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TECHNICAL REPORT

**Satellite Earth Stations and Systems (SES);
Study of potential updates to certain harmonised ENs due to technology evolution, methods of measurements and regulatory updates**

Reference

DTR/SES-00485

Keywords

earth station, measurement, regulation, satellite, testing

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

Modal verbs terminology

In the present document "**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).

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Executive summary

The project reviews the contents of several Harmonised European Norms under the purview of ETSI TC-SES to ensure their requirements remain current amid the rapid expansion of satellite-based services. The study has focused on an initial list provided by the contractual requirements of ETSI plus additional ENs proposed by the Experts Group, in summary, assessing 14 HENs for continued compliance with the RED while identifying specific topics requiring further consideration due to technology evolution since the ENs were initially produced. The study also identifies solutions that strengthen the applicability and technological relevance of satellite earth stations ENs, enhance their use, and streamline modern compliance checks for manufacturers and laboratories.

1 Scope

The present document as part of the Experts Group activities aims to deliver a comprehensive report detailing the necessary technological updates and the assessment of currently adopted measurement methods in order to ensure the validity of the ENs in the current market environment, reducing uncertainties in the interpretation of requirements as well as facilitating the mechanisms (test methods) to demonstrate conformity with the Harmonised European Norms requirements.

Overall, it further provides recommendations on the prioritization of updates to the existing hENs, ensuring their continued relevance, clarity, and alignment with current and emerging satellite earth station technologies. The present document is the basis for selection of priority hENs which require updates and guide the priority elements which should be subject of further consideration when reviewing the hENs.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

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 may be useful in implementing an ETSI deliverable or add to the reader's understanding, but are not required for conformance to the present document.

[i.1] ETSI EN 303 699: "Satellite Earth Stations and Systems (SES); Fixed earth stations communicating with non-geostationary satellite systems in the 20 GHz and 30 GHz FSS bands; Harmonised Standard for access to radio spectrum".

[i.2] ETSI EN 302 977: "Satellite Earth Stations and Systems (SES); Harmonised Standard for Vehicle-Mounted Earth Stations (VMES) operating in the 14/12 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.3] ETSI EN 303 978: "Satellite Earth Stations and Systems (SES); Earth Stations on Mobile Platforms (ESOMP) communicating with satellites in geostationary orbit, operating in the 27,5 GHz to 30,0 GHz and 17,3 GHz to 20,2 GHz frequency bands; Harmonised Standard for access to radio spectrum".

[i.4] ETSI EN 303 979: "Satellite Earth Stations and Systems (SES); Harmonised Standard for Earth Stations on Mobile Platforms (ESOMP) transmitting towards satellites in non-geostationary orbit, operating in the 27,5 GHz to 29,1 GHz and 29,5 GHz to 30,0 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.5] ETSI EN 303 980: "Satellite Earth Stations and Systems (SES); Fixed and in-motion Earth Stations communicating with non-geostationary satellite systems (NEST) in the 11 GHz to 14 GHz frequency bands; Harmonised Standard for access to radio spectrum".

[i.6] ETSI EN 301 427: "Satellite Earth Stations and Systems (SES); Harmonised Standard for low data rate Mobile satellite Earth Stations (MES) except aeronautical mobile satellite earth stations, operating in the 11/12/14 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.7] ETSI EN 301 442: "Satellite Earth Stations and Systems (SES); NGSO Mobile Earth Stations (MES) including handheld earth stations, for Satellite Personal Communications Networks (S-PCN) operating in the 1 980 MHz to 2 010 MHz (earth-to-space) and 2 170 MHz to 2 200 MHz (space-to-earth) frequency bands under the Mobile Satellite Service (MSS); Harmonised Standard for access to radio spectrum".

