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Satellite Earth Stations and Systems (SES);
Harmonised Standard for tracking
Earth Stations on Trains (ESTs)
operating in the 14/12 GHz frequency bands
covering the essential requirements
of article 3.2 of the Directive 2014/53/EU

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Contents

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Foreword

This Harmonised European Standard (EN) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.5] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [4].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

National transposition dates	
Date of adoption of this EN:	16 May 2016
Date of latest announcement of this EN (doa):	31 August 2016
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	28 February 2017
Date of withdrawal of any conflicting National Standard (dow):	28 February 2018

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Introduction

The present document is part of a set of standards developed by ETSI and is designed to fit in a modular structure to cover all radio equipment within the scope of the Directive 2014/53/EU [4]. The modular structure is shown in ETSI EG 201 399 [i.3].

1 Scope

The present document applies to Earth Stations located on board Trains, which have the following characteristics.

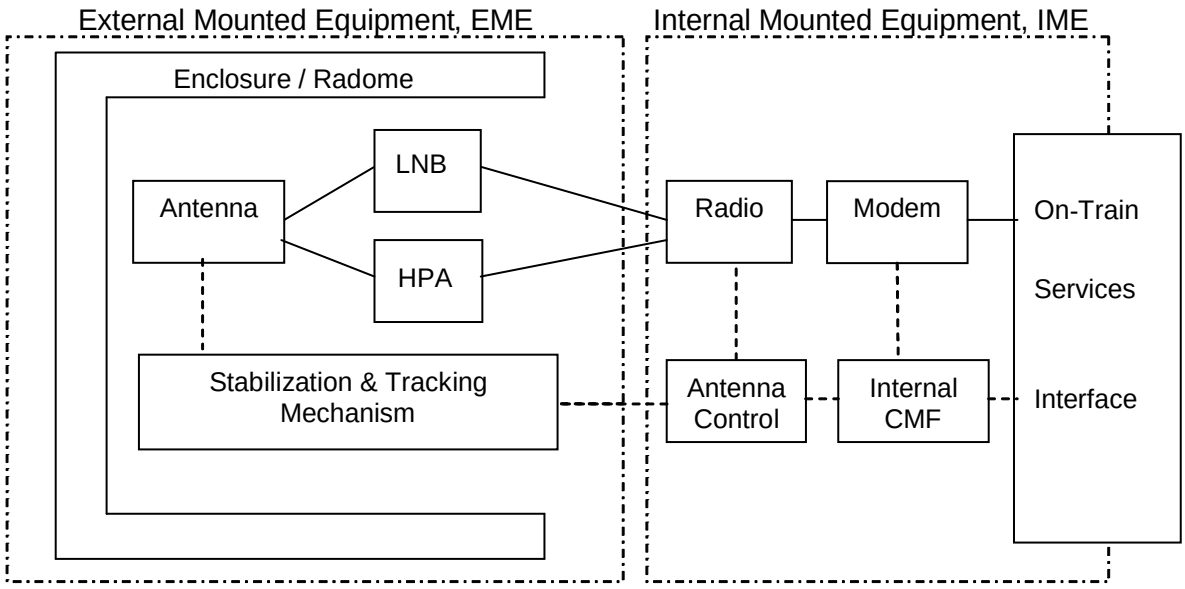


Figure 1: EST System Overview

- The EST may transmit and receive data when the train is in motion and also when the train is stationary.
- The EST operates in a railway environment and, therefore, may be subject to occasional disturbances and interruptions in the satellite link.
- The EST is operating as part of a satellite network (e.g. star, mesh or point-to-point) used for the distribution and/or exchange of information.
- The EST is comprised of all the equipment, electrical and mechanical, from the antenna itself to the interface with other communications equipment on a train (usually referred to as the terrestrial interface).
- The EST transmits on single carrier in the frequency range 14,00 GHz to 14,25 GHz, which is a portion of a band allocated to the Fixed Satellite Services (FSS) (Earth-to-space).
- The EST receives in one or more frequencies within the range from 10,70 GHz to 12,75 GHz in bands allocated to the Fixed Satellite Services (FSS) (space-to-Earth) or the Broadcast Satellite Service (BSS) (space-to-Earth), depending on the ITU Region where the EST is located.
- The EST uses linear or circular polarization.
- The EST is designed to operate through a geostationary satellite (or a cluster of co-located geostationary satellites) that is at least 3° away from any other geostationary satellite operating in the same frequencies and over the same coverage area.
- The EST transmits at elevations greater than or equal to 7° relative to the local horizon.
- The EST is designed for unattended operation.
- The EST is controlled and monitored by a Network Control Facility (NCF). The NCF is outside the scope of the present document.

The present document applies to the EST with its ancillary equipment and its various telecommunication ports, and when operated within the boundary limits of the operational environmental profile as declared by the applicant and when installed as required by the applicant's declaration or in the user documentation.

The present document is intended to cover the provisions of Directive 2014/53/EU [4] (RE Directive) article 3.2, which states that "… *radio equipment shall be so constructed that it both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference*".

NOTE 1: Operational requirements are defined by national administrations and by relevant ECC Decisions.

In addition to the present document, other ENs that specify technical requirements in respect of essential requirements under other parts of article 3 of the Directive 2014/53 [4] (RE Directive) may apply to equipment within the scope of the present document.

NOTE 2: A list of such ENs is included on the web site http://www.newapproach.org/.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] Void.

[2] Void.

[3] CISPR 16-1-5 (2014): "Specification for radio disturbance and immunity measuring apparatus and methods; Part 1-5: Radio disturbance and immunity measuring apparatus - Antenna calibration sites and reference test sites for 5 MHz to 18 GHz".

[4] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC (RE Directive).

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Void.

[i.2] CEPT Recommendation T/R 25-09: "Designation of frequencies in the 900 MHz band for railway purposes".

[i.3] ETSI EG 201 399: "Electromagnetic compatibility and Radio spectrum Matters (ERM); A guide to the production of Harmonized Standards for application under the Radio & Telecommunication Terminal Equipment Directive 1999/5/EC (R&TTE) and a first guide on the impact of the Radio Equipment Directive 2014/53/EU (RED) on Harmonized Standards".

[i.4] ETSI TR 102 215 (2004): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Recommended approach, and possible limits for measurement uncertainty for the measurement of radiated electromagnetic fields above 1 GHz".

[i.5] Commission Implementing Decision C(2015) 5376 final of 4.8.2015 on a standardisation request to the European Committee for Electrotechnical Standardisation and to the European Telecommunications Standards Institute as regards radio equipment in support of Directive 2014/53/EU of the European Parliament and of the Council.

[i.6] CENELEC EN 50155: "Railway applications - Electronic equipment used on rolling stock".

[i.7] CENELEC BS EN 60068: "Environmental testing. Test methods for vibration and shock".

[i.8] CENELEC EN 61373: "Railway applications. Rolling stock equipment. Shock and vibration tests".

[i.9] CENELEC EN 60945: "Maritime navigation and radiocommunication equipment and systems - General requirements - Methods of testing and required test results".

[i.10] CENELEC EN 55022: "Limits and methods of measurement of radio disturbance characteristics of information technology equipment".

[i.11] ETSI TR 102 375 (2005): "Satellite Earth Stations and Systems (SES); Guidelines for determining the parts of satellite earth station antenna radiation patterns concerned by the geostationary satellite orbit protection".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in Directive 2014/53/EU [4] and the following apply:

ancillary equipment: equipment used in connection with an EST is considered as ancillary if the three following conditions are met:

- the equipment is intended for use in conjunction with the EST to provide additional operational and/or control features (e.g. to extend control to another position or location); and
- the equipment cannot be used on a stand alone basis, to provide user functions independently of the EST; and
- the absence of the equipment does not inhibit the operation of the EST.

applicant: manufacturer or his authorized representative within the European Community or the person responsible for placing the apparatus on the market

carrier-off radio state: radio state in which the EST may transmit and does not transmit any carrier

NOTE 1: The phrase "the EST may transmit" means that all the conditions for transmission are satisfied (e.g. in a state where transmissions are permitted, no failure detected, and the EST is correctly pointed towards the satellite).

NOTE 2: The existence of a "Carrier-off" radio state depends on the system of transmission used. For ESTs designed for continuous transmission mode there may be no "Carrier-off" state.

carrier-on radio state: radio state in which the EST may transmit and transmits a carrier

Control Channel (CC): channel or channels by which ESTs receive control information from the NCF

$EIRP_{max}$: maximum e.i.r.p. capability of the EST as declared by the applicant

emissions disabled radio state: radio state in which the EST does not emit

NOTE: Examples of cases where the EST is in this radio state: before system monitoring pass, before the control channel is received, when a failure is detected, when an EST is commanded to disable, and when the EST is in a location requiring cessation of emissions.

external control channel: control channel which is either (i) carried by the EST network via the same or another satellite, but not within the internal protocol of the EST system, or (ii) carried by any other radio communication system

external response channel: response channel which is either (i) carried by the EST network via the same or another satellite, but not within the internal protocol of the EST system, or (ii) carried by any other radio communication system

Externally Mounted Equipment (EME): that part of the EST intended to be installed on the outside of the train (usually the roof), as declared by the applicant, or as indicated in the user documentation

NOTE 1: The EME unit is usually comprised of the following main parts:

a) The antenna sub-system which converts the incident radiation field into a guided wave and vice versa.

b) The Low Noise Block (LNB) down converter, which is a device that amplifies, with very low internal noise, the received signals in the Radio Frequency (RF) band and converts them to intermediate frequencies.

c) The up-converter and the power amplifier which convert from the intermediate frequency to RF and amplify the low level RF signals for transmission through the antenna subsystem.

d) The stabilization and tracking mechanics that ensure pointing of the antenna main beam towards the satellite within the required accuracy.

NOTE 2: The installation equipment (means of attachment) is outside the scope of the present document. However, the antenna structures and other components directly mounted on the antenna and forming an integral part of it, are subject to the specifications of the present document.

NOTE 3: Certain configurations may include more than one EME per EST. As for example, the EST may have separate transmit and receive antennas or it may have redundant transmit/receive antenna units.

integral antenna: antenna which may not be removed during the tests according to the applicant's statement

internal control channel: control channel which is carried by the EST network via the same satellite as used for transmission of user data and within the internal protocol structure of the EST system

internal response channel: response channel which is carried by the EST network via the same satellite as used for transmission of user data and within the internal protocol structure of the EST system

Internally Mounted Equipment (IME): part of the EST equipment which is installed inside the train and its connection cables with the EME

NOTE: The IME is usually comprised of:

a) the modem and the IF radio equipment;

b) the control logic, including that for the internal control and monitoring subsystem and the antenna tracking subsystem; and

c) the interfaces to equipment and services onboard the train.

maximum relative wind speed: addition of the magnitudes of the maximum wind speed and the maximum train velocity

Network Control Facility (NCF): set of functional entities that, at system level, monitor and control the correct operation of all ESTs in a network

nominal antenna diameter: antenna diameter declared by the manufacturer that is a parameter in performance characteristics and that allows reference to a certain performance

NOTE: An antenna with circular aperture of diameter equal to the nominal diameter does typically have the performance specified.

