderungen unterliegen kann

ANMERKUNG 1 Änderungen des Spalts können durch mechanische, thermomechanische oder andere Einflüsse auf die Einheit oder einen Teil der Einheit entstehen.

ANMERKUNG 2 Änderungen umfassen die Auswirkungen von MIT-Abläufen, Umweltprüfungen, Alterung und die Verwendung von Isolierstoffen.

NA.2 Abkürzungen

Für die Anwendung dieser Norm gelten die Abkürzungen nach ECSS-S-ST-00-01 und die folgenden Abkürzungen:

Abkürzung	Bedeutung
A	Analyse (en: analysis)
AC	Wechselstrom (en: alternating current)
AOCS	Untersystem für die Lage- und Umlaufbahnkontrolle (en: attitude and orbit control subsystem)
AR	Abnahme-Review (en: acceptance review)
BOL	Beginn der Lebensdauer (en: beginning-of-life)
CDR	kritisches Design-Review (en: critical design review)
DC	Gleichstrom (en: direct current)
DDF	Datei der Entwurfsdefinition (en: design definition file)
DJF	Datei zur Begründung des Entwurfs (en: design justification file)
DOD	Entladetiefe (en: depth of discharge)
DRB	Lieferungs-Untersuchungsausschuss (en: delivery review board)
DRD	Definition der Anforderungen an Dokumente (en: document requirement definition)
DRL	Dokumenten Anforderungsliste (en: document requirement list)
EED	elektrisches Anzünd- und Zündmittel (en: electro-explosive device)
EGSE	elektrische Bodendienstgeräte (en: electrical ground support equipment)
EIDP	Endeinheit-Datenpaket (en: end item data-package)
EMC	elektromagnetische Verträglichkeit (en: electromagnetic compatibility)
EMCAB	beratender Ausschuss für elektromagnetische Verträglichkeit (en: EMC Advisory Board)
EMEVP	Prüfplan für elektromagnetische Auswirkungen (en: electromagnetic effects verification plan)
EMEVR	Prüfbericht für elektromagnetische Auswirkungen (en: electromagnetic effects verification report)
EMI	elektromagnetische Störung (en: electromagnetic interference)
EOL	Ende der Lebensdauer (en: end of life)
EPS	Energieversorgungssystem (en: electrical power subsystem)
ESA	Europäische Weltraumorganisation (en: European space agency)
ESD	elektrostatische Entladung (en: electrostatic discharge)
FCL	Foldback-Strombegrenzer (en: fold-back current limiter)
FDIR	Fehlererkennung und -isolierung sowie Wiederherstellung (en: failure detection isolation and recovery)
FMEA	Analyse von Ausfallmodi und Auswirkungen (en: failure modes and effects analysis)
FMECA	Analyse von Ausfallmodi, Auswirkungen und Kritikalität (en: failure modes, effects and criticality analysis)
GDIR	allgemeine Design- und Schnittstellenanforderungen (en: general design and interface requirements)
ICD	Schnittstellenüberwachungsdokument (en: interface control document)

INS	Inspektion (en: inspection)
I-V	Stromspannung (en: current-voltage)
LCL	Sperrstrombegrenzer (en: latching current limiter)
MPPT	maximale Leistungspunktverfolgung (maximum power point tracker)
MRB	Herstellungs-Prüfausschuss (en: manufacturing review board)
OBC	Bordcomputer (en: on-board computer)
PCB	gedruckte Leiterplatte (en: Printed Circuit Board)
PDR	vorläufiges Design-Review (en: preliminary design review)
PVA	fotovoltaische Baugruppe (en: photovoltaic assembly)
QTR	Qualifikationsprüfbericht (en: qualification test report)
RF	Hochfrequenz (en: radio frequency)
RLCL	nachtriggerbarer Sperrstrombegrenzer (en: retriggerable latching current limiter)
RoD	Entwurfsbewertung (en: review of design)
PSA	Belastungsanalyse für Teile (en: part stress analysis)
SA	Solarmodul (en: solar array)
SAA	solarer Aspektwinkel (en: solar aspect angle)
SADM	Mechanismus zum Drehen von Solarmodulen (en: solar array drive mechanism)
SAR	Solarmodulregler (en: solar array regulator)
SCA	Solarzellen-Baugruppe, Solarzellenanordnung (en: solar cells assembly)
SEE	Auswirkungen durch ein Einzelereignis (en: single event effects)
SEU	Einzelereignis-Upsets (en: single event upsets)
SPF	Einzelausfall (en: single point failure)
SRR	Systemanforderungsüberprüfung (en: system requirements review)
T	Prüfung (en: test)
TM&TC	Telemetrie/Fernsteuern (en: telemetry/telecommand)
TRB	Ausschuss für die Bewertung der Prüfung (en: test review board)
TRR	Testbereitschafts-Review (en: test readiness review)
UV	ultraviolett (en: technology readiness level)
VCD	Verifizierungskontrolldokument (en: verification control document)
WCA	Analyse des ungünstigen Falls (en: worst case analysis)

— Leerseite —

English version

Space engineering - Electrical and electronic

Ingénierie spatiale - Électrique et électronique

Raumfahrttechnik - Elektrik und Elektronik

This European Standard was approved by CEN on 20 November 2023.

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European Foreword

This document (EN 16603-20:2023) has been prepared by Technical Committee CEN-CENELEC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-20:2023) originates from ECSS-E-ST-20C Rev.2.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2024, and conflicting national standards shall be withdrawn at the latest by May 2024.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 16603-20:2020.

The main changes with respect to EN 16603-20:2020 are listed below:

- clause 4.2.1.1 added due to addition of new clause 4.2.1.2;
- addition of requirements in new clause 4.2.1.2 "Reliable insulation";
- the addition of the new clause 4.2.1.2 made it necessary to add the new header 4.2.1.1 "General requirements" to separate the requirement from the former clause 4.2.1 "Failure containment and redundancy" from the new requirements for "Reliable insulation";
- update to cover the aspects of "reliable insulation" also known as "double insulation";
- addition of several terms in clause 3.2 related to the added subject of "Reliable insulation".