[i.8] ETSI EN 301 443: "Satellite Earth Stations and Systems (SES); Harmonised Standard for Very Small Aperture Terminal (VSAT); Transmit-only, transmit-and-receive, receive-only satellite earth stations operating in the 4 GHz and 6 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.9] ETSI EN 301 447: "Satellite Earth Stations and Systems (SES); Satellite Earth Stations on board Vessels (ESVs) operating in the 4/6 GHz frequency bands allocated to the Fixed Satellite Service (FSS); Harmonised Standard for access to radio spectrum".

[i.10] ETSI EN 301 459: "Satellite Earth Stations and Systems (SES); Harmonised Standard for Satellite Interactive Terminals (SIT) and Satellite User Terminals (SUT) transmitting towards satellites in geostationary orbit, operating in the 29,5 GHz to 30,0 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.11] ETSI EN 301 721: "Satellite Earth Stations and Systems (SES); Harmonised Standard for Mobile Earth Stations (MES) providing Low Bit Rate Data Communications (LBRDC) using Low Earth Orbiting (LEO) satellites operating below 1 GHz frequency band covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.12] ETSI EN 302 340: "Satellite Earth Stations and Systems (SES); Harmonised Standard for satellite Earth Stations on board Vessels (ESVs) operating in the 11/12/14 GHz frequency bands allocated to the Fixed Satellite Service (FSS) covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.13] ETSI EN 302 448: "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".

[i.14] ETSI EN 302 574 (all parts): "Satellite Earth Stations and Systems (SES); Harmonised Standard for Mobile Earth Stations (MES) operating in the 1 980 MHz to 2 010 MHz (earth-to-space) and 2 170 MHz to 2 200 MHz (space-to-earth) frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.15] ETSI EN 303 984: "Satellite Earth Stations and Systems (SES); Earth Stations on board Aircraft (ESOA) communicating with non-geostationary satellite systems in the 10,7 GHz to 12,75 GHz and 12,75 GHz to 13,25 GHz frequency bands; Harmonised Standard for access to radio spectrum".

[i.16] ECC/DEC/(17)04 of 30 June 2017 on the harmonised use and exemption from individual licensing of fixed earth stations operating with NGSO FSS satellite systems in the frequency bands 10.70-12.75 GHz and 14.00-14.50 GHz.

[i.17] ECC/DEC/(18)05 of 6 July 2018 on the harmonised use, exemption from individual licensing and free circulation and use of Earth Stations In-Motion (ESIM) operating with NGSO FSS satellite systems in the frequency bands 10.7-12.75 GHz and 14.0-14.5 GHz.

[i.18] ECC/DEC/(09)01 of 13 March 2009 on the harmonised use of the 63.72-65.88 GHz frequency band for Intelligent Transport Systems (ITS).

[i.19] Recommendation ITU-R SM.1541: "Unwanted emissions in the out-of-band domain".

[i.20] ERC/REC 74-01 of 1998 on unwanted Emissions in the Spurious Domain.

[i.21] ITU Radio Regulations.

[i.22] Recommendation ITU-R SM.329: "Unwanted emissions in the spurious domain".

[i.23] Recommendation ITU-R S.465: "Reference radiation pattern of earth station antennas in the fixed-satellite service for use in coordination and interference assessment in the frequency range from 2 to 31 GHz".

[i.24] Recommendation ITU-R S.580: "Radiation diagrams for use as design objectives for antennas of earth stations operating with geostationary satellites".

[i.25] Recommendation ITU-R S.524: "Maximum permissible levels of off-axis e.i.r.p. density from earth stations in geostationary-satellite orbit networks operating in the fixed-satellite service transmitting in the 6 GHz, 13 GHz, 14 GHz and 30 GHz frequency bands".

[i.26] Reports ITU-R S.2278: "Use of very small aperture terminals (VSATs)".

[i.27] Reports ITU-R S.2223: "Technical and operational requirements for GSO FSS earth stations on mobile platforms in bands from 17.3 to 30.0 GHz".