Network operators might request antennas of a certain diameter. Then an antenna that is compliant with the requirement for nominal antenna diameter equal to the requested antenna diameter can be used. Manufacturers can mark their equipment with antenna diameters used in the requirements during compliance test.

nominated bandwidth: bandwidth of the EST radio frequency transmission nominated by the applicant. The nominated bandwidth is centred on the transmit frequency and does not exceed 5 times the occupied bandwidth

NOTE: The nominated bandwidth is wide enough to encompass all spectral elements of the transmission which have a level greater than the specified spurious radiation limits. The nominated bandwidth is wide enough to take account of the transmit carrier frequency stability. This definition is chosen to allow flexibility regarding adjacent channel interference levels which will be taken into account by operational procedures depending on the exact transponder carrier assignment situation.

off-axis angle: angle between the direction of the axis of the antenna main beam and the considered direction

removable antenna: antenna which may be removed during the tests according to the applicant's statement

Response Channel (RC): channel by which EST transmit monitoring information to the NCF

spurious radiation: any radiation outside the nominated bandwidth

transmission disabled state: EST is in this state when it is not authorized by the NCF to transmit

transmission enabled state: EST is in this state when it is authorized by the NCF to transmit

Wanted signal occupied Bandwidth (BW):

- for a digital modulation scheme: the width of the signal spectrum 10 dB below the maximum in-band density;
- for an analogue modulation scheme: the width of a frequency band such that, below the lower and above the upper frequency limits, the mean power emitted is equal to 0,5 % of the total mean power of the emission.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

dBc	ratio expressed in decibels relative to the e.i.r.p. of the unmodulated carrier
dBi	ratio of an antenna gain to the gain of an isotropic antenna, expressed in decibels
dBsd	Ratio expressed in decibels relative to the spectral density
dBW	ratio of a power to 1 watt, expressed in decibels
dBpW	ratio of a power to 1 picowatt, expressed in decibels
dBµV/m	ratio of an electric field to 1 µV/m, expressed in decibels (20 log(electric field /1 µV/m))

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

BW	Bandwidth
BSS	Broadcast Satellite Service
CC	Control Channel
CCF	Control Channel reception Failure
CCR	Control Channel correctly Received
CENR	Cessation of Emissions Not Requested
CEPT	Conférence Européenne des Postes et Télécommunications (European Conference of Postal and Telecommunications Administrations)
CER	Cessation of Emissions Requested

CISPR	Comité International Spécial des Perturbations Radioélectriques (International Special Committee on Radio Interference)
CMF	Control and Monitoring Functions
e.i.r.p.	equivalent isotropically radiated power
EIRP	Equivalent Isotropically Radiated Power
ECC	Electronic Communications Committee (of CEPT)
EMC	Electro-Magnetic Compatibility
EME	Externally Mounted Equipment
EN	European Standard
EST	Earth Station on board a Train
EUT	Equipment Under Test
FEC	Forward Error Correction
FS	Fixed Service
FSS	Fixed Satellite Service
GSM-R	Global System for Mobile Communications - Railway
GSO	Geostationary Satellite Orbit
IME	Internally Mounted Equipment
IPR	Intellectual Property Rights
ITU	International Telecommunications Union
LNB	Low Noise Block down converter
LO	Local Oscillator
LV	Low Voltage
NCF	Network Control Facility
R&TTE	Radio and Telecommunications Terminal Equipment
RC	Response Channel
RE	Radio Equipment
RED	RE Directive
RF	Radio Frequency
SMF	System Monitoring Fail
SMP	System Monitoring Pass
STE	Special Test Equipment
TDMA	Time Division Multiple Access
TxD	Transmission Disable command
TxE	Transmission Enable command
XPD	Cross-Polarization Discrimination
XPDEST	Cross-Polarization Discrimination of the EST

4 Technical requirements specifications

4.1 General

4.1.1 Environmental profile

The applicant shall declare the environmental profile of the EST equipment and it shall include conditions for both survivability and operation. The declared environmental profile shall include, but not be limited to, a statement of conditions regarding: train velocity, tangential and longitudinal acceleration, temperature range, damp heat, dry heat, relative humidity stress, shock and vibration, antenna pressure pulses and pressure gradients.

NOTE: For guidance on the range of values for parameters in the environmental profile, applicants should consult the following standards: CENELEC EN 50155 [i.6]; CENELEC BS EN 60068 [i.7]; CENELEC EN 61373 [i.8]. For certain environmental parameters not covered in these standards, it may be useful to consult CENELEC EN 60945 [i.9]. The equipment should comply with the performance requirements of the present document under all operational environmental conditions.

4.1.2 Operational configurations

Under operational conditions an EST may dynamically change the occupied bandwidth and other transmission parameters (e.g. FEC, modulation, symbol rate) of the transmitted signal. For each occupied bandwidth an $EIRP_{max}$ and a nominated bandwidth shall be declared by the applicant. For the purposes of verifying that the EST complies with these specifications, the applicant may declare the worst case combination of transmission parameters. The following specifications apply to the EST for each occupied bandwidth and other transmission parameters.

4.1.3 EST states and radio states

For the purpose of the present document the following four EST states are defined, without presuming the effective implementation of the EST state machine:

- "Non valid";
- "Initial phase";
- "Transmission disabled"; and
- "Transmission enabled".

The four EST states are represented on figure 2 and are used in clause 4.2.8 for the specification of the Control and Monitoring Functions (CMFs).

In the "Non-valid" state and in the "Transmission disabled" state the EST is not allowed to transmit. In the "Transmission-enabled" state the EST is allowed to transmit. In the "Initial phase" state the EST is only allowed to transmit initial bursts or is waiting for a transmit enable/disable command.

The "Initial phase" is divided into three substates:

- "Initial phase-Standby" prior to the transmission of the first initial burst or when no initial bursts are transmitted;
- "Initial phase-BurstOn" during the transmission of the initial bursts;
- "Initial phase-BurstOff" between initial bursts.

NOTE: ESTs which do not transmit initial bursts have no "Initial phase-BurstOn" state and no "Initial phase-BurstOff" state.

The EST "may transmit" when all the conditions for transmission are satisfied (e.g. in a state where transmissions are permitted, no failure detected, correctly pointed towards the satellite and there is no requirement for cessation of emissions).

The following radio states of the EST are defined:

- "Emissions disabled" when the EST does not transmit any carrier;
- "Carrier-off" when the EST may transmit and does not transmit any carrier;
- "Carrier-on" when the EST may transmit and transmits a carrier.

Table 1a gives the only possible combinations of the EST states and radio states which shall apply, with some examples of associated events.

When the EST transmits several carriers having different frequencies, an EST state machine as described above may be associated with each carrier or each set of carriers.

Table 1a: EST states and radio states of the EST

EST states and substates	Radio states	Examples of events
"Non valid"	"Emissions disabled"	After-power on, or After any failure, or During the checking phase
"Initial phase"		When waiting for a transmission enable or disable command from the NCF
"Initial phase-Standby"	"Emissions disabled"	Before the first initial burst transmissions; or In locations where no transmission is allowed
"Initial phase-BurstOn"	"Carrier-on"	During the transmission of each initial burst, and the pointing is correct
"Initial phase-BurstOff"	"Carrier-off"	Between initial bursts, or When the pointing threshold is exceeded
"Transmission enabled"	"Carrier-off"	When no carrier is transmitted, or When receive synchronization is lost, or When the pointing threshold is exceeded
	"Carrier-on"	During transmission of carrier(s), and the pointing is correct
"Transmission disabled"	"Emissions disabled"	When a disable command from the NCF has been received and waiting for a transmission enable command from the NCF, or In locations where no transmission is allowed

4.2 Conformance requirements

4.2.1 Off-axis spurious radiation

4.2.1.1 Justification

To limit the level of interference to terrestrial and satellite radio services.

4.2.1.2 Specification

The following specifications apply to the EST transmitting at equivalent isotropically radiated power (e.i.r.p.) values up to and including $EIRP_{max}$.

1) The electric field strength level of any radiation from the EST in the frequency range from 30 MHz to 1 GHz shall not exceed the limits specified in table 1b.

Table 1b: Limits of radiated electric field strength

Frequency range	Limit (Quasi Peak)	Limit (Peak)	Measurement bandwidth	Measuring distance
30 MHz to 230 MHz (see note 1)	40 dBµV/m	no limit applies	120 kHz	10 m
230 MHz to 1 GHz (see note 1) (see note 3)	47 dBµV/m	no limit applies	120 kHz	10 m
876 MHz to 880 MHz (see note 2)	22 dBµV/m	no limit applies	120 kHz	3 m
921 MHz to 925 MHz (see note 2)	22 dBµV/m	no limit applies	120 kHz	3 m
NOTE 1: The limits in these rows are taken from CENELEC EN 55022 [i.10]. NOTE 2: The frequency ranges 876 MHz to 880 MHz and 921 MHz to 925 MHz are the base and mobile receive bands respectively of GSM-R (see CEPT Recommendation T/R 25-09 [i.2]). NOTE 3: Except in the band from 876 MHz to 880 MHz and from 921 MHz to 925 MHz as specified in this table.				

The Peak and Quasi Peak detectors shall be in accordance with CISPR 16-1-5 [3].

2) When the EST is in the "Emissions disabled" radio state, the off-axis spurious e.i.r.p. from the EST, in any 100 kHz band, shall not exceed the limits in table 2, for all off-axis angles greater than 7° or greater than the minimum elevation angle declared by the applicant, whichever is lower.

Table 2: Limits of spurious e.i.r.p. - "Emissions disabled" radio state

Frequency band	e.i.r.p. limit (dBpW)	Measurement bandwidth
1,0 GHz to 10,7 GHz	48	100 kHz
10,7 GHz to 21,2 GHz	54	100 kHz
21,2 GHz to 40,0 GHz	60	100 kHz

The lower limits shall apply at the transition frequency.

3) This specification applies outside the nominated bandwidth. In the "Carrier-on" and "Carrier-off" radio states, the off-axis spurious e.i.r.p. density from the EST, shall not exceed the limits in table 3, for all off-axis angles greater than 7° or greater than the minimum elevation angle declared by the applicant, whichever is lower.

Table 3: Limits of spurious e.i.r.p. - "Carrier-on" and "Carrier-off" radio states

Frequency band	e.i.r.p. limit (dBpW)	Measurement bandwidth	Remarks
1,0 GHz to 3,4 GHz	49	100 kHz	
3,4 GHz to 10,7 GHz	55	100 kHz	
10,7 GHz to 13,75 GHz	61	100 kHz	
13,75 GHz to 14,0 GHz	95	10 MHz	See note 1
14,00 GHz to 14,25 GHz			See note 2
14,250 GHz to 14,75 GHz	95	10 MHz	See note 1
14,75 GHz to 21,2 GHz	61	100 kHz	
21,2 GHz to 40,0 GHz	67	100 kHz	
NOTE 1: This limit may be exceeded in a frequency band which shall not exceed 50 MHz, centred on the carrier frequency, provided that the on-axis e.i.r.p. density at the considered frequency is 50 dB below the maximum on-axis e.i.r.p. density of the signal (within the nominated bandwidth) expressed in dBW/100 kHz.			
NOTE 2: A limit may be required in regions outside CEPT where FS systems have an allocation and are operating in the band 14,00 GHz to 14,25 GHz. This requirement is outside the scope of the present document.			

The lower limits shall apply at the transition frequency.

In the frequency band 28,0 GHz to 29,0 GHz, for any 20 MHz band within which one or more spurious signals exceeding the above limit of 67 dBpW/100 kHz are present, then the power of each of those spurious signals exceeding the limit shall be added in watts, and the sum shall not exceed 78 dBpW.

4) These limits are applicable to the complete EST equipment, comprising the IME and EME including cabling between the units.