This document has been prepared under a standardization request given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1

Scope

This Standard establishes the basic rules and general principles applicable to the electrical, electronic, electromagnetic, microwave and engineering processes. It specifies the tasks of these engineering processes and the basic performance and design requirements in each discipline.

It defines the terminology for the activities within these areas.

It defines the specific requirements for electrical subsystems and payloads, deriving from the system engineering requirements laid out in ECSS-E-ST-10 "Space engineering – System engineering general requirements".

This standard may be tailored for the specific characteristics and constraints of a space project in conformance with ECSS-S-ST-00.

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 revision 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 more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	<i>ECSS system – Glossary of terms</i>
EN 16603-10	ECSS-E-ST-10	<i>Space engineering – System engineering general requirements</i>
EN 16603-20-06	ECSS-E-ST-20-06	<i>Space engineering – Spacecraft charging</i>
EN 16603-20-07	ECSS-E-ST-20-07	<i>Space engineering – Electromagnetic compatibility</i>
EN 16603-20-08	ECSS-E-ST-20-08	<i>Space engineering - Photovoltaic assemblies and components</i>
EN 16603-20-20	ECSS-E-ST-20-20	<i>Space engineering - Electrical design and interface requirements for power supply</i>
EN 16603-33-11	ECSS-E-ST-33-11	<i>Space engineering – Explosive systems and devices</i>
EN 16603-50-05	ECSS-E-ST-50-05	<i>Space engineering – Radio frequency and modulation</i>
EN 16603-50-14	ECSS-E-ST-50-14	<i>Space engineering – Spacecraft discrete interfaces</i>
EN 16602-30-02	ECSS-Q-ST-30-02	<i>Space product assurance – Failure modes, effects (and criticality) analysis (FMEA/FMECA)</i>
EN 16602-30-11	ECSS-Q-ST-30-11	<i>Space product assurance – Derating – EEE components</i>
EN 16602-40	ECSS-Q-ST-40	<i>Space product assurance – Safety</i>
EN 16602-70-12	ECSS-Q-ST-70-12	<i>Space product assurance – Design rules for printed circuit boards</i>
	IEEE 145-1993	Antenna Terms
	Impedance Specifications for Stable DC Distributed Power Systems, EEE transactions on power electronics, Vol. 17, no. 2, March 2002	Impedance Specifications for Stable DC Distributed Power Systems, X. Feng, J. Liu, F.C. Lee, IEEE Transactions on power electronics, Vol. 17, no. 2, March 2002

Terms, definitions and abbreviated terms

3.1 Terms from other standards

- a. For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply.
- b. For the purpose of this Standard, the following terms and definitions from ECSS-E-ST-20-20 apply:
 - 1. latching current limiter (LCL);
 - 2. retriggerable latching current limiter (RLCL).

3.2 Terms specific to the present standard

3.2.1 antenna farm

ensemble of all antennas accommodated on the spacecraft and provides for all the transmission and reception of RF signals

3.2.2 antenna port

abstraction of the physical connection among the antenna and its feeding lines, realised by means of connectors or waveguide flanges

3.2.3 antenna RF chain

sequence of microwave components inserted between an antenna input port or a BFN output port and a corresponding individual radiating element

NOTE Examples of microwave components are: ortho-mode transducers, polarisers, transformers as well as filters.

3.2.4 antenna support structure

part of an antenna having no electrical function, which can however impact its electrical performances, either directly due to scattering or indirectly

NOTE Example of indirect effect is induced thermo-elastic deformations.

3.2.5 array antenna

antenna composed by a number of, possibly different, elements that radiate RF signals directly into free space operating in combination, such that all or a part of them radiate the same signals

3.2.6 array-fed reflector antenna

antenna composed by a feed array, which can include or not a beam forming network, and one or more optical elements like reflectors and lenses

3.2.7 battery bus

primary power bus directly connected to the battery

NOTE Battery bus is sometimes called unregulated bus (although the battery charge is regulated).

3.2.8 beam forming network (BFN)

wave-guiding structure composed a chain of microwave components and devices aimed at distributing the RF power injected at the input ports to a number of output ports; in a transmitting antenna the RF power injected from the transmitter is routed to the radiating elements, in a receiving antenna the RF power coming from the radiating elements is routed to the antenna ports connected to the receiver

NOTE Examples of microwave components and devices are lines, phase shifters, couplers, loads.

3.2.9 conducted emission (CE)

desired or undesired electromagnetic energy that is propagated along a conductor

3.2.10 critical line

[CONTEXT: reliable insulation] line that is part of a critical net

NOTE As an example, limited to a solar array, typically a critical line is a line that carries the current of a section downstream from the electrical node collecting the current from the different strings that constitute the section. However, in case a short between strings within a section leads to a failure propagation, then correspondingly a string is considered as a critical line.

3.2.11 critical net

[CONTEXT: reliable insulation] electrical net that if short circuited with another electrical net or another conductor including satellite and launcher structure can cause critical effects

NOTE For “critical effects” see Table 4-1 of ECSS-Q-ST-30-02.

3.2.12 critical pressure

pressure at which corona or partial discharge can occur in an equipment

3.2.13 diffusivity

ability of a body to generate incoherent diffuse scattering due to local roughness, inhomogeneity or anysotropy when illuminated by RF waves

3.2.14 depth of discharge (DOD)

ampere-hour removed from a battery expressed as a percentage of the nameplate capacity

3.2.15 double insulation

see “reliable insulation”

3.2.16 electrical bonding

process of connecting conductive parts to each other so that a low impedance path is established for grounding and shielding purposes

3.2.17 electromagnetic compatibility (EMC)

ability of equipment or an element to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

3.2.18 electromagnetic compatibility control

set of techniques to effectively regulate the electromagnetic interference environment or susceptibility of individual space system components or both

NOTE They include, among others, the design, placement of components, shielding, and employment of rejection filters.