[i.28] Recommendation ITU-R S.1503: "Functional description to be used in developing software tools for determining conformity of non-geostationary-satellite orbit fixed-satellite service systems or networks with limits contained in Article 22 of the Radio Regulations".

[i.29] Recommendation ITU-R S.1717: "Electronic data file format for earth station antenna patterns".

[i.30] Recommendation ITU-R S.1855: "Alternative reference radiation pattern for earth station antennas used with satellites in the geostationary-satellite orbit for use in coordination and/or interference assessment in the frequency range from 2 to 31 GHz".

[i.31] ECC Report 152: "The use of the frequency bands 27.5-30.0 GHz and 17.30-20.2 GHz by satellite networks".

[i.32] ECC Report 184: "The Use of Earth Stations on Mobile Platforms Operating with GSO Satellite Networks in the Frequency Range17.3-20.2 GHz and 27.5-30.0 GHz".

[i.33] ECC/DEC/(05)01 of 18 March 2005 on the use of the band 27.5-29.5 GHz by the Fixed Service and uncoordinated Earth stations of the Fixed-Satellite Service (Earth-to-space).

[i.34] ECC/DEC/(05)08 of 24 June 2005 on the availability of frequency bands for high density applications in the Fixed-Satellite Service (space-to-Earth and Earth-to-space).

[i.35] ECC/DEC/(06)03 of 24 March 2006 on Exemption from Individual Licensing of high e.i.r.p. satellite terminals (HEST) operating with geostationary satellites and in the frequency bands 10.70-12.75 GHz or 19.70-20.20 GHz space-to-Earth and 14.00-14.25 GHz or 29.50-30.00 GHz Earth-to-space.

[i.36] ECC/DEC/(13)01 of 8 March 2013 on the use, free circulation, and exemption from individual licensing of Earth stations on mobile platforms (ESOMPs) in the frequency bands available for use by uncoordinated FSS Earth stations within the ranges 17.3-20.2 GHz and 27.5-30.0 GHz.

[i.37] 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.

[i.38] ECC/DEC/(06)09 of 1 December 2006 on the designation of the bands 1980-2010 MHz and 2170-2200 MHz for use by systems in the Mobile-Satellite Service including those supplemented by a Complementary Ground Component (CGC).

[i.39] ECC Report 197: "Compatibility studies – MSS terminals transmitting to a satellite in the band 1980-2010 MHz and adjacent channel UMTS services".

[i.40] ECC Report 233: "Adjacent band compatibility studies for aeronautical CGC systems operating in the bands 1980-2010 MHz and 2170-2200 MHz".

[i.41] Decision No 626/2008/EC of the European Parliament and of the Council of 30 June 2008 on the selection and authorisation of systems providing mobile satellite services (MSS).

[i.42] Commission Decision 2007/98/EC of 14 February 2007 on the harmonised use of radio spectrum in the 2 GHz frequency bands for the implementation of systems providing mobile satellite services.

[i.43] Commission Decision 2009/449/EC of 13 May 2009 on the selection of operators of pan-European systems providing mobile satellite services (MSS).

[i.44] CEPT Report 013: "Report from CEPT to the European Commission in response to the Mandate on - Harmonised technical conditions for the use of the 2 GHz bands for Mobile Satellite Services in the European Union".

[i.45] ECC/DEC/(05)11 of 24 June 2005 on the free circulation and use of Aircraft Earth Stations (AES) in the frequency bands 14-14.5 GHz (Earth-to-space), 10.7-11.7 GHz (space-to-Earth) and 12.5-12.75 GHz (space-to-Earth).

[i.46] ECC/DEC/(18)04 of 6 July 2018 on the harmonised use, exemption from individual licensing and free circulation and use of land based Earth Stations In-Motion (ESIM) operating with GSO FSS satellite systems in the frequency bands 10.7-12.75 GHz and 14.0-14.5 GHz.

[i.47] ECC Report 279: "The Use of Earth Stations In-Motion (ESIM) operating to NGSO Satellite Systems in the 10.7-12.75 GHz and 14-14.5 GHz Band".