4.2.1.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.2.

4.2.2 On-axis spurious radiation for EST

4.2.2.1 Justification

To limit the level of interference to satellite radio services.

4.2.2.2 Specification

4.2.2.2.1 "Carrier-on" radio state

The following specification applies to the EST transmitting at e.i.r.p. values up to $EIRP_{max}$.

In the 14,0 GHz to 14,25 GHz band the e.i.r.p. spectral density of the spurious radiation and outside a bandwidth of 5 times the occupied bandwidth centred on the carrier centre frequency shall not exceed 4 - K dBW in any 100 kHz band.

The e.i.r.p. spectral density of the spurious radiation outside the nominated bandwidth and within a bandwidth of 5 times the occupied bandwidth centred on the carrier centre frequency, shall not exceed 18 - K dBW in any 100 kHz band.

Where K is the factor that accounts for a reduction on the on-axis spurious radiation level in case of multiple ESTs operating on the same frequency and the value is given by one the following cases:

1) For the case where only one EST transmits at any one time on a given carrier frequency, the value of K is 0.

2) For the case where several ESTs are expected to transmit simultaneously on a given carrier frequency at the same e.i.r.p. then K = 10 log (N) where N is the maximum number of these ESTs. The value of N shall not be exceeded for more than 0,01 % of the time. The value of N and the operational conditions of the system shall be declared by the applicant.

3) For the case where several ESTs are expected to transmit simultaneously on a given carrier frequency at different e.i.r.p. levels then K = 10 log ($EIRP_{Aggregate}$/EIRP), where:

   - EIRP is the on-axis e.i.r.p. (Watts) of the EST within the nominated bandwidth; and
   - $EIRP_{Aggregate}$ is the maximum on-axis aggregate e.i.r.p. (Watts) within the nominated bandwidth of the EST system towards the satellite;
   - $EIRP_{Aggregate}$ shall not be exceeded for more than 0,01 % of the time.

The value of $EIRP_{Aggregate}$ and the operational conditions of the EST network shall be declared by the applicant.

NOTE 1: The on-axis spurious radiations, outside the 14,0 GHz to 14,25 GHz band, are indirectly limited by clause 4.2.1.2. Consequently no specification is needed.

NOTE 2: Intermodulation limits inside the band 14,0 GHz to 14,25 GHz are to be determined by system design and are subject to satellite operator specifications.

For ESTs designed to transmit several carriers on different frequencies simultaneously (multicarrier operation), the above limits only apply to each individual carrier when transmitted alone.

4.2.2.2.2 "Carrier-off" and "Emissions disabled" radio states

In the 14,0 GHz to 14,25 GHz band the e.i.r.p. spectral density of the spurious radiation outside the nominated bandwidth shall not exceed -21 dBW in any 100 kHz band.

4.2.2.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.3.

4.2.3 Off-axis e.i.r.p. emission density within the band

4.2.3.0 General

The present clause deals with the off-axis e.i.r.p. emission density (co-polarization and cross-polar) within the band 14,0 GHz to 14,25 GHz.

4.2.3.1 Justification

Protection of other satellite (uplink) systems.

4.2.3.2 Specification

The following specifications apply to the EST transmitting at e.i.r.p. values up to $EIRP_{max}$.

The maximum e.i.r.p. in any 40 kHz band within the nominated bandwidth of the co-polarized component in any direction ϕ degrees from the antenna main beam axis shall not exceed the following limits:

$$33 - 25 \log (\phi + \delta\phi) - H \text{ dBW} \quad \text{for} \quad 2{,}5° \leq \phi + \delta\phi \leq 7{,}0°;$$

$$+12 - H \text{ dBW} \quad \text{for} \quad 7{,}0° < \phi + \delta\phi \leq 9{,}2°;$$

$$36 - 25 \log (\phi + \delta\phi) - H \text{ dBW} \quad \text{for} \quad 9{,}2° < \phi + \delta\phi \leq 48°;$$

$$- 6 - H \text{ dBW} \quad \text{for} \quad \phi + \delta\phi > 48°;$$

where:

- ϕ is the angle, in degrees, between the main beam axis and the direction considered; and
- $\delta\phi$ is the pointing error threshold, in degrees, as declared by the applicant (see clause 4.2.5.2).

For ESTs designed to transmit always at $EIRP_{max}$, H (in dB) is the maximum number of ESTs which may transmit at $EIRP_{max}$ in the same carrier frequency band as declared by the applicant.

For ESTs designed to operate in an FSS network where the e.i.r.p. of each EST is determined by the NCF and where the NCF is in charge of the compliance of the aggregate e.i.r.p. density with the above mask, H is the margin as declared by the applicant for compliance with the mask when the EST is transmitting at $EIRP_{max}$. In the case where the NCF uses the antenna pattern or the off-axis $EIRP_{sd}$ the applicant shall declare the applicable pattern, the value of H shall be set to 0 dB and the EST e.i.r.p. density shall not exceed the e.i.r.p. density corresponding to the declared pattern. This margin H or this pattern may be a function of the position of the EST relative to the GSO arc (e.g. in the case of active antennas).

For $\phi > 70°$ the values given above may be increased to 4 - H dBW over the range of angles for which the particular feed system may give rise to relatively high levels of spillover.

In addition the maximum e.i.r.p. in any 40 kHz band within the nominated bandwidth of the cross-polarized component in any direction ϕ degrees from the antenna main beam axis shall not exceed the following limits:

$$23 - 25 \log (\phi + \delta\phi) - H \text{ dBW} \quad \text{for} \quad 2{,}5° \leq \phi + \delta\phi \leq 7{,}0°;$$

$$+2 - H \text{ dBW} \quad \text{for} \quad 7{,}0° < \phi + \delta\phi \leq 9{,}2°;$$

where ϕ, and H are as defined above.

For non-continuous transmission, the above limits may not apply for a specific portion of each burst as declared by the applicant. This excluded portion shall not exceed 50 µsec or 10 % of the burst, whichever is the smaller.

The excluded portion shall have characteristics similar to the remaining part of the burst:

- same symbol rate and modulation; and
- same or lower maximum amplitude.

NOTE 1: The specification above is intended to take account of the spectrum of the preamble of bursts in TDMA systems.

NOTE 2: The satellite operator may require lower off-axis e.i.r.p. limits in compliance with FSS intersystem coordination agreements. In all cases, off-axis e.i.r.p. emissions are subject to compliance with national regulations and the relevant FSS intersystem coordination agreements.

Any antenna off-axis direction may be defined by a pair of values (α, φ) where φ is the off-axis angle of that direction with the antenna main beam axis and α is the angle of the plane defined by that direction and the antenna main beam axis with any arbitrary plane containing the antenna main beam axis.
The range of values of φ and α is from φ_{min} - $\delta\varphi$ to 180° for φ, and from -180° to +180° for α.

The above limits only apply to any off-axis direction (α, φ) within ± 3° of the visible part of the GSO. The concerned directions shall be any direction within the (α, φ) domain unless it can be demonstrated by documentary evidence that only a limited subset of the (α, φ) domain is concerned.

The determination of the (α, φ) subset shall take into account the operational conditions for which the EST is designed, as declared by the applicant or indicated within the user documentation. These conditions shall include:

- the range of latitudes of the EST;
- the minimum elevation pointing angle;
- the type of antenna mount (e.g. with azimuth and elevation axes or equatorial);
- the maximum static and dynamic alignment errors of the antenna mount axes;
- the maximum static and dynamic alignment errors of the antenna major axis with respect to the GSO arc;
- the range of adjustment for the major axis of the antenna for antennas with asymmetric main beam;
- the direction of the electric field radiated by the satellite with respect to the Earth's axis, when the electric field is used for the antenna alignment.

The alignment errors shall not exceed the declared maximum values when applying the alignment method declared by the applicant or indicated within the user documentation.

NOTE 3: ETSI TR 102 375 [i.11] gives guidance for the determination of the concerned subset within the (α, φ) domain.

4.2.3.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.4.1 with the results being computed in accordance with clause 6.4.2.

4.2.4 Carrier suppression

4.2.4.1 Justification

To allow for the satisfactory suppression of transmissions of the EST by the NCF, under any fault condition and under any cessation of emissions condition.

4.2.4.2 Specification

In the "Carrier-off" and in the "Emissions disabled" radio states the on-axis e.i.r.p. density shall not exceed 4 dBW in any 100 kHz band within the nominated bandwidth.

4.2.4.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.5.

4.2.5 Antenna pointing and polarization alignment for ESTs

4.2.5.1 Justification

Protection of transmissions to adjacent satellites and cross-polarized transponders on the same satellite.

4.2.5.2 Specification

a) Mechanical stability:

The applicant shall declare the maximum values within which the EST is designed to operate in accordance with clause 4.1.1 for the following parameters:

- maximum train speed;
- maximum wind speed, which shall not be less than 100 km/h;
- maximum pressure pulse, which shall not be less than 6 kPa (Peak to peak for 3 s); and
- maximum pressure gradient, which shall not be less than 100 kPa/s.

The EST shall not show any sign of permanent distortion that could affect the radiation subsystem after the application of the load under the maximum values declared by the applicant for parameters above, including the Maximum relative wind speed.

b) Pointing error detection:

The EST shall be able to detect the pointing error. The EST, when in the "Carrier-on" radio state, shall enter the "Carrier-off" radio state when the instantaneous pointing error exceeds the pointing error threshold, $\delta\phi$, relative to the direction of the wanted satellite at its actual position, within T seconds. The values of $\delta\phi$ and T shall be declared by the applicant and the value of T shall not exceed 5 seconds. The EST shall not re-enter the "Carrier-on" radio state until the instantaneous pointing error is within $\delta\phi$ for a period of $2 \times T$ seconds.

The applicant shall declare the maximum time (IT_{max}) that the EST can remain in "Transmission enabled" state and "Carrier off" radio state (see clause 4.2.8.8). If the pointing error threshold is exceeded for more than IT_{max} then the EST shall enter the "Initial phase" state.

The applicant may declare ranges of values for $\delta\phi$ as functions of on-axis e.i.r.p. spectral density such that the e.i.r.p. density limits in clause 4.2.3.2 are not exceeded.

c) Polarization angle alignment capability:

- The polarization angle shall be adjustable over the range declared by the applicant. For a range lower than 90°, the applicant shall also declare the geographical region (latitude and longitude) relative to the satellite orbital position for which the EST is designed to operate, taking into account the inclination of the electric field radiated by the satellite.
- The misalignment error, α, of the transmit antenna polarization is the sum of the misalignment errors due to the tracking process plus, for ESTs that set the transmit polarization by tracking the receive polarization, the misalignment error of the transmit polarization plane relative to the receive polarization plane. The misalignment error, α, shall not exceed the maximum polarization misalignment, α_{max}, declared by the applicant, such that:

$$\alpha_{\max} = ArcTan\left(\sqrt{\frac{XPD_{antenna} - XPD_{EST}}{XPD_{antenna}.XPD_{EST} - 1}}\right)$$

where:

- XPD_{EST} is the equivalent cross polarization discrimination (XPD) of the EST, expressed as a ratio, as declared by the applicant;
- $XPD_{antenna}$ is the antenna XPD at the centre frequency of the transmit band, expressed as a ratio.

NOTE 1: Satellite operators may require specific values for XPD_{EST} and they may also require the EST to stop its transmissions (e.g. to enter the "Carrier-off" radio state) if the value falls below XPD_{EST}.