3.2.19 electromagnetic interference (EMI)

undesired electrical phenomenon that is created by, or adversely affects any device whose normal functioning is predicated upon the utilization of electrical phenomena

NOTE It is characterized by the manifestation of degradation of the performance of an equipment, transmission channel, or element caused by an electromagnetic disturbance.

3.2.20 electromagnetic interference safety margin (EMISM)

ratio between the susceptibility threshold and the interference present on a test point

3.2.21 emission

electromagnetic energy propagated by radiation or conduction

3.2.22 energy balance

situation in which the spacecraft energy budget is positive when elaborated over a considered period of time

NOTE 1 Energy budget is generation minus consumption and losses.

NOTE 2 The considered period of time can be one orbit, several orbits or any relevant mission period.

3.2.23 energy reserve

energy that remains available from the energy storage assembly at the worst-case, most depleted, point of nominal operations

NOTE It is important that the energy reserve is sufficient to permit reaching a safe operating mode upon occurrence of an anomaly.

3.2.24 essential function

function without which the spacecraft cannot be recovered following any conceivable on-board or ground-based failure

NOTE Examples of unrecoverable spacecraft is when spacecraft cannot be commanded, or permanently losses attitude and control, or the energy balance is no longer ensured, or the spacecraft consumables (e.g. hydrazine or Xenon) are depleted to such an extent that more than 10 % of its lifetime is affected, or the safety of the crew is threatened.

3.2.25 faulty signal

signal generated by a circuit, appearing at its interface to another circuit, going out of its nominal range because of a failure

3.2.26 foldback current limiter (FCL)

non latching current-limiting function where the current limit decreases with the output voltage

NOTE This function is used for power distribution and protection typically for essential loads.

3.2.27 fully regulated bus

bus providing power during sunlight and eclipse periods with a regulated voltage

3.2.28 grounding

process of establishing intentional electrical conductive paths between an electrical circuit reference or a conductive part and equipment chassis or space vehicle structure

NOTE Grounding is typically performed for safety, functionality, signal integrity, EMI control or charge bleeding purpose.

3.2.29 high Priority telecommand (HPC)

command originated from ground and issued by the telecommand decoder for essential spacecraft functions without main on board software intervention

3.2.30 high voltage

AC or DC voltage at which partial discharges, corona, arcing or high electrical fields can occur

3.2.31 insulation

separation of elements either by material or by a distance

NOTE Etymologically, insulation is the act of protecting something with a material that prevents heat, sound, electricity, etc. from passing through. To insulate will then correspond to the action to protect by adding a material, an insulation (materials or device used for this protection).

3.2.32 invariable gap

physical distance among electrically conductive elements respecting the specified minimum limits independent from the stresses applied to the unit or part of the unit

NOTE 1 Changes of the gap can result from effects of mechanical, thermomechanical or other nature, applied to the unit or part of the unit.

NOTE 2 Stresses include the impacts of AIT operations, environmental tests, ageing and the use of insulation materials.

3.2.33 isolation

separation of elements put far from each other, with the notion of distance

NOTE To isolate is the action to separate by adding distance and to be isolated means protected by a distance.

3.2.34 lens antenna

antenna composed by a number of RF lenses and reflecting surfaces illuminated by a primary source, the feed

3.2.35 lightning indirect effects

electrical transients induced by lightning in electrical circuits due to coupling of electromagnetic fields

3.2.36 major reconfiguration function

function used to recover from system failures of criticality 1, 2 or 3

NOTE Criticality categories are defined in ECSS-Q-ST--30 and ECSS-Q-ST-40.

3.2.37 nameplate capacity

capacity stated by the manufacturer of an energy storage cell or battery

NOTE It is given in ampere-hours. It is not necessarily equal to any measurable capacity.

3.2.38 non essential loads

loads related to units which do not implement essential functions for the spacecraft

3.2.39 passive intermodulation products (PIM)

spurious signals generated by non-linear current-voltage characteristics in materials and junctions exposed to sufficiently RF high power carried by guided or radiated fields and currents, possibly triggered by microscopic mechanical movement

3.2.40 photovoltaic assembly (PVA)

power generating network comprising the interconnected solar cell assemblies, the shunt and blocking diodes, the busbars and wiring collection panels, the string, section and panel wiring, the wing transfer harness, connectors, bleed resistors and thermistors

3.2.41 primary cell or battery

battery or cell that is designed to be discharged once and never to be recharged

3.2.42 primary power bus

spacecraft electrical node closest to the power sources where power is controlled and made available to the user equipment

3.2.43 radiofrequency (RF)

frequency band used for electromagnetic waves transmission

3.2.44 radiated emission (RE)

radiation and induction field components in space

3.2.45 recharge ratio (k)

ampere-hours charged divided by the ampere-hours previously discharged, starting and finishing at the same state of charge

NOTE It is also known as the k factor.

3.2.46 reflector antenna

antenna composed by a number of reflecting surfaces, RF reflectors, illuminated by a primary source, the feed

3.2.47 reliable insulation

barrier between conductors or elements of an electrical circuit such that after any credible single failure, conductors or elements of an electrical circuit are still insulated from each other

NOTE The term “**reliable insulation**” is preferred to the term “**double insulation**” that was used in the previous version.

3.2.48 RF chain

sequence of microwave components inserted between the RF power amplifier and the antenna input port

3.2.49 RF lens

plastic, composite or metallic structure acting on transmitted RF waves to control the antenna pattern

NOTE Example of metallic structures are waveguide array lenses.

3.2.50 RF reflector

metallic or composite structure, possibly metallised or with printed or embedded metallic elements, acting on reflected RF waves to control the antenna pattern

NOTE Frequency and polarisation surfaces as well as other fully reflecting or partially reflecting and transmitting structures, also having non-uniform or anisotropic scattering behaviour, are considered reflectors

3.2.51 secondary cell or battery

battery or cell that is designed to be charged and discharged multiple times.