[i.48] ECC Report 271: "Compatibility and sharing studies related to NGSO satellite systems operating in the FSS bands 10.7-12.75 GHz (space-to-Earth) and 14-14.5 GHz (Earth-to-space)".

[i.49] ECC/DEC/(06)10 of 1 December 2006 on transition of terrestrial service operations from the Bands 1980-2010 MHz and 2170-2200 MHz in order to facilitate the Harmonised Introduction and Development of Systems in the mobile-satellite service including those supplemented by a Complementary Ground Component.

[i.50] Recommendation ITU-T M.1036: "Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications in the bands identified for IMT in the Radio Regulations".

[i.51] Recommendation ITU-R S.1428: "Reference FSS earth-station radiation patterns for use in interference assessment involving non-GSO satellites in frequency bands between 10.7 GHz and 30 GHz".

[i.52] ERC/DEC/(00)08 of 19 October 2000 on the use of the band 10.7 - 12.5 GHz by the fixed service and Earth stations of the broadcasting-satellite and fixed-satellite Service (space-to-Earth).

[i.53] ECC/REC/(25)01 of 14 February 2025 on Emission limit requirements for Wireless Power Transmission (WPT).

[i.54] Recommendation ITU-R S.728: "Maximum permissible level of off-axis e.i.r.p. density from very small aperture terminals (VSATs)".

[i.55] Recommendation ITU-R SM.1539: "Variation of the boundary between the out-of-band and spurious domains required for the application of Recommendations ITU-R SM.1541 and ITU-R SM.329".

[i.56] ECC Report 322: "Compatibility analysis (inter-service and intra service) for S-PCS below 1 GHz".

[i.57] ECC Report 273: "E.164 Numbering and Over-The-Top (OTT) Communications Services".

3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

Void.

3.3 Abbreviations

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

ACM	Adaptive Coding and Modulation
AES	Aeronautical Earth Station
AI	Artificial Intelligence
ANFR	National Agency of frequencies of France
BER	Bit Error Rate
BW	Bandwidth
CEPT	European Conference of Postal and Telecommunications Administrations
CGC	Complementary Ground Component
CMF	Control and Monitoring Functions
CW	Continuous Wave
DTP	Digital Transparent Processor
DUT	Device under test
EC	European Commission
ECC	Electronic Communications Committee
EIRP	Equivalent Isotropically Radiated Power
EIS	Effective Isotropic Sensitivity
EISMEA	European Innovation Council and Small and Medium-sized Enterprises Executive Agency
EMC	Electromagnetic Compatibility
EN	European Norm
EPFD	Equivalent Power Flux Density
ERC	Electronic Radiocommuinication Committee
ESA	Electronically Steerable Antenna
ESIM	Earth Station In Motion
ESOA	Earth Stations on board Aircraft
ESOMP	Earth Station on Mobile Platform
ESV	Earth Station on Vessel
ETSI	European Telecommunications Standards Institute
EU	European Union
EUT	Equipment Under Test
FAR	Fully Anechoic Room
FCC	Federal Communications Commission USA
FES	Fixed Earth Stations
FS	Fixed Service
FSS	Fixed Satellite Service
GEO	Geostationary Earth Orbit
GMDSS	Global Maritime Distress and Safety System
GNSS	Global Navigation Satellite System
GSO	Geostationary Satellite Orbit
hEN	harmonised European Norm
HS	Harmonised Standard
HTS	High Throughput Satellite
IEC	International Electrotechnical Committee
IMT	International Mobile Telecommunications
IoT	Internet of Things
IP	Internet Protocol
ITU	International Telecommunications Union
LBRDC	Low Bit Rate Data Communication
LEO	Low Earth Orbit
LMES	Land Mobile Earth Station
LNB	Low Noise Block
M2M	Machine to Machine
MEO	Medium Earth Orbit
MES	Mobile Earth Station