NOTE 2: The lower bound XPD_{er} of the global XPD of the EST antenna with a receiving antenna is given by the following formula:

$$XPD_{er} \geq \frac{1 + XPD_{EST}.XPD_r - 2.\sqrt{XPD_{EST}}.\sqrt{XPD_r}}{XPD_{EST} + XPD_r + 2.\sqrt{XPD_{EST}}.\sqrt{XPD_r}} = \left(\frac{1 + \sqrt{XPD_{EST}}.\sqrt{XPD_r}}{\sqrt{XPD_{EST}} + \sqrt{XPD_r}} \right)^2$$

where XPD_r is the XPD of the receiving antenna.

4.2.5.3 Conformance tests

Conformance tests shall be carried out in accordance with clauses 6.7 to 6.9. In addition, clause 6.11.8 contains the conformance test for inhibition of transmission when the outage time exceeds IT_{max}.

4.2.6 Cessation of emissions of the EST

4.2.6.1 Justification

For cessation of emissions of the EST where the EST is not allowed to transmit.

4.2.6.2 Specification

4.2.6.2.1 Specification 1: Mode of cessation of emissions

At least one of the following two modes of cessation of emissions shall be implemented:

a) the NCF determines that the EST shall cease emissions; and/or

b) the EST autonomously determines that it shall cease emissions.

In addition, there shall be a "single-action" means (e.g. operating a switch) by which a local operator may disable the EST and thereby cease emissions.

The applicant shall declare the EST interfaces involved in the cessation of emissions:

- the list of relevant parameters which are collected by the EST or the NCF for determination as to whether the EST should cease emissions;
- the list of these relevant parameters which are used by the EST;
- the list of these relevant parameters which are transmitted by the EST to the NCF;
- the list of the relevant parameters which are received by the EST from the NCF;
- for the collected relevant parameters, the EST interface (s), including the protocols, the timing, the ranges of the values, the speed of the variations and the required accuracies;
- for the relevant parameters transmitted to the NCF, the EST interface with the NCF, including the protocols and the timing;
- for the transmission parameter received from the NCF, the EST interface with the NCF, including the protocols and the timing;
- these declared EST interfaces shall be in accordance with the user documentation.

4.2.6.2.2 Specification 2: Conditions under which the EST shall cease emissions

For EST networks where the NCF determines completely or partially where and under which conditions the emissions of the EST shall be ceased, the collection of the relevant parameters by the EST and the exchange of information between the EST and the NCF shall be sufficient for the NCF to determine when to cease emissions with the accuracy declared by the applicant and to inform in time the EST to cease emissions.

For ESTs which determine completely where and under which conditions the emissions shall be ceased, the collection of the relevant parameters by the EST shall be sufficient for the EST to determine when to cease emissions with the accuracy declared by the applicant.

The determination of these conditions shall take into account the inaccuracy of the EST location and of the boundaries of the authorized operating areas in the data base used either by the EST or the NCF, as declared by applicant.

The conditions for cessation of emissions shall take into account at least the following parameters:

- the location of the EST and the boundaries of the authorized operating area;
- the operating parameters specified in clauses 4.2.1 through 4.2.6;
- the carrier frequency and the authorized frequency bands.

4.2.6.2.3 Specification 3: Cessation of emissions

A condition requiring cessation of emissions occurs either when the EST receives the command from the NCF at its input or when the EST determines autonomously on the need to cease emissions.

When in the "Transmission enabled" state a condition requiring cessation of emissions occurs, the EST shall cease transmissions and enter the "Initial Phase" state.

When in the "Transmission disabled" state, the EST shall not leave that state for the "Transmission enable" state as long as a condition requiring cessation of emissions exists or the last CC command received from the NCF is a transmission disable command.

When in the "Initial phase-BurstOn" or "Initial phase-BurstOff" substate a condition requiring cessation of emissions occurs, the EST shall cease transmissions and enter the "Initial phase-Standby" substate.

When in the "Initial phase-Standby" substate, the EST shall not leave that state for the "Initial phase-BurstOn" or the "Transmission enabled" states as long as a condition requiring cessation of emissions exists.

The time for transition in any state from the occurrence of a condition requiring cessation of emissions to the "Emissions disabled" radio state shall not exceed 1 second.

4.2.6.2.4 Specification 4: Fault conditions

Any collection of the relevant parameters by the EST or transmission of these parameters to the NCF, which have not been completed correctly within the required delay(s) as declared by the applicant, shall be considered as a fault condition.

Any transmission parameter not received or not correctly received from the NCF within the required delay declared by the applicant shall be considered as a fault condition.

These fault conditions shall be processed as conditions requiring cessation of emissions.

4.2.6.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.9.

4.2.7 Identification of EST

4.2.7.1 Justification

To fulfil the requirements for network management and for potential use by duly authorized entities.

4.2.7.2 Specification

The EST shall be designed such that it is possible for the network operator to identify which ESTs are transmitting with at least 100 m resolution in a given geographic area. The applicant shall declare the means by which identification of

ESTs is accomplished. In the case where an external system is required, the applicant shall declare which additional means are necessary for identification of the EST.

4.2.7.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.10.

4.2.8 Control and Monitoring Functions (CMFs)

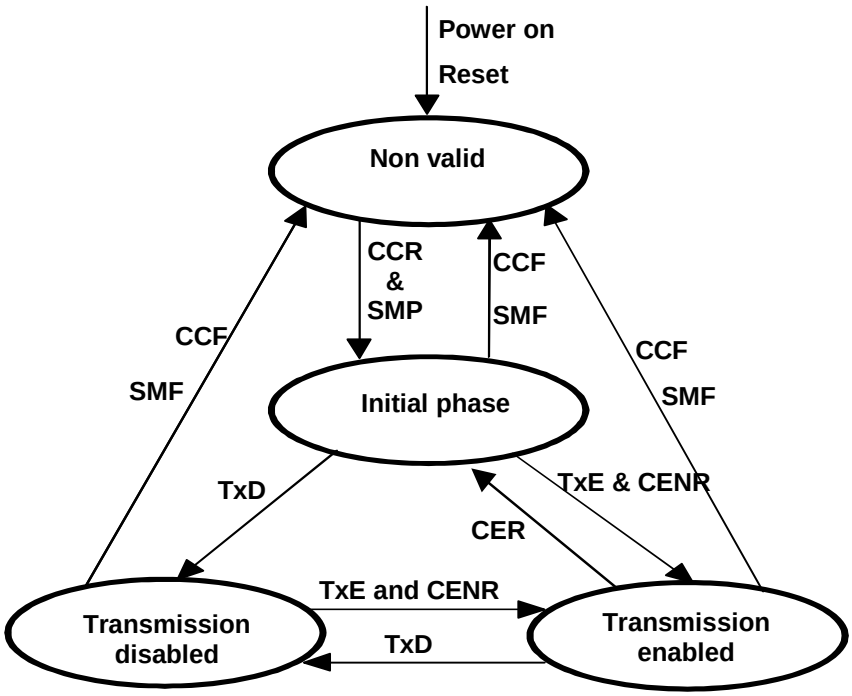
4.2.8.1 CMF state diagram

The following minimum set of CMFs shall be implemented in ESTs in order to minimize the probability that they originate unwanted transmissions that may give rise to harmful interference to other systems.

In the "Non-valid" state and in the "Transmission disabled" state the EST shall not transmit. In the "Transmission-enabled" state the EST is allowed to transmit. In the "Initial phase" state the EST is only allowed to transmit initial bursts.

NOTE 1: The restrictions in the "Initial phase" state are for the protection of other systems when the EST is entering the system after a power-on or a reset. These initial burst restrictions do not apply to the EST transmissions in the "Transmission-enabled" state and once a transmission enable command has been received by the EST the EST may transmit or not transmit as required.

Under any fault condition the EST shall enter the "Non-valid" state where the e.i.r.p. limits for the "Emissions disabled" radio state apply.



CER: Cessation of Emissions Required;
CENR: Cessation of Emissions Not Required;
SMP: System Monitoring Pass;
SMF: System Monitoring Fail;
TxE: Transmission Enable command;
TxD: Transmission Disable command;
CCR: Control Channel correctly Received;
CCF: Control Channel reception Failure.

Figure 2: State transition diagram of the control and monitoring function of an EST

NOTE 2: From "Transmission disabled" state a TxE command may also result in a transition towards the "Initial phase" state.

When the EST transmits several carriers having different frequencies, an EST state machine as described above may be associated with each carrier or each set of carriers. The events then apply to the subsystem associated with the specific carrier or the specific set of carriers, rather than the whole EST.

4.2.8.2 Processor monitoring

4.2.8.2.1 Justification

To ensure that the EST can suppress its transmissions in the event of a processor sub-system failure.

4.2.8.2.2 Specification

The EST shall incorporate a processor monitoring function for each of its processors involved in maintaining the performance requirements of the present document and in Control and Monitoring Functions (CMF).

The processor monitoring function shall detect failures of these processors' hardware and software.

In the "Transmission enabled" state, the EST shall enter the "Non valid" state or the "Carrier-off" radio state no later than 1 second after any fault condition occurs, and in any case it shall enter the "Non valid" state within 30 seconds until the processor monitoring function has determined that all fault conditions have been cleared. In any other state after any fault condition occurs, the EST shall enter the "Non valid" state within 30 seconds until the processor monitoring function has determined that all fault conditions have been cleared.

4.2.8.2.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.11.2.

4.2.8.3 Transmit subsystem monitoring

4.2.8.3.1 Justification

To ensure the inhibition of transmissions that are potentially harmful to other systems in the event of incorrect operation of the transmit frequency generation sub-system.

4.2.8.3.2 Specification

The EST shall monitor the operation of its transmit frequency generation sub-system and shall be able to detect:

a) loss of frequency lock;

b) absence of Local Oscillator (LO) output signal.

No later than 1 second after any of these fault conditions of the transmit frequency generation sub-system occurs, the EST shall enter the "Non-valid" state until the transmit sub-system monitoring function has determined that all fault conditions have been cleared.

4.2.8.3.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.11.3.

4.2.8.4 Power-on/Reset

4.2.8.4.1 Justification

To demonstrate that the EST achieves a controlled non-transmitting state following the powering of the unit, or the occurrence of a reset made by a local operator when this function is implemented.

4.2.8.4.2 Specification

Following a manual reset, when this function is implemented, the EST shall enter the "Non-valid" state.

During and following "power-on" the EST shall remain in the "Non-valid" state until all the conditions for entering "Initial phase" have been satisfied.

4.2.8.4.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.11.4.

4.2.8.5 Control Channel (CC) and Response Channel (RC)

4.2.8.5.1 Justification

Control Channels (CC) are used by ESTs to receive control information from the NCF and Response Channels (RCs) to respond to the NCF. For EST designed to operate within networks where the NCF determines that the EST shall cease emissions, then the CCs and RCs are also used for the dialogue with the NCF.

To ensure that the EST cannot transmit unless it correctly receives the CC messages from the NCF.

4.2.8.5.2 Specification

4.2.8.5.2.1 Specification 1: types of CCs and RCs

a) The EST shall have at least one CC from the NCF. If exchange of information with the NCF is necessary for operation of the EST then the EST shall have at least one RC to the NCF (see clause 4.2.6). Each CC and each RC may be internal or external.

The types (internal or external) of each CC and each RC shall be declared by the applicant.

NOTE 1: The availability of the network carrying the external CC(s) and RC(s) and the numbers of external CC(s) and RC(s) are not within the scope of the present document.