3.2.52 solar aspect angle (SAA)

angle between the normal to a solar panel and the sun vector

3.2.53 solar cell assembly (SCA)

solar cell together with interconnector, coverglass and if used, also a by-pass diode

3.2.54 susceptibility

malfunction, degradation of performance, or deviation from specified indications, beyond the tolerances indicated in the individual equipment or subsystem specification in response to other than intended stimuli

3.2.55 susceptibility threshold

interference level at a test point which just causes malfunction in the equipment, subsystem, or system

3.2.56 vacuum

environment with a pressure of 10 Pa or below

3.2.57 variable gap

physical distance among electrically conductive elements that can be subject to changes due to different effects

- NOTE 1 Changes of the gap can result from effects of mechanical, thermomechanical or other nature, applied to the unit or part of the unit.
- NOTE 2 Changes include the impacts of AIT operations, environmental tests, ageing and the use of insulation materials.

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
A	analysis
AC	alternating current
AOCS	attitude and orbit control subsystem
AR	acceptance review
BOL	beginning-of-life
CDR	critical design review
DC	direct current
DDF	design definition file
DJF	design justification file
DOD	depth of discharge
DRB	delivery review board
DRD	document requirement definition
DRL	document requirement list
EED	electro-explosive device
EGSE	electrical ground support equipment
EIDP	end item data-package
EMC	electromagnetic compatibility
EMCAB	EMC Advisory Board
EMEVP	electromagnetic effects verification plan
EMEVR	electromagnetic effects verification report
EMI	electromagnetic interference
EOL	end of life
EPS	electrical power subsystem
ESA	European space agency
ESD	electrostatic discharge
FCL	fold-back current limiter
FDIR	failure detection isolation and recovery

Abbreviation	Meaning
FMEA	failure modes and effects analysis
FMECA	failure mode effect and criticality analysis
GDIR	general design and interface requirements
ICD	interface control document
INS	inspection
I-V	current-voltage
LCL	latching current limiter
MPPT	maximum power point tracker
MRB	manufacturing review board
OBC	on-board computer
PCB	printed circuit board
PDR	preliminary design review
PVA	photovoltaic assembly
QTR	qualification test report
RF	radio frequency
RLCL	retriggerable latching current limiter
RoD	review of design
PSA	part stress analysis
SA	solar array
SAA	solar aspect angle
SADM	solar array drive mechanism
SAR	solar array regulator
SCA	solar cells assembly
SEE	single event effects
SEU	single event upsets
SPF	single point failure
SRR	system requirement review
T	test
TM&TC	telemetry/telecommand
TRB	test review board
TRR	test readiness review
UV	ultraviolet
VCD	verification control document
WCA	worst case analysis

3.4 Nomenclature

The following nomenclature applies throughout this document:

- a. The word “shall” is used in this Standard to express requirements. All the requirements are expressed with the word “shall”.
- b. The word “should” is used in this Standard to express recommendations. All the recommendations are expressed with the word “should”.

NOTE It is expected that, during tailoring, recommendations in this document are either converted into requirements or tailored out.

- c. The words “may” and “need not” are used in this Standard to express positive and negative permissions, respectively. All the positive permissions are expressed with the word “may”. All the negative permissions are expressed with the words “need not”.
- d. The word “can” is used in this Standard to express capabilities or possibilities, and therefore, if not accompanied by one of the previous words, it implies descriptive text.

NOTE In ECSS “may” and “can” have completely different meanings: “may” is normative (permission), and “can” is descriptive.

- e. The present and past tenses are used in this Standard to express statements of fact, and therefore they imply descriptive text.

General requirements

4.1 Interface requirements

4.1.1 Overview

ECSS-E-ST-10 specifies that interfaces external or internal to a system are adequately specified and verified. The following requirements address this issue and are processed in phase B, C and D of a project (see ECSS-E-ST-10).

4.1.2 Signals interfaces

- a. Interface engineering shall ensure that the characteristics on both sides of each interface are compatible, including source and load impedances, the effects of the interconnecting harness and the grounding network between both sides comprising: common mode impedance conducted and radiated susceptibility and emission.
- b. In order to minimize the number of interface types, standard interface circuitry shall be defined to be applied throughout a project.
- c. Reconfiguration, high level or high priority command lines shall be immune to spurious activation.
- d. The application of the nominal signals or a faulty signal to an un-powered interface shall not cause damage to that interface.

NOTE This requirement covers all types of interfaces.
Standard interfaces are covered in clauses
4.2.4.3 and 4.2.4.4 of ECSS-E-ST-50-14.

- e. An undetermined status at the interfaces of a powered unit shall not cause damage to an un-powered interface.

NOTE Undetermined status includes: non-nominal
operating modes, permanent and non-
permanent failure modes, powered and un-
powered interfaces.

- f. Signal interfaces shall withstand without damage positive or negative nominal voltages that are accessible on the same connector, coming from the unit itself, from the interfaced units or from EGSE.

4.1.3 Commands

- a. Every command (intended to be sent to the spacecraft) shall be assessed for criticality at equipment level, and confirmed at subsystem/system level.

NOTE The criticality of a command is measured as its impact on the mission in case of inadvertent function (erroneous transmission), incorrect function (aborted transmission) or loss of function. The definition of criticalities can be found in ECSS-Q-ST-30 and ECSS-Q-ST-40.

- b. All executable commands shall be explicitly acknowledged by telemetry.
- c. High Priority telecommand decoding and generation shall be independent from the main on-board processor and its software.

NOTE For failure case, refer to requirement 4.2.1.1a.

- d. With the exception of pyrotechnic commands, the function of an executable command shall
 - 1. not change throughout a mission; and
 - 2. not depend on the history of previous commands.
- e. For commands of category 1 and 2 criticality, at least two separate commands for execution: an arm/safe or enable/disable followed by an execute command shall be used.