MIL	Military
MMES	Maritime Mobile Earth Station
MSS	Mobile Satellite Service
NCF	Network Control Facility
NGSO	Non-Geostationary Satellite Orbit
NTN	Non Terrestrial Network
OATS	Open Area Test Site
OJ	Official Journal
OOB	Out of Band
OTA	Over-the-Air
PCS	Personal Communications System
PER	Packet Error Rate
RAS	Radio Astronomy Service
RED	Radio Equipment Directive
RF	Radio Frequency
RR	Radio Regulations
RSPG	Radio Spectrum Policy Group
SAC	Semi-Anechoic Chamber
SCADA	Supervisory Control and Data Acquisition
SDR	Satellite Design Radio
SE	Spectrum Engineering
SIM	Station in Motion
SINR	Signal-to-Interference-plus-Noise Ratio
SIT	Satellite Interactive Terminal
SNR	Signal-to-Noise Ratio
STD	Standard
STE	Special Test Equipment
SUT	Satellite User Terminal
ToR	Terms of Reference
UAV	Unmanned Aircraft Vehicle
UE	User Equipment
VCM	Variable coding and Modulation
VMES	Vehicle Mounted Earth Station
VSAT	Very Small Aperture Terminal
WP	Work Package
WRC	World Radiocommunications Conference
XPD	Cross Polar Discrimination

4 Overview of Experts Group and WP2

4.1 Experts Group Objectives

The creation of an Experts Group to optimise Harmonised European Norms (hENs) for Satellite Earth Stations, is a strategic initiative funded under the European Commission's Grant Agreement 101260993. The project addresses the need to modernize, harmonize, and ensure the long-term applicability of the Harmonised European Standards developed under the responsibility of ETSI Technical Committee Satellite Earth Stations (TC SES). These standards support compliance with the Radio Equipment Directive (RED) 2014/53/EU [i.37], enabling manufacturers to demonstrate conformity with essential requirements related to efficient use of the radio spectrum and electromagnetic compatibility.

The satellite communications sector is undergoing a profound transformation driven by the emergence of multi-orbit constellations (LEO, MEO, GEO), new antenna architectures such as electronically steerable flat panel arrays, increasingly dynamic mobility scenarios (ESIMs for maritime, aeronautical, land mobile platforms), and evolving regulatory frameworks at European and international levels. As highlighted in the Terms of Reference, "there is still a need to improve the requirements, measurement methods and technology updates, based on new and future use cases, for satellite earth stations in the new ecosystem of Low Earth Orbit (LEO), Medium Earth Orbit (MEO) and Geostationary Earth Orbit (GEO) satellite networks". The Expert Group activity responds directly to this need by providing a structured, expert-driven framework for updating the relevant ENs.

The project is implemented through a dedicated Specialist Task Force (Experts Group) composed of technical experts appointed by ETSI. The Experts Group operates under the supervision of the Technical Committee Satellite Earth Stations (TC SES), which includes representatives from TC SES leadership and ensures alignment with the broader standardization roadmap, and works in close collaboration with TC SES Working Groups, particularly WG HARM, responsible for the maintenance and development of Harmonised Standards. In addition, the project benefits from voluntary contributions from TC SES members and from interactions with external stakeholders such as manufacturers, notified bodies, test laboratories, and satellite operators.

The activities of the Experts Group is structured into five Work Packages (WPs), each addressing a specific dimension of the project:

- WP1 Project Management and Coordination: Ensures administrative and technical coordination, planning, reporting, and liaison with ETSI and the European Commission. WP1 also oversees risk management, quality assurance, and the timely delivery of project milestones.
- WP2 Identification of Use Cases and Technology Evolution: The focus of this Technical Report. WP2 analyses the technological, operational, and regulatory evolution affecting satellite earth stations and identifies the updates required across the targeted ENs. It includes expert input collection, technology evolution analysis, gap identification, and the formulation of recommendations.
- WP3 Deployment Scenarios and Potential Merging of hENs: Examines overlaps between standards, maps use cases to ENs and identifies opportunities for consolidation or merging of standards addressing similar technologies or operational scenarios.
- WP4 Elaboration of Revised hENs: Produces updated versions of at least ten hENs and supports their examination within TC SES. WP4 ensures that the revised standards are technically robust, aligned with RED requirements, and suitable for citation in the OJEU.
- WP5 Dissemination: Ensures visibility of project results and promotes adoption by industry, notified bodies, national standardization organizations, and regulatory authorities worldwide.