NOTE 2: Some satellite operators may require that internal CC(s) and or RC(s) are available.

b) The connection between the NCF and the EST via the CCs and RCs shall be either permanent or shall be set up on a call by call basis through a switched network. In case of connection through a switched network the EST shall be able to receive calls from the NCF and to initiate calls towards the NCF in order to set up the CCs and RCs.

c) The EST with an external CC shall not transmit without receiving an appropriate signal from the NCF through the satellite to which the EST transmits, indicating to the EST that the NCF is alive and insuring that the EST is pointing to the target satellite.

4.2.8.5.2.2 Specification 2: CC Reception

a) The EST shall enter the "Non-valid" state immediately after a period not exceeding 30 seconds without correct reception of the CC from the NCF, i.e. without being able to receive CC messages from the NCF. This event is called a "CC disruption".

- In the case of external CCs and RCs without permanent connection of the NCF with the EST, the ability to receive CC messages from the NCF is the ability at any time to receive calls and messages within the timing requirements of the present document from the network through which is connected the NCF.

- The inability to receive CC messages from the NCF may be due to the following various causes but not limited to them: no received signal from the NCF or from the network, a too low level received signal, no network accessible, the inability to lock onto the received carrier frequency, to demodulate, to decode, to receive calls and/or messages, a hardware failure or power off.

b) The EST shall remain in the "Non-valid" state as long as the EST is unable to receive CC messages from the NCF.

c) From the "Non-valid" state the EST may enter the "Initial phase" state if the following conditions are met:

- the EST is able to receive CC messages from the NCF; and

- no fault conditions are present.

4.2.8.5.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.11.5.

4.2.8.6 Network control commands

4.2.8.6.1 Justification

These requirements ensure that the EST is capable of:

a) retaining a unique identification in the network;

b) receiving commands from the NCF through its CC(s) and executing those commands.

4.2.8.6.2 Specification

The EST shall hold, in non-volatile memory, its unique identification code in the network.

The EST shall be capable of receiving through its CCs dedicated messages (addressed to the EST) from the NCF, and which contain:

- Transmission Enable commands (TxE);
- Transmission Disable commands (TxD).

When in the "Initial phase" or "Transmission enabled" states, once a transmission disable command is received, within 1 second the EST shall enter into, and shall remain in the "Transmission disabled" state until the transmission disable command is superseded by a subsequent transmission enable command (see also clause 4.2.6).

When in the "Initial phase" or "Transmission disabled" states, once a transmission enable command is received, the EST may enter into the "Transmission enabled" state.

When entering the "Initial phase" from the "Non-valid" state, the last TxE or TxD command received from the NCF may be used by the EST to enter the "Transmission enabled" state or the "Transmission disabled" state, respectively, if since the time of reception of that command no "CC disruption" occurred.

NOTE: The physical unit in charge of the reception of the CCs, of the transmissions of the RCs and of the CC commands reception may be a separate and independent unit from the other units of the EST and it may be common to several ESTs.

4.2.8.6.3 Conformance test

Conformance tests shall be carried out in accordance with clause 6.11.6.

4.2.8.7 Initial burst transmission

4.2.8.7.1 Justification

Restrictions on the initial burst transmissions are necessary to limit disturbance to other services.

4.2.8.7.2 Specification

For systems where no transmission enable command is foreseen without request from the EST, in the "Initial phase" state the EST may transmit initial bursts:

a) The EST shall not start the transmission of initial bursts before having obtained a confirmation that no cessation of emission applies where the EST is located. This confirmation shall be obtained either by local means of determination of the cessation of emissions (see clause 4.2.6) or from the NCF via an external control channel.

b) The duty cycle of the burst retransmission shall not exceed 0,2 %, where the duty cycle is defined as the ratio of burst duration to the duration between two successive bursts.

c) Each burst shall not carry more than the minimum number of data bytes excluding the burst preambles and the FEC coding bits necessary to establish synchronization.

d) The initial burst shall be transmitted at an e.i.r.p. no greater than $EIRP_{max}$.

e) The duration between two successive bursts shall not be less than the required NCF response time as declared by the applicant. This response time is defined as the duration, measured at the EST, between an initial burst transmission and the reception and processing of a transmission enable or disable command from the NCF which is never exceeded during 99 % of the cases under normal conditions in the system for which the EST is designed, as declared by the applicant.

4.2.8.7.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.11.7.

4.2.8.8 Inhibition of transmissions

4.2.8.8.1 Justification

To ensure the correct inhibition of transmissions that are potentially harmful to other systems and persons in the event of signal blockage.

4.2.8.8.2 Specification

The EST shall inhibit transmissions whenever there is a loss of receive carrier (e.g. synchronization or signal level).

EST shall enter the "Carrier-off" radio state within a period not exceeding 0,5 seconds, when these conditions persist during that period, and shall remain in this radio state until the receiver carrier has been restored.

The applicant shall declare the maximum outage time (IT_{max}) for this condition ("Transmission enabled" state and "Carrier off" radio state). If the receive carrier is not restored within IT_{max}, then the EST shall transition to the "Initial phase" state.

The applicant shall declare the time to transition from "Carrier off" to "Carrier on" radio state (IT_{trans}) when in "Transmission enabled" state after the receive carrier is restored within IT_{max}.

4.2.8.8.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.11.8.

4.2.9 Receive antenna off-axis gain pattern

4.2.9.1 Justification

To protect the wanted signals from interference from terrestrial services and from other satellite services.

4.2.9.2 Specification

The maximum antenna gain of each of the co-polarized components in any direction φ degrees from the antenna main beam axis shall not exceed the following limits:

$G = 32 - 25 \log \varphi$	dBi	for $\varphi_{min} \leq \varphi < 48°$
$G = -10$	dBi	for $48° \leq \varphi \leq 85°$
$G = 0$	dBi	for $85° \leq \varphi \leq 180°$

where:

φ_{min} = 1° or 100 λ/*D* degrees, whichever is the greater, for *D*/λ ≥ 50.

φ_{min} = 2° or 114 (D/λ)$^{-1.09}$ degrees, whichever is the greater, for *D*/λ < 50.

D is the nominal diameter of the antenna.

In addition the maximum antenna gain of each of the cross-polarized components in any direction ϕ degrees from the antenna main beam axis shall not exceed the following limits:

$$G_x(\varphi) = 23 - 20 \log \varphi \quad \text{dBi} \quad \text{for } \varphi_r \leq \varphi \leq 7°$$

where φ_r is equal to 1° or 100 λ/*D*, whichever is greater.

4.2.9.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.12.

4.2.10 Blocking performance

4.2.10.1 Justification

To prevent high power signals outside the receive frequency band from blocking the reception of signals inside the receive frequency band.

4.2.10.2 Specification

Receiver blocking is characterized here through gain compression for a signal inside the receive frequency band that is caused by another signal outside the receive frequency band at high power. The level of the other signal is compared to the level of a signal inside the receive frequency band that would cause the same gain compression.

Receiver blocking rejection at a particular frequency is defined as the level of a second signal at this frequency that causes a certain gain compression to a first signal inside the receive frequency band, minus the level of a second signal at a frequency inside the receive frequency band that causes the same gain compression.

The first signal shall be at the centre frequency of the receive frequency band and have a level in the operational range. The second signal shall cause a gain compression for the first signal of 1 dB.

The rejection shall comply with table 4.

Table 4: Receiver blocking rejection

Frequency	Minimum rejection
below 9 GHz	20 dB
9 to 10 GHz	10 dB
14 to 16 GHz	10 dB
Above 16 GHz	20 dB
NOTE: In the frequency ranges 10 to 10,7 GHz and 12,75 to 14 GHz, the rejection needs further studies.	

4.2.10.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.13.

4.2.11 Adjacent Signal Selectivity

4.2.11.1 Justification

To enable reception of a wanted signal in presence of other signals on adjacent frequencies which are transmitted with high EIRP density from target satellite orbital position.

NOTE: The power level of signals transmitted from the same orbital position are under control of the satellite operator. Signals transmitted from an adjacent orbital position that is not near-by are suppressed by the antenna gain pattern.

4.2.11.2 Specification

Adjacent Signal Selectivity is a measure of a receiver's ability to receive a signal at its assigned channel frequency in the presence of an adjacent signal at a given frequency offset from the centre frequency of the assigned channel. The adjacent signal shall occupy the same bandwidth as the wanted signal. Frequency offset and relative power level of the adjacent signal compared to the wanted signal shall take the value given in table 5. BW is the wanted signal occupied bandwidth.

Table 5: Adjacent signal frequency and Power level

Signal	Centre frequency offset from wanted signal	Power level relative to wanted signal
Adjacent Carrier	BW	7 dBsd

The decrease in the required signal to noise ratio in the presence of an adjacent signal shall be no more than 0,5 dB.

4.2.11.3 Conformance tests

Conformance tests shall be carried out in accordance with clause 6.14.

5 Testing for compliance with technical requirements

5.1 Environmental conditions for testing

Survivability testing shall be carried out prior to tests on the radiation and stabilization subsystems.

Tests defined in the present document shall be carried out at representative points within the boundary limits of the declared operational environmental profile.

5.2 Essential radio test suites

The essential radio test suites for a complete EST are given in clause 6.

6 Test methods for all aspects of the EST

6.1 General

The present clause describes the general requirements for verifying that the performance of the EUT complies with the specifications. However, the specific testing methodology to be used for measuring performance is left to the applicant in order to allow the methodology to be matched to the EUT. The applicant shall maintain documentary evidence of the results obtained in performing the essential radio tests At a minimum, the documentary evidence shall include:

- test setup (configurations, test equipment and calibration status);
- test conditions (environmental and operational parameters);
- method of testing;
- results of measurements, measurement resolution & uncertainty; and
- statement of compliance with technical specifications of the present document.

The test conditions for each test shall be representative of the intended operational environment and be noted in the test report where it has a significant effect on the measurement results.

The type, termination and length of each cable used shall be representative of the intended installation and recorded in the test report. For maximum cable lengths longer than 10 m, as declared by the applicant, the tests shall be performed with cables no shorter than 10 m.

ETSI TR 102 215 [i.4] provides a recommended approach to measurement uncertainty and interpretation of results. Where the measurement approach does not conform to the guidance in ETSI TR 102 215 [i.4], the applicant shall declare the method of measurement and the uncertainty achieved under this method.

The test site and the method of measurement shall also be in accordance with CISPR 16-1-5 [3] as applicable.

To enable the performance tests to be carried out the use of an NCF or a Special Test Equipment (STE), made available by the applicant or system provider, may be necessary. Since this STE will be specific for the particular system, it is not possible to provide detailed specifications in the present document. However, the following baseline is provided:

- if the EST requires to receive a modulated carrier from the satellite in order to transmit, then special test arrangements are required to simulate the satellite signal, thus enabling the EST to transmit allowing measurement of transmission parameters;
- any characteristic of these special test arrangements which may have direct or indirect effects on the parameters to be measured shall be clearly stated by the applicant.

All tests with carrier-on shall be undertaken with the transmitter operating at $EIRP_{max}$, as per the specific requirement, and with the normal radio operating parameters, as declared by the applicant.

If the Equipment Under Test (EUT) is an EST that requires hardware and/or software modification(s) performed by the applicant for these tests then full documentation of such modification(s) shall be provided to demonstrate that the modification(s) will simulate the required test condition, without its main characteristics being changed.