NOTE For criticality categories, see ECSS-Q-ST-30 or ECSS-Q-ST-40.

- f. The functionality shall be provided to repeat the transmission of all the executable commands without degradation of the function or a change of its status.
- g. In case of critical commands of category 1 and 2, at least two physically independent electrical barriers, including associated control circuits, shall be implemented for arming and executing the command.

NOTE 1 For criticality categories, see ECSS-Q-ST-30 or ECSS-Q-ST-40.

NOTE 2 Mechanical barriers can be considered.

NOTE 3 Physically independent electrical barriers and associated control circuits are the ones not sharing any hardware function and without risk of reciprocal failure propagation.

- h. Processor and simple logic circuits shall not be able to issue category 1 and 2 critical commands without a ground commanded arm/safe or enable/disable command.

NOTE To avoid inadvertent activation of processes enabled/disabled by category 1 or 2 critical commands during ground operations and in low earth orbit phases, it is necessary to foresee safety barriers (arm/safe commands) to inhibit the execution of such critical commands. Such safety barriers might be spacecraft skin connections (to be established or broken just before flight) or connections/disconnection plugs to be activated by launcher stages release

(in flight). The activation/deactivation of such barriers has to be independent from on board processor.

- i. Any on-board processing which issues commands to reconfigure subsystems or payloads shall be overridable and potentially inhibited by ground command.

NOTE For criticality categories, see ECSS-Q-ST-30 or ECSS-Q-ST-40.

- j. No valid command shall be issued until the transmitter power supply is within operational voltage range and ready to transmit the command.

4.1.4 Telemetry

- a. Telemetry data devoted to the spacecraft subsystem and payloads monitoring shall allow:
 - 1. the retracing of the overall configuration at least up to all reconfigurable elements;
 - 2. the location of any failure able to impact the mission performances and reliability at least up to all reconfigurable elements.
- b. The operational status (On/Off, enabled/disabled, active/not-active) of each element of any telemetry acquisition chain should be provided to the on-board computer in order to determine without ambiguity the validity of the telemetry data at the end of the overall chain.
- c. Primary bus load currents shall be monitored by telemetry, to enable, together with the bus voltage telemetry, a complete monitoring of a primary bus power load.
- d. Telemetry shall be implemented to monitor the evolution of the power-energy resources and the source temperatures during the mission.

4.2 Design

4.2.1 Failure containment and redundancy

4.2.1.1 General requirements

- a. Failure propagation shall meet the following conditions:
 - 1. a single hardware failure does not propagate to neighbouring components circuits or interfaces in an undetermined way;
 - 2. failure propagation is verified by analysis;
 - 3. mechanical, thermal or electrical propagation of single hardware failures does not impair the corresponding protection or redundancy implemented at equipment or system level;

4. single hardware failure does not propagate to equipment or functions under different contractual responsibility than the item where the failure takes place.

NOTE 1 4.2.1.1a.4 is normally covered by specification of fault emission and tolerance conditions.

NOTE 2 Component assembly (e.g. single cavity hybrid) and integrated circuits, especially if they contain redundancy or protection, require special attention."

- b. Redundant signal or power lines should be segregated via physically separated connectors and harnesses.
- c. Routing of redundant power or signal lines within common harness or connector shall be justified by analysis showing that inside the electrical unit and at external connector interface level there is no potential single failure leading to affect both nominal and redundant lines or to generate electrical or electromagnetic interference between both.

NOTE 1 Typical analysis for demonstrating compliance is provided within FMEA and EMC coupling analysis.

NOTE 2 Potential single failure includes short-circuit cases."

- d. Redundant functions shall be physically separated with no risk of failure propagation by thermal or other coupling and as a minimum, contained within different integrated circuits to avoid failure propagation.
- e. For redundant functions implemented on the same PCB, a physical separation shall be provided, with no risk of thermal or other failure propagation.

NOTE Example of physical separation are by a minimum distance, insulation, or cut-out.

- f. For redundant functions implemented on the same PCB, any deviation of the physical separation specified in 4.2.1.1e shall be tracked in the Critical item List.

- g. <<deleted>>

- h. In case a cold redundant function is simultaneously activated together with the nominal one, by a deliberate or wrong command or due to a fault, this shall not induce permanent degradation of either of the two functions or loss of the mission before FDIR action.

NOTE E.g. thermal and EMC functions.

- i. <<deleted>>

- j. Any active equipment, excluding heaters, continuously dissipating more than 20 W in nominal or failure condition shall include a temperature monitoring function, which is implemented and provides continuous temperature monitoring.

- k. In case of signal cross-strapping, no single failure of either interface circuit shall propagate to the other one.

- l. In the case of hot redundant essential functions, latching protection shall not be used unless it has an autonomous periodic reset.
- m. Disabling critical on-board autonomous functions shall be allowed only if an interlock mechanism is implemented, which prevents the disabling of both main and redundant functions at the same time.

NOTE Critical functions refers to functions which prevent the satellite from being recovered when both main and redundant are switched off, e.g. RF receiver or command decoder.

- n. Any protection latch, which does not have autonomous reset capability, shall be at least re-settable from ground command.
- o. Any protection of an essential function shall not share with the essential function itself the same component or integrated circuit nor utilize common references or auxiliary supply.
- p. Essential functions shall not be lost upon a single failure of other functions which are centrally powered or controlled.

NOTE 1 E.g. on synchronization and auxiliary supply.

NOTE 2 That can imply the capability of an equipment performing an essential function of operating independently of any external synchronization and auxiliary power supply if these are not SPF free.

- q. For essential functions supplied by an FCL, lock-up phenomenon requiring recovery via the removal of external power shall be prevented.
- r. All units to be powered during launch shall be designed for operation with critical pressure.
- s. A venting analysis shall be performed for all units not designed to operate under critical pressure and not powered during launch, to determine when they can safely be turned-on.
- t. Any on-board autonomous function, the failure of which can result in malfunctions of category 1 and 2 criticality, shall have override capability.