6.2 Off-axis spurious radiation

6.2.0 General

The tests for the EST specification in clause 4.2.1.2 shall be conducted in "Carrier on", "Carrier off" and "Emissions disabled" radio states as required. The tests in "Carrier on" radio state shall be undertaken with the transmitter operating at $EIRP_{max}$.

6.2.1 Test method

The applicant shall declare the test methods used to identify frequencies of off-axis spurious radiation and to measure (or calculate) the radiated power levels of identified spurious radiations.

NOTE: The measuring antenna should be aligned in the polarization which produces the largest response between the EUT and the measuring antenna.

6.3 On-axis spurious radiation

6.3.0 General

The tests for the EST specification in clause 4.2.2.2 shall be conducted in "Carrier on", "Carrier off" and "Emissions disabled" radio states as required.

The tests in "Carrier on" radio state shall be undertaken with the transmitter operating at $EIRP_{max}$. Test measurements shall be made at least three points within the operating band including: locating the carrier at the centre frequency of the operating band; as close to the lower operating frequency limit as possible; and as close to the upper operating frequency limit as possible.

6.3.1 Test method

The applicant shall declare the test methods used to identify frequencies of on-axis spurious radiation and to measure (or calculate) the radiated power levels of identified spurious radiations.

NOTE: The measuring antenna should be aligned in the polarization which produces the largest response between the EUT and the measuring antenna.

6.4 Off-axis e.i.r.p. emission density within the band

6.4.0 General

The tests for the EST specification in clause 4.2.3.2 for off-axis e.i.r.p. emission density (co-polarization and cross-polarization) within the band 14,0 GHz to 14,25 GHz shall be conducted in the "Carrier on" radio state. The tests shall be undertaken with the transmitter operating at $EIRP_{max}$.

The tests in "Carrier on" radio state shall be undertaken with the transmitter operating at $EIRP_{max}$. Test measurements shall be made at least three points within the operating band including: locating the carrier at the centre frequency of the operating band; as close to the lower operating frequency limit as possible; and as close to the upper operating frequency limit as possible.

6.4.1 Test method

6.4.1.1 General

The applicant shall declare the test methods used to identify frequencies of off-axis radiation and to measure (or calculate) the radiated emission power density levels within the band.

NOTE: The measuring antenna should be aligned in the polarization which produces the largest response between the EUT and the measuring antenna.

The measurement shall be made in the operational configuration(s) (including occupied bandwidth, $EIRP_{max}$) producing the highest emission density in the frequency band. The selected configuration(s) shall be recorded in the test report.

If the test is to be carried out with an STE, then the STE shall provide all the signals needed by the ESTs under normal operation (e.g. a radio beacon if it is expected to be received by the satellite).

The e.i.r.p. densities are determined from the measurements of the antenna copolarization and crosspolarization gain patterns, and of the power density at the antenna flange. These e.i.r.p. densities shall be compared to the specified masks of clause 4.2.3.2.

To ascertain the off-axis e.i.r.p. it is necessary to know the transmit power density and antenna transmit radiation pattern. To ascertain the radiation pattern it is necessary to know the antenna transmit gain.

The following three measurement procedures shall, therefore, be performed:

a) transmit output power density (dBW/40 kHz);

b) antenna transmit gain (dBi);

c) antenna transmit radiation patterns (dBi).

6.4.1.2 Transmit output power density

The EUT output power shall be set to the power corresponding to $EIRP_{max}$. The measurements shall be made in the operational configuration(s) producing the highest emission density in the frequency band. The selected configuration(s) shall be recorded in the test report.

6.4.1.3 Antenna transmit gain

For the purpose of the present document, the antenna transmit gain is defined as the ratio, expressed in decibels (dBi), of the power that would have to be supplied to an isotropic radiator isolated in space, to the power supplied to the antenna being considered, so that they produce the same field strength at the same distance in the same direction. Unless otherwise specified the transmit gain is for the direction of maximum radiation (i.e. peak transmit gain).

This test is normally performed with the antenna removed and the measurements made at the antenna flange. For an EUT where the antenna is integrated within the unit, the applicant shall declare the test method to be used to derive the antenna transmit gain.

6.4.1.4 Antenna transmit radiation patterns

For the purpose of the present document, the antenna transmit radiation patterns are diagrams relating field strength to the angle of the direction pointed by the antenna at a constant large distance from the antenna (in the far field of the antenna).

Tests shall be performed and the results recorded for co- and cross-polarization antenna transmit radiation patterns and in the elevation and azimuth planes. The co-polarization transmit pattern measurement shall be performed in azimuth from -180° to +180° and from -15° to +90° in elevation with the results recorded. The cross-polarization transmit pattern measurement shall be performed in azimuth from -10° to +10° and from -1° to +10° in elevation with the results recorded. In the case of antennas where the sidelobes vary as a function of the elevation angle, the elevation transmit radiation pattern measurements shall be made with the antenna set to the elevation angle that produces the maximum sidelobe level.

6.4.2 Computation of results

The results shall be computed by producing a "mask" to the specified limits with the reference level being equal to the sum of the transmitter output power density and the gain of the antenna. This reference shall then be placed on the maximum point of the plots obtained from the transmit radiation pattern measurements, so as to ascertain that the off-axis e.i.r.p. density is within the mask, and thus conforming to the specification in clause 4.2.3.

6.5 Carrier suppression

6.5.1 Test method

For the purposes of this test, the EUT shall transmit one carrier modulated continuously, or at its maximum burst rate where applicable, centred on the middle frequency of the operating frequency band as declared by the applicant. The "transmission disabled state" shall be obtained by use of the NCF or an STE, if required. For conducted measurements the maximum residual carrier power density within the nominated bandwidth shall be measured and added to the antenna on-axis gain. For radiated measurements the maximum residual e.i.r.p. density within the nominated bandwidth shall be measured and recorded. If the results obtained are within the limit given in clause 4.2.4.2, then the EUT shall be declared compliant with the requirements.

6.6 Antenna pointing for EST

6.6.1 General

The antenna pointing test method is designed to verify the ability of the EUT to detect and correctly respond to pointing errors that exceed the threshold, $\delta\phi$, declared by the applicant as required in clauses 4.2.3 and 4.2.5.

For the purpose of these tests the EUT is the EST with its antenna connected.

6.6.2 Test method

There shall be a means for measuring and analysing true pointing error values declared by the applicant. The means of measuring and analysing pointing errors shall be included in the test report.

There shall be a means of dynamically inducing pointing errors that exceed the threshold declared by the applicant. The means for inducing pointing errors shall be representative of actual operating train dynamics, within the dynamic limits declared by the applicant. If dynamic means alone are not sufficient to induce pointing errors that exceed the threshold for pointing errors, then an alternative means shall be used. Pointing errors shall be induced in at least two orthogonal directions; but not necessarily during the same test sequence. The means of inducing pointing errors shall be included in the test report.

It shall be verified that the EUT correctly detects that the induced pointing error has exceeded the pointing error threshold and enters the "Carrier-off" radio state no later than T seconds after the pointing error threshold is exceeded, where T is the response time declared by the applicant.

After the pointing error has been decreased below the pointing error threshold, it shall be verified that the EUT does not re-enter the "Carrier-on" radio state for at least $2 \times T$ seconds.

The tests shall be repeated a number of times to ensure reliability of pointing error detection and appropriate response.

6.7 Antenna mechanical stability

6.7.1 Test method

The applicant shall declare the methodology used to test and verify compliance with the requirements for mechanical stability, see clause 4.2.5.

The methodology described in annex B may be used to show compliance with the specification for mechanical stability.

6.8 Polarization angle alignment capability

6.8.1 Test method

The adjustment facilities shall be examined to determine both the angular movement possible and the means of establishing and fixing the alignment.

The applicant shall demonstrate by documentary evidence that the EST complies with the specification c) in clause 4.2.5.2.

6.9 Cessation of emissions of the EST

6.9.0 General

There shall be a means of simulating a condition where cessation of emissions is required. The spectrum analyser or the oscilloscope may be used to measure the time difference between the occurrence of the condition and the cessation of emissions. In all test methods, it shall be verified that the time difference does not exceed 1 second as specified in clause 4.2.6.2.3.

Where the EUT adds an operational margin around areas where cessation of emissions is required to account for the position determination accuracy and latency, the test procedure may simulate the actual behaviour of an EUT as its enters into an area where cessation of emissions is required. For example, if the EUT adds a margin of X metres around areas where cessation of emissions is required, then the test may begin with the EUT being simulated at a position more than X metres outside of an area where cessation of emissions is required. The test may then simulate the motion of the EUT towards the area where cessation of emissions is required. In any event, the EUT shall enter the "emission disabled" radio state within 1 second of entering the actual area where cessation of emissions is required.

For the purpose of these tests the EUT is the EST either with, or without its antenna connected.

6.9.1 Test Method

6.9.1.1 Required documentation

The applicant shall declare the mode(s) of cessation of emissions implemented in the EUT and the EST interfaces involved in the cessation of emissions as specified in clause 4.2.6.2.1.

The applicant shall demonstrate compliance with specification 2 in clause 4.2.6.2.2 for the determination of the conditions under which the EST shall cease emissions.

6.9.1.2 Cessation of emissions from the "Transmission enabled" state

a) The EUT shall be set in the "Transmission enabled" EST state.

b) The EUT shall be set in the "Carrier on" radio state.

c) A condition requiring the cessation of emission shall be initiated either by the STE or the EUT.

d) It shall be verified that the EUT enters the "Emissions disabled" radio state.

e) In order to verify that the EUT is in the "Transmission disabled" EST state, it shall be verified that the EUT remains in the "Emissions disabled" radio state when the EUT is requested to transmit data.

6.9.1.3 Cessation of emission from the "Transmission disabled" state

a) The EUT shall be set in the "Transmission disabled" state.

b) A condition requiring the cessation of emission shall be initiated either by the STE or the EUT.

c) In order to verify that the EUT remains in the "Transmission disabled" EST state, it shall be verified that the EUT remains in the "Emissions disabled" radio state when the EUT is requested to transmit data.

d) The STE shall send a TxE command to the EUT.

e) In order to verify that the EUT remains in the "Transmission disabled" EST state, it shall be verified that the EUT remains in the "Emissions disabled" radio state when the EUT is requested to transmit data.

f) The STE shall send a TxD command to the EUT.

g) The condition requiring the cessation of emissions shall be removed.

h) In order to verify that the EUT remains in the "Transmission disabled" EST state, it shall be verified that the EUT remains in the "Emissions disabled" radio state when the EUT is requested to transmit data.

6.9.1.4 Cessation of emission from the "Initial Phase" state

6.9.1.4.1 EUTs transmitting initial bursts

This applies only to EUTs transmitting initial bursts (i.e. where "Initial phase-BurstOn" and "Initial phase-BurstOff" are implemented).

a) The EUT shall be set in "Initial phase-BurstOn" state.

b) The STE shall not send the TxE command and the EUT shall be allowed to cycle between "Initial phase-BurstOn" and "Initial phase-BurstOff" as it would under normal operations.

c) A condition requiring the cessation of emission shall be initiated either by the STE or the EUT.

d) It shall be verified that the EUT enters the "Emissions disabled" radio state.

e) In order to verify that the EUT is in the "Initial phase-Standby" EST state, it shall be verified that the EUT remains in the "Emissions disabled" radio state when the EUT is requested to transmit data.

f) The STE shall send a TxE command to the EUT.

g) In order to verify that the EUT remains in the "Initial phase-Standby" EST state or enters the "Transmission disabled" EST state, it shall be verified that the EUT remains in the "Emissions disabled" radio state when the EUT is requested to transmit data.

h) Repeat the test steps a) through g) using a TxD command in step f) instead of the TxE command.

6.9.1.4.2 EUTs not transmitting initial bursts

This applies only to EUTs that do not transmit initial bursts (i.e. where only "Initial phase-Standby" is implemented).

a) The EUT shall be set in "Initial phase-Standby" EST state.

b) The STE shall not send the TxE command to maintain the EUT in "Initial phase-Standby" EST state.

c) A condition requiring the cessation of emission shall be initiated either by the STE or the EUT.

d) In order to verify that the EUT remains in the "Initial phase-Standby" EST state, it shall be verified that the EUT remains in the "Emissions disabled" radio state when the EUT is requested to transmit data.

e) The STE shall send a TxE command to the EUT.

f) In order to verify that the EUT remains in the "Initial phase-Standby" EST state or enters the "Transmission disabled" EST state, it shall be verified that the EUT remains in the "Emissions disabled" radio state when the EUT is requested to transmit data.

g) Repeat the test steps a) through f) using a TxD command in step e) instead of the TxE command.

6.9.1.5 "Single action" means of cessation of emissions

a) It shall be verified that there is a "single action" means of ceasing emissions of the EUT (e.g. the switch thrown).

b) The EUT shall be set in the "Transmission enabled" EST state.

c) The EUT shall be set in the "Carrier on" radio state.

d) The "single action" means of cessation of emissions shall be activated.

e) It shall be verified that the EUT enters the "Emissions disabled" radio state.

f) In order to verify that the EUT is in the "Transmission disabled" EST state, it shall be verified that the EUT remains in the "Emissions disabled" radio state when the EUT is requested to transmit data.

g) The STE shall send a TxE command to the EUT.

h) In order to verify that the EUT remains in the "Transmission disabled" EST state, it shall be verified that the EUT remains in the "Emissions disabled" radio state when the EUT is requested to transmit data.

i) The EUT shall be switched off and then switched on and the EUT shall enter the "Initial phase" EST state without receiving a TxE from the STE.

j) The "single action" means of cessation of emissions shall be activated.

k) The STE shall send a TxE command to the EUT.

l) In order to verify that the EUT remains in the "Initial phase" EST state or enters the "Transmission disabled" EST state, it shall be verified that the EUT remains in the "Emissions disabled" radio state when the EUT is requested to transmit data.

m) The EUT shall be switched off and then switched on and the EUT shall enter the "Initial phase" EST state without receiving a TxE from the STE.

n) The STE shall send a TxD command to the EUT so that it enters the "Transmission disabled" EST state.

o) The "single action" means of cessation of emissions shall be activated.

p) The STE shall send a TxE command to the EUT.

q) In order to verify that the EUT remains in the "Transmission disabled" EST state, it shall be verified that the EUT remains in the "Emissions disabled" radio state when the EUT is requested to transmit data.

6.9.1.6 Fault conditions

The applicant shall declare the means of generating fault conditions.

a) The EUT shall be set in the "Transmission enabled" EST state.

b) The EUT shall be set in the "Carrier on" radio state.

c) A fault condition requiring the cessation of emission shall be generated either by the STE or directly on the EUT.

d) It shall be verified that the EUT enters the "Emissions disabled" radio state as long as the fault condition persists.

e) Steps a) through d) shall be repeated for each fault condition declared by applicant.

6.10 Identification of EST

6.10.1 Test arrangement

The test shall be arranged such that EUT can determine its own location, or if external means are employed, the test shall be arranged so that the EUT can be located by the means declared by the applicant. The STE shall be arranged to simulate the NCF. The actual location of the EME shall be known within the resolution required in clause 4.2.7.2.

6.10.2 Test method

a) The EUT shall be in the "Transmission enabled" state.

b) The EUT shall report its location to the STE.

c) The difference between the reported EUT location and actual location of the EUT (as simulated in the test) shall be within twice the resolution required in clause 4.2.7.2.

6.11 Control and monitoring functions

6.11.0 General

The applicant may modify an EST for the purpose of these tests provided that full documentation is given to prove that the modifications accurately simulate the required test conditions.

The EUT shall transmit at $EIRP_{max}$.

For the purpose of these tests the EUT is the EST either with, or without its antenna connected.

The measurement of the e.i.r.p. spectral density shall be limited within either the nominated bandwidth or to a 10 MHz bandwidth centred on the carrier frequency, whichever is the greater.

6.11.1 Test arrangement

The EUT shall be authorized to transmit and shall be in the "Transmission enabled" state at the commencement of each test, unless otherwise stated. The time difference between the command, or failure, and the occurrence of the expected event (e.g. the transmission suppression) shall be measured and recorded.

6.11.2 Processor monitoring- Test method

a) Each of the processors within the EUT shall, in turn, be caused to fail.

b) Within 1 second of such failure the EUT shall cease to transmit.

c) It shall be confirmed that the transmissions have been suppressed within the limits of the "Carrier-off" radio state emission levels.

d) Within 30 seconds of such failure it shall be confirmed that the transmissions have been suppressed within the limits of the "Emissions disabled" radio state emission levels.

e) The failed processor shall be restored to normal working condition and the EUT shall restore automatically to normal working before the next processor shall be induced to fail.

6.11.3 Transmit subsystem monitoring-Test method

a) The frequency generation subsystem within the EUT shall be caused to fail in respect of:

- loss of frequency lock (if applicable);
- absence of Local Oscillator (LO) output signal.

b) Recognition of each failure in turn by the subsystem monitor shall constitute an SMF event.

c) Within 1 second of such failure the EUT shall cease to transmit.

d) It shall be observed that the transmissions have been suppressed within the limits of the "Emissions disabled" radio state emission levels.

e) The failed elements shall be restored to normal working state and the EUT shall be restored to normal working condition before the next induced failure.

6.11.4 Power-on/Reset-Test method

a) The EUT shall be switched off and the STE shall not transmit the CC.

b) The EUT shall be switched on.

c) The EUT shall not transmit during and after switching-on, and shall enter the "Non valid" state.

If a manual reset function is implemented the following test shall be performed:

d) The EUT shall be restored to the "Initial phase" state and the STE shall transmit the CC.

e) The EUT shall remain in the "Initial phase" state.

f) The reset function shall be initiated.

g) The EUT shall enter the "Non valid" state.

h) The EUT shall be restored to the "Initial phase" state and the STE shall transmit the CC as well as a TxE.

i) The EUT shall enter the "Transmission enabled" state.

j) The reset function shall be initiated.

k) The EUT shall enter the "Non valid" state.

6.11.5 Control Channel and Response Channel -Test method

For the purposes of these tests, the period without correct reception of the CC (T1) shall be as specified in clause 4.2.8.5.2.2.

These test procedures require simulation of the following events:

- The CC has never been received by the EUT after power-on.
- The CC is lost by the EUT after reception of a Transmission Enable command.
- The CC is lost by the EUT without reception of a Transmission Enable command.
- The CC is being lost by the EUT and a call is initiated within the period T1.

a) Case where the CC has never been received by the EUT after power-on:

   a1) the EUT shall be switched off and the STE shall not transmit the CC;

   a2) the EUT shall be switched on;

   a3) the EUT shall remain in the "Non valid" state.

b) Case where the CC is lost by the EUT after reception of a Transmission Enable command:

   b1) the EUT shall be switched-on and the STE shall transmit the CC and a Transmission Enable command;

   b2) the EUT shall enter the "Initial phase" state and go, if applicable, to the "Transmission enabled" state;

   b3) a transmission request shall be initiated from the EUT;

   b4) the STE shall stop transmitting the CC;

   b5) within the period T1 from event b4), the EUT shall enter the "Non valid" state.

c) Case where the CC is lost by the EUT without reception of a Transmission Enable command:

   c1) the EUT shall be switched on and the STE shall transmit the CC;

   c2) the EUT shall enter the "Initial phase" state;

   c3) the STE shall stop transmitting the CC;

   c4) the EUT shall enter in the "Non valid" state not later than T1;

   c5) a transmission request shall be initiated and the EUT shall remain in the "Non valid" state.

d) Case where the CC is being lost by the EUT and a call is initiated within the T1 period:

   d1) the EUT shall be switched on and the STE shall transmit the CC;

   d2) the STE shall stop transmitting the CC;

   d3) within the period T1 from d2), a transmission request shall be initiated from the EUT;

   d4) the EUT may transmit but within the T1 period the EUT shall enter the "Non valid" state.

6.11.6 Network Control commands-Test method

The tests shall be performed in the following sequence:

- Transmission Enable command;
- Transmission Disable command received in the "Transmission enabled" state;
- Transmission Disable command received in the "Initial phase" state.

a) Transmission Enable command:

a1) the EUT shall be switched-on and the STE shall transmit the CC;

a2) the EUT shall enter the "Initial phase" state;

a3) a transmission request shall be initiated from the EUT, the EUT shall remain in the "Initial phase" state;

a4) the STE shall transmit a transmit enable command to the EUT;

a5) a transmission request shall be initiated from the EUT;

a6) the EUT shall enter the "Transmission enabled" state and shall transmit.

b) Transmission Disable command received in the "Transmission enabled" state:

b1) continue from a6);

b2) the STE shall transmit a disable command to the EUT;

b3) the EUT shall enter the "Transmission disabled" state within 1 second;

b4) a transmission request shall be initiated from the EUT;

b5) the EUT shall remain in the "Transmission disabled" state;

b6) the STE shall transmit an enable command;

b7) the EUT shall enter either the "Transmission enabled" state or the "Initial phase" state;

b8) if the EUT is in the "Transmission enable" state then the test continues with b11);

b9) the STE shall transmit a TxE command;

b10) the EUT shall enter the "Transmission enable" state;

b11) if a transmission request is not active any more than a new transmission request shall be initiated;

b12) the EUT shall transmit;

b13) the EUT transmission shall be terminated.

c) Transmission disable command received in the "Initial phase" state:

c1) the EUT shall be switched-on and the STE shall transmit the CC;

c2) the EUT shall enter the "Initial phase" state;

c3) the STE shall transmit a Transmission Disable command to the EUT;

c4) the EUT shall enter the "Transmission disabled" state within 1 second;

c5) a transmission request shall be initiated from the EUT;

c6) the EUT shall remain in the "Transmission disabled" state;

c7) the STE shall transmit a Transmission Enable command;

c8) the EUT shall enter either the "Transmission enabled" state or the "Initial phase" state;

c9) if the EUT is in the "Transmission enable" state then the test continues with c12);

c10) the STE shall transmit a TxE command;

c11) the EUT shall enter the "Transmission enable" state;

c12) if a transmission request is not active any more than a new transmission request shall be initiated;

c13) the EUT shall transmit;

c14) the EUT transmission shall be terminated.

6.11.7 Initial burst transmission-Test method

The applicant shall declare the initial burst duration.

The following test shall be performed in sequence:

a) the EUT shall be switched-off and the STE shall transmit the CC;

b) the EUT shall be switched-on;

c) the EUT shall not transmit, except the initial bursts;

d) it shall be verified that the specifications given in clause 4.2.8.7.2 are fulfilled.

6.11.8 Inhibition of transmission-Test method

The applicant shall declare the values for IT_{max} and IT_{trans}, as specified in clause 4.2.8.8.