NOTE Examples of override are:

- a simple inhibition or isolation (e.g. cold or hot redundant chain[s] exists);
- an H/W reset (e.g. in case of SEU);
- an inhibition + by-pass (e.g. a stepper motor control loop by-passed by a direct step by step command as back-up).

- u. Any on-board autonomous protection override, leading to hazardous situation for the mission (category 1 and 2 criticality), shall not be implemented.

NOTE E.g. an LCL function for instance protecting the main power Bus against a short circuit at Bus user level or Main Bus over-voltage protection.

- v. SEE shall not activate protection circuits of essential functions.

NOTE Mitigation techniques can be implemented to avoid such phenomena: filtering, majority voting, etc

- w. The spacecraft electrical system shall be single failure tolerant for unmanned mission and double failure tolerant for manned mission.
- x. Occurrence of a non-destructive SEE after a failure shall not lead to the loss of the mission.

NOTE Accordingly, a non-destructive SEE cannot derail a reconfiguration process after first hardware failure.

- y. For electrical connections of critical lines directly exposed to free space, the distance between power lines or between power and return lines shall not be considered an effective insulation from dielectric point of view, including inside connectors.

4.2.1.2 Reliable insulation

4.2.1.2.1 Reliable insulation assumptions

“Reliable insulation” was previously called “Double insulation”.

Reliable Insulation requirements present in this standard:

- are intended to avoid short circuit of critical lines or nets due to foreign conductive particles;
- are intended to reduce to negligible the risks of short circuit of critical nets or lines due to errors or marginality in design, manufacturing or integration;
- do not cover short circuits that might be caused by meteorites hitting a spacecraft;
- do not intend to prevent insulation losses inside EEE components. The effects of components internal short-circuit risk is managed through FMECA and mitigated by design. Nevertheless, when an internal short-circuit risk between the chip or the leads and the component case (if metallic) is possible, external insulation or other mitigation actions are required.

NOTE 1 For EEE components, different ECSS standards are applicable.

NOTE 2 Wires/cables are an exception to this assumption. For them all layers of insulation, including those between wire cores and the respective wire/cable shield, are subject to reliable insulation.

For EEE components (like opto, relay, hybrid, MOS-FET) their internal construction is key to demonstrate compliance to reliable insulation requirements.

Additionally for solar arrays, reliable insulation requirements present in this standard:

- are intended to avoid short circuit of critical lines or nets due to foreign conductive particles, or to plasma or ESD effects.

4.2.1.2.2 Reliable insulation applicability

- a. Reliable insulation requirements in this standard shall apply to all critical nets.

NOTE 1 Examples of critical nets are:

- non-protected sections of a main bus power distribution system up to and including the first overload or overcurrent protection device;
- cross-strapped power or signal critical lines or nets and associated common links, connecting main and redundant circuits and matrices;
- lines or nets where short circuits would result into failure propagation of critical nature;
- lines or nets where basic insulation provisions may be damaged by mission environment or mechanical interference.

NOTE 2 Insulation loss due to mechanical interference is for example present when there are sharp edges and there is the need for harness protection.

NOTE 3 For Reliable Insulation rules for PCBs, refer to ECSS-Q-ST-70-12.

NOTE 4 For a solar array, it is assumed that Reliable Insulation requirements apply to lines carrying the current of a section because they are critical; otherwise the Reliable Insulation requirements are tailored in an appropriate way, for example by increasing solar array capability allowing loss of at least one section.

4.2.1.2.3 Reliable Insulation requirements

- a. For those space applications where electrical lines insulation can be damaged by meteorites or micro-meteorites, dedicated Reliable Insulation requirements or agreed equivalent solution shall be established before satellites development according to the environment encountered and to the required reliability figure at system level.
- b. The presence of foreign particles inside equipment, subsystem or system shall be treated as a credible event.

NOTE 1 Example of foreign particles are the materials used for manufacturing, piece of wire, nuts, washers, components and pins.

NOTE 2 Visual inspection is normally done to avoid the presence of foreign conductive particles that can create loss of insulation. Such particles might be there before equipment/subsystem/system closure or integration, or being the result of vibration exposure due to poor fixation. Potential particles and the activities that leads to emerging of these particles are identified and control plan is created if needed.

NOTE 3 Visual inspection is done on equipment, subsystem or system level before final assembly to avoid the presence of such particles that might create loss of insulation.

NOTE 4 The visual inspection method used is compatible with the minimum size of the particle to be detected.

- c. The non-existence of foreign particles shall be verified by visual inspection or test.
- d. The presence of foreign particles shall be assessed, recorded in the DJF, and resolved if not compatible with the application.
- e. All conductive elements of critical nets shall be provided with insulation means.

NOTE Insulation means are intended as insulating coating, or confinement of bolted connections or conductor inside insulation box (for example in the case of bus bars). Distance alone is not considered as a valid insulation means.

- f. Requirement 4.2.1.2.3e shall not apply to:
 - 1. Solar Array solar cells, by-pass diodes, conductive coverglasses, solar cell interconnectors, blocking diode assembly and terminations, where no insulating material apart from vacuum is present among them;
 - 2. Solar Array Drive Mechanism slip rings; and
 - 3. Battery cell technologies for which loss of insulation is covered by other specific provisions.

NOTE For example NiH₂.

- g. To ensure an effective insulation from dielectric point of view, the gap among critical lines or between a critical line and any other conductor shall comply to the following two cases, for operational voltages up to 250 V:
 - 1. Case 1: invariable gap greater than 1mm: use of 1 insulating material (non-gaseous/non-vacuum);
 - 2. Case 2: variable gap or gap smaller than 1mm: use of 2 different materials (including at least 1 rigid).

NOTE 1 For rigid material, see requirements 4.2.1.2.3o and 4.2.1.2.3p.

NOTE 2 In case 2, two different materials or two layers of individually cured material are used.