The receive carrier to the EUT shall be removed:

a) Within 0,5 seconds of such failure the EUT shall cease to transmit.

b) It shall be observed that the EUT remains in the "Transmission enabled" state and that transmissions have been suppressed within the limits of the "Carrier off" radio state emission levels given in clause 4.2.1.2, table 3.

c) The receive carrier to the EUT shall be restored within IT_{max}.

d) It shall be observed that the EUT enters the "Carrier on" radio state and begins transmission within IT_{trans}.

e) The receive carrier to the EUT shall be removed.

f) It shall be observed that after IT_{max} the EUT enters the "Initial phase" state.

6.12 Receive antenna off-axis gain pattern

6.12.1 Test Method

6.12.1.1 Test site

This test shall be performed on either an outdoor far field test site or compact test range. However if the near field scanner technology to convert near field measurements to far field results is proven and sufficiently accurate by reference to tests taken in both regions then antenna measurements may be taken in the near field. Fully automated systems can be used for these tests providing that the results can be proven to be as accurate as if they were done according to the specified method.

6.12.1.2 Method of measurement

Figure 3: Test arrangement - antenna receive pattern measurement

a) The test arrangement shall be as shown in figure 3 with the EUT connected to the test receiver.

b) A signal proportional to the angular position from the servo mechanism shall be applied to the X-axis and the signal level from the test receiver shall be applied to the Y-axis of the plotter.

c) The test frequencies shall be the centre frequency of each applicable frequency range. The E plane shall be vertical.

d) The EUT shall be aligned to maximize the received signal level and the X-Y plotter shall be adjusted to give the maximum reading on the chart.

e) The EUT shall be driven in azimuth through 180°.

f) The pattern measurement is then obtained by driving the EUT in azimuth through 360° with the plotter recording the results.

g) The tests in b) to e) shall be repeated with the frequency changed to the lower limit of the applicable band as declared by the manufacturer.

h) The tests in b) to e) shall be repeated with the frequency changed to the upper limit of the applicable band as declared by the manufacturer.

i) The tests in b) to h) shall be repeated with the frequencies changed to the others specified if the design of the equipment is such that operation is possible, but not necessarily simultaneously, in all bands.

j) The tests in b) to h) shall be repeated with the test signal being transmitted in the H-plane instead of the E-plane.

k) The tests in b) to h) shall be repeated with the test signal being transmitted in a plane at 45° to the H-plane.

l) The tests in b) to h) shall be repeated with the test signal being transmitted in a plane at 90° to that in k).

m) The tests in b) to l) shall be repeated between the angles of φ_r and 7° with the EUT rotated through 90°, or the test antenna or the polarization subsystem of the EUT rotated by 90°, to give the cross-polar measurement.

6.13 Blocking performance

6.13.1 Test method

a) The output signals of two signal generators shall be combined with equal weight. The combined signal shall be coupled to the LNB input in a reasonable and appropriate way.

b) A spectrum analyser shall be connected to the LNB output in a way that allows to supply the LNB with power.

c) f_c is the center frequency of the receive frequency band.

d) The first signal generator frequency shall be set to f_c.

e) The first signal generator level shall be set to a level in the LNB operational input level range.

f) The spectrum analyser shall be set for measuring the level of the converted first signal at the LNB output.

g) The second signal generator frequency shall be set to $f_c - 20$ MHz.

h) The second signal generator level shall be adjusted so that the measured level is 1 dB less than in absence of the second signal.

i) The second signal generator level shall be noted down as reference level.

j) The second signal generator frequency shall be set to the frequency of interest.

k) The second signal generator level shall be adjusted so that the measured level is 1 dB less than in absence of the second signal.

l) The rejection at the frequency of interest is equal to the second signal generator level minus the reference level determined in step i).

m) Steps j) to l) shall be repeated for frequencies in the ranges of table 4.

NOTE: The worst case rejection in a particular frequency range can be determined after step i) by sweeping the second signal generator frequency over the frequency range and observe the gain compression, then perform steps j) to l) with the frequency where gain compression is highest.

6.14 Adjacent Signal Selectivity

6.14.1 Test method

a) Two test signal generators shall be used. Each signal generator shall generate a modulated signal in the IME input frequency range and thermal noise.

b) The signal generators shall be connected to the IME input through a splitter (combiner).

c) The test signal generators shall be set to the frequencies and levels according to table 5.

d) The IME shall be set to receive the signal of the first test signal generator.

e) The second test signal generator shall be set to signal off.

f) The noise level (or signal to noise ratio) of the first test signal generator shall be varied in order to determine the threshold reference sensitivity level.

g) The second signal generator shall be set to signal on.

h) The noise level (or signal to noise ratio) of the first test signal generator shall be varied in order to determine the threshold reference sensitivity level.

i) The degradation is equal to the noise level (or signal to noise ratio) determined in step h) minus that determined in step f).

j) The result is the highest degradation found.

Annex A (normative): Relationship between the present document and the essential requirements of Directive 2014/53/EU

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.5] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [4].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

The present document is therefore intended to cover the provisions of Directive 2014/53/EU [4] (RE Directive) article 3.2 which states that "….*radio equipment shall be so constructed that it both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference*".

Recital 10 of Directive 2014/53/EU [4] states that "*in order to ensure that radio equipment uses the radio spectrum effectively and supports the efficient use of radio spectrum, radio equipment should be constructed so that: in the case of a transmitter, when the transmitter is properly installed, maintained and used for its intended purpose it generates radio waves emissions that do not create harmful interference, while unwanted radio waves emissions generated by the transmitter (e.g. in adjacent channels) with a potential negative impact on the goals of radio spectrum policy should be limited to such a level that, according to the state of the art, harmful interference is avoided; and, in the case of a receiver, it has a level of performance that allows it to operate as intended and protects it against the risk of harmful interference, in particular from shared or adjacent channels, and, in so doing, supports improvements in the efficient use of shared or adjacent channels*".

Recital 11 of Directive 2014/53/EU [4] states that "*although receivers do not themselves cause harmful interference, reception capabilities are an increasingly important factor in ensuring the efficient use of radio spectrum by way of an increased resilience of receivers against harmful interference and unwanted signals on the basis of the relevant essential requirements of Union harmonisation legislation*."

As a consequence, the present document includes both transmitting and receiving parameters to maximize the efficient use of radio spectrum.

Table A.1: Relationship between the present document and the essential requirements of Directive 2014/53/EU

Harmonised Standard ETSI EN 302 448 The following requirements are relevant to the presumption of conformity under the article 3.2 of Directive 2014/53/EU [4]				
Requirement			**Requirement Conditionality**	
No	**Description**	**Reference: Clause No**	**U/C**	**Condition**
1	Off-axis spurious radiation	4.2.1	U	
2	On-axis emissions	4.2.2	U	
3	Off-axis e.i.r.p. emission density within the band	4.2.3	U	
4	Carrier suppression	4.2.4	U	
5	Antenna pointing	4.2.5	U	
6	Cessation of emissions of the EST	4.2.6	U	
7	Identification of EST	4.2.7	U	
8	Control and Monitoring Functions (CMFs)	4.2.8	U	
9	Antenna mechanical stability	4.2.5	U	
10	Antenna polarization alignment	4.2.5	U	

Harmonised Standard ETSI EN 302 448 The following requirements are relevant to the presumption of conformity under the article 3.2 of Directive 2014/53/EU [4]				
Requirement			**Requirement Conditionality**	
No	**Description**	**Reference: Clause No**	**U/C**	**Condition**
11	Receive antenna off-axis gain pattern	4.2.9	C	Satellite communications networks may contain a central control unit that keeps received interference low by taking into account the actual antenna gain pattern of earth stations. The requirement is not relevant for earth stations that are always operated as part of such a network. The requirement is relevant in all other cases. If the receive antenna performance does not meet the requirement of clause 4.2.9, then the earth station shall accept an additional co-frequency interference caused by its off-axis gain which is not compliant to the mask.
12	Blocking performance	4.2.10	U	
13	Adjacent Signal Selectivity	4.2.11	U	

Key to columns:

Requirement:

No A unique identifier for one row of the table which may be used to identify a requirement.

Description A textual reference to the requirement.

Clause Number Identification of clause(s) defining the requirement in the present document unless another document is referenced explicitly.

Requirement Conditionality:

U/C Indicates whether the requirement shall be unconditionally applicable (U) or is conditional upon the manufacturers claimed functionality of the equipment (C).

Condition Explains the conditions when the requirement shall or shall not be applicable for a requirement which is classified "conditional".

Presumption of conformity stays valid only as long as a reference to the present document is maintained in the list published in the Official Journal of the European Union. Users of the present document should consult frequently the latest list published in the Official Journal of the European Union.

Other Union legislation may be applicable to the product(s) falling within the scope of the present document.

Annex B (informative): Mechanical stability methodology

This test based on an analytical or numerical analysis should be performed in two stages.

In the first stage the loads generated by the maximum wind speed should be computed on the EME, taking into account the intrinsic properties of the materials.

In the second stage the computed loads should be applied to the structure.

The purpose of the analysis is twofold:

a) To show that the torque and the fields of force applied to the EME structure under nominated conditions do not reach any of the following:

- the point where deformation fouls the antenna pointing mechanism;
- the yield point of any element of the structure;
- the buckling point of any element of the structure.

NOTE: The yield point is elastic limit of the material and the buckling point is the failure point for the material.

b) To compute equivalent static loads (force and torque) applied to the critical attachment points of the structures, e.g.:

- for antennas without a radome:
  - reflector-mounting legs fixing point;
  - reflector-struts;
  - LNB- struts;
- for antennas with a radome:
  - radome surface;
  - radome mounting points.

Analysis and load applications procedure:

a) The air related parameters, namely the kinetic viscosity used to calculate drags at the rims of the structure should be calculated with the standard atmospheric environmental conditions (temperature = 293 K, air pressure = $1{,}013 \times 10^5$ Pascal).

b) The computations needed to derive the field of force and torque and the equivalent static stresses should be carried out for each of the following variables:

- elevation angle: maximum and minimum for antennas without a radome;
- wind direction: in steps of 45° around the EME unit;
- maximum relative wind speed: 100 km/h;
- gust wind speed: 130 km/h for 3 seconds.

It should be verified with the simulated results that yield point limits are not exceeded for any self-contained element.

The calculated equivalent static loads should be applied at any identified critical fixing point of the assembly, whilst the loads are applied the above deck unit should be observed and any distortion noted.

The test report should contain the following information:

- the computation method used;
- the description of the test equipment;
- the description of the tests performed;
- the results of the safety margin test;
- any signs of distortion observed;
- the results of the measurements of the deviation of the antenna or radome position;
- the component deviation with respect to each other.

Annex C (informative): Bibliography

- Council Directive 73/23/EEC of 19 February 1973 on the harmonisation of the laws of Member States relating to Electrical Equipment designed for use within certain voltage limits (LV Directive).
- Council Directive 89/336/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive).
- Directive 2004/40/EC of the European Parliament and of the Council of 29 April 2004 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (18th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC).
- ETSI ETR 169 (1995): "Satellite Earth Stations and Systems (SES); Common Technical Regulations (CTRs) in the satellite earth station equipment field".
- CENELEC EN 50121-3-2 (2000): "Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus".
- CENELEC EN 50121-3-1 (2000): "Railway applications - Electromagnetic compatibility - Part 3-1: Rolling stock - Train and complete vehicle".
- CEPT/ERC/Recommendation 74-01 (2005): "Unwanted emissions in the spurious domain".
- Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).
- Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations.

History

Document history		
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