NOTE 3 In the few particular cases where no suitable insulation layer can be added, the distance between the critical potential and any other potential is increased and guaranteed. The absence of risk of a particle with a size that could jeopardize the insulation at that level is guaranteed by inspection and by design (e.g. quasi-hermetic area).

h. The worst case minimum thickness of the materials for reliable insulation shall be taken into account, and not their nominal or design values.

i. It shall be demonstrated that no critical air bubbles to cause discharges are present in adhesives.

NOTE 1 The absence of critical air bubbles in adhesives is demonstrated by a quality control sample and DPA.

NOTE 2 Adhesives are normally not considered as insulators for reliable insulation purposes.

j. The physical implementation of the reliable insulation shall be documented and recorded.

NOTE The implementation of reliable insulation is provided either in a project specific or in a standard document from the equipment provider and recorded in the respective manufacturing documentation (e.g. traveler or inspection record).

k. The rigid and non-rigid materials used to ensure reliable insulation shall be listed in the document mentioned in 4.2.1.2.3j with their thickness and characteristics or the reference to the respective ESCC standard be indicated.

NOTE As an information on rigid and non-rigid materials, consult Table 4-1.

Table 4-1: List of rigid and non-rigid materials

Material	Characteristic
Epoxy fiberglass	Rigid (thickness $\geq 100 \mu\text{m}$)
PEEK	Rigid (thickness $\geq 100 \mu\text{m}$)
ULTEM Polyetherimide (PEI)	Rigid (thickness $\geq 100 \mu\text{m}$)
DURATRON Polyetherimide (PEI)	Rigid (thickness $\geq 100 \mu\text{m}$)
KYNAR (shrinkable sleeves)	Rigid
Epoxy FR4 laminate and pre-preg	Rigid
Polyimide laminate and pre-preg	Rigid
Ceramic (no crack risk under constraint)	Rigid
Scotchweld EC2216 (epoxy resin)	Rigid
Enamel grade 2	Rigid
Araldite AW 139 (epoxy resin)	Rigid (thickness $\geq 100 \mu\text{m}$)
Stycast 2850FT and 2651 (epoxy resin)	Rigid (thickness $\geq 100 \mu\text{m}$)
Kapton	Rigid (thickness $\geq 50 \mu\text{m}$)
Solithane 113 + cabosil (silice load) used as resin	Non-rigid
Mapatox41B varnish (PCB conformal coating)	Non-rigid
DC 93500 (varnish)	Non-rigid
DC 6-1104 (thick varnish)	Non-rigid
Cho-therm T500 and R1671	Non-rigid
TIM (thermal material interface)	Non-rigid
RTV silicon	Non-rigid
Mapsil 213	Non-rigid
Enamel grade 1	Non-rigid

1. The electrical insulation materials shall have a dielectric strength in excess of 2 times the peak operative voltage in the actual application.

NOTE As a reference, the dielectric strength value of Air (3 kV/mm) can be used as selection criterion for materials.

For resistivity, typical value is $10\text{E}9 \text{ Ohm.m}$.

The selection of insulation material needs to take into account potential charging/ESD constraints (see ECSS-E-ST-20-06).

- m. The electrical insulation materials shall be resistant to the different phases of the unit MAIT (Manufacturing, Assembly, Integration and Test) process.
- n. Materials used in direct contact between 2 parts to be reliably insulated and between which an electrical field is present, shall not be

contaminated, or contain other non-homogeneous pathway for leakage current to develop in clean room conditions, with max 65 % RH.

NOTE For instance, epoxy fiberglass or laminate/pre-preg can be procured against standards that allow some contamination to be present. Other types of non-homogenous pathway could be caused by agglomeration of fillers or flame retardant.

- o. In relation to reliable insulation, a material shall be treated as rigid if its Vickers hardness is greater than 20, either in raw state or after treatment.
- p. In relation to reliable insulation and in alternative to requirement 4.2.1.2.3o, a material shall be considered as rigid if the insulation layer produced with it can guarantee the required minimum thickness, for all required operative conditions including manufacturing and test process.

NOTE The required minimum thickness is guaranteed either by process or by verification.

- q. For critical lines and nets involving voltages exceeding 250 V, a minimum of 2x the distance identified by a dedicated analysis shall be used.

NOTE The dedicated analysis is performed to demonstrate the ability to cope with HV effects for critical nets.

- r. For critical lines and nets involving voltages exceeding 250 V, insulation shall be demonstrated by test with the application of 2x the operational voltage limit.
- s. A foreign particle should not jeopardise one insulation layer of the reliable insulation.
- t. Conductors with sharp edges, or geometries preventing the access to conformal coating shall be locally insulated with suitable material.

NOTE Example of geometries with difficult access are pins of PCB connectors or bus bars, components leads end (at PCB verso).

- u. Where the use of shielded wires and/or over-shielded harness together with reliable insulation is required:
 - 1. the issue shall be brought to customer attention; and
 - 2. the absence of any short-circuit risk between wire core and shield shall be demonstrated all along the harness, as well as at shield grounding connection points.

NOTE It is best practice not to use shielded or over-shielded harness and wires for signals to be reliable insulated.

- v. In case flexible connections are used, i.e. flex PCBs, the applicable requirements of Clause 8 of ECSS-Q-ST-70-12 shall be applied.

- w. In the connectors mating area, the risk of short-circuit between a pin to be reliably insulated and a conductor at any other potential, due to a particle or to a bent pin shall be avoided.

NOTE 1 For example, conductor at any other potential can be a pin at a different potential or connector metallic case.

NOTE 2 Such short-circuit risk can be mitigated either by design (interfacial seal implementation, provision of not mounted pins locations, no risk of pin bending by design) or by inspection (absence of particle).

- x. Critical lines and nets shall be identified as part of a FMECA process or of a dedicated analysis at the beginning of the system, subsystem or equipment development, at relevant PDR at the latest.
- y. A dedicated analysis shall confirm that reliable insulation of critical lines or nets is not jeopardized by failures, at system, subsystem or equipment level.

NOTE Failures can be of electrical, thermal or mechanical nature (for example issues of interference especially in integration and manufacturing phases). Dissipative failures are part of the analysis required.

- z. Critical lines or nets shall be clearly identifiable in electrical diagrams and in layout and assembly drawings.

NOTE The critical lines are preferably identified for example with colour codes on assembly drawings or, if not possible, via a statement or note on the drawing.

- aa. The electrical diagrams, layout and assembly drawings providing the information of the critical lines or nets may be part of the relevant analysis report.
- bb. Compliance to reliable insulation requirements of critical lines or nets shall be verified by review of design as well as by inspection and/or by test if possible.

NOTE The method of verification is matter of agreement between customer and supplier.

- cc. Verification of reliable insulation requirements should take place any time when it might be jeopardised by integration or rework activities, exposure to specific environment, electrical connection or disconnection.

4.2.2 Data processing

4.2.2.1 Overview

All operational and mission specific data are processed for acquisition, algorithm application, transmission, storage. On board time is managed by data handling

subsystem, in line with the mission requirements. Data processing includes the man machine, interface if any. The data processing system includes all hardware and software elements used for that purpose (e.g. microprocessor and its instruction set, interface means, data busses and remote terminals).

4.2.2.2 Provisions

- a. For technical budgets and margin policy the requirements of ECSS-E-ST-10 clause 5.4.1.2 shall be applied.
- b. The margin for available memory size and load factors of processors should be:
 1. for new developments, 50 % as a minimum at PDR for new on board software parts;
 2. 25 % at launch.
- c. The margin on the throughput of on-board communication networks should be:
 1. for new developments, 50 % as a minimum at PDR on the average throughput;
 2. such that real time overflow is avoided.
- d. In the absence of specific mission requirements the following applies: After error correction, reset or data corruption of main functions at equipment level should be kept to a rate of occurrence less or equal to 10^{-4} per day for worst case conditions of environment.
- e. For programmable logic devices (FPGA), the available margin of unused blocks and pin shall be agreed at FPGA SRR based on design complexity, requirement stability and experience return.

NOTE 1 To consider experience return, a factor of heritage of each block/IP can be used to multiply the estimated occupancy to have at the end, an overall occupancy < 100 %. Possible examples of heritage factor are:

- completely new component: 40 %;
- full heritage for code, but ported to another technology: 25 %;
- full heritage for both code and technology: 10 %.

If the requirements are not stable or possible modifications to accommodate future products/designs need are foreseen, a factor can also be applied to the overall design (i.e. 10 %).

NOTE 2 Design is highly re-used (> 80 % of the overall design), technology is mature (i.e. RTAX2000) and requirements are considered stable.

- A margin of 20 % is not considered a high risk.

- A margin of 10 % is still acceptable, but a mitigation plan can be requested (i.e. identifying some functions that can be removed or optimised, check if a pin-compatible bigger device is available, etc.).

NOTE 3 Most of the design is new and it is implemented in relatively new technology (i.e. RTG4).

- In this case, the risk related to low margin is much higher and a margin lower than 40 % is considered high risk. The risk can be assessed, the cost/benefit relation be evaluated and eventually the device selection might be re-assessed.

4.2.3 Electrical connectors

- a. A connector carrying source power or external test connectors on units shall have no contact areas exposed to possible short circuit during mating and de-mating process.

NOTE They generally are female type connectors.

- b. All external test connectors on a unit and spacecraft skin connectors shall be covered for flight.

NOTE Umbilical connectors (detached during launch) are not part of skin connectors (detached or connected before launch).

- c. The test connector covers should be metallic or metallized and grounded to structure.

- d. The use of a connector saver for ground testing shall not alter the performance of the equipment.

NOTE RF savers are known to introduce extra insertion losses, in the range of 0,1 dB.

- e. It shall be ensured that erroneous mating is avoided by connector keying or marking.

NOTE The requirement is met either by harness routing, or by using keyed connectors, or adequate positioning of connectors, or connectors of different type or size, or connector marking.

- f. If the equipment has several connectors, visibility and clearance around each of them should be such as to enable mating or de-mating without disturbing others already in place or necessitating custom-made tooling.

NOTE A usual practice is the insertion of a breakout box for trouble shooting.

- g. For supplies and signals of pyrotechnics and non-explosive single shot device drivers, different connectors should be used for different classes of electrical functions.
- h. When 4.2.3g is not met, power, signals, and telemetry shall be separated in the connector by a set of unused pin locations.
- i. Except when pin allocation is imposed by a standard specification, spare contacts or sockets should be available on each connector.
- j. For new developments, when the connection is not aligned to a defined standard, 10 % spare contacts at unit PDR and at least 5 % at CDR shall be achieved with in any case a minimum of two spare contacts available at CDR.
- k. In the absence of grounding provision at connector shell level, at least one contact per connector shall be connected to the unit structure as provision for potential additional grounding at subsystem or system level.
- l. Provision shall be taken to avoid arcing or short circuits in connectors.

NOTE For example: unused pins, placed between positive and return lines; specific connector design.

- m. The following shall be performed for any connector the loss of which can lead to the loss of the mission:
 - 1. document the connector in the single point failure list;
 - 2. verify and document its integrity up to the highest spacecraft integration level, to avoid accidental demating.
- n. <<deleted>>
- o. Battery and solar array power shall be distributed by multiple contacts on both positive and return lines.

4.2.4 Testing

- a. Test-stimulus points shall be accessible without the need of modifying the electrical configuration of an item of equipment.
- b. Test-stimulus points shall be protected for flight operation.
- c. For the purpose of meeting requirement 4.2.4a and 4.2.4b, dedicated test connectors should be used.
- d. <<deleted>>
- e. Test points on equipment shall be protected against damage up to the maximum fault voltage present on the connector either coming from the equipment or the EGSE.

NOTE It is expected that the design of the EGSE incorporates protections limiting the fault voltage emission to a level acceptable by the unit.