The organizational structure of the Experts Group reflects the need for both technical depth and cross-standard consistency. WP2 plays a central role in this structure by providing the analytical foundation upon which WP3 and WP4 build. Specifically, WP2 delivers:

- A comprehensive review of 14 targeted ENs, including the 10 hENs identified as requiring urgent revision.
- A structured methodology for collecting and consolidating expert input from relevant stakeholders.
- A detailed analysis of technology evolution, including changes in satellite architectures, antenna systems, waveforms, mobility patterns, and measurement techniques.
- An analysis of the required updates across the ENs identifying inconsistencies, outdated assumptions, missing requirements, and limitations in current measurement methods.
- Recommendations that guide the revision work in WP4 and inform the strategic decisions in WP3 regarding potential merging of standards.

The project also recognizes the international relevance of ETSI satellite standards. As stated in the ToR, "the adoption of ETSI TC SES standards by many countries around the world has brought ETSI and Europe at the front of leadership regarding satellite communications". Maintaining this leadership requires ensuring that the standards remain technically robust, internationally aligned, and responsive to emerging technologies and regulatory developments. The Experts Group work therefore incorporates considerations related to ITU and CEPT decisions, global spectrum allocations, and cross-border interoperability.

In summary, Experts Group activities provides a coordinated, expert-driven framework to modernize the Harmonised European Standards for satellite earth stations. WP2, through the technical analysis documented in the present document, establishes the foundation for the subsequent revision and optimization of the ENs, ensuring their continued applicability in a rapidly evolving technological environment and supporting the long-term competitiveness of the European satellite communications sector.

4.2 WP2 Objectives and Scope

The methodology adopted in WP2 for collecting, structuring, and validating expert input was designed to ensure technical completeness, traceability, and consistency across the 14 ENs under review. Given the diversity of satellite earth station technologies, operational scenarios, and regulatory environments addressed by these standards, the collection of expert contributions required a structured, multi-stage process capable of capturing detailed clause-level insights while enabling systematic consolidation and analysis. The approach followed in WP2 is based on four elements:

- Standardized expert template, ensuring uniformity in the structure and content of contributions.
- Controlled consultation process, engaging manufacturers, notified bodies, laboratories, satellite operators, and TC SES experts through an online survey hosted on the official ETSI website.
- Structured extraction and database workflow, enabling traceability and supporting the automated semantic consolidation workflow.
- Validation loop, ensuring technical accuracy and alignment with the objectives of the Experts Group activities.

This methodology ensures that the technical analysis presented in the present document is based on expert knowledge, and aligned with the evolving satellite communications ecosystem.

On the view of EISMEA, the following 10 harmonised standards need urgent revision:

- ETSI EN 301 427 [i.6].
- ETSI EN 301 442 [i.7].
- ETSI EN 301 443 [i.8].
- ETSI EN 301 447 [i.9].
- ETSI EN 301 721 [i.11].
- ETSI EN 302 340 [i.12].
- ETSI EN 302 448 [i.13].
- ETSI EN 302 977 [i.2].
- ETSI EN 303 984 [i.15].
- ETSI EN 302 574-3 [i.14].

The Experts Group has reviewed this list and concluded that an initial group of 14 hENs /ENs (including all the above listed ENs) should be part of the study carried out. The resulting full list of studied hENs/ENs is the following:

- ETSI EN 301 427 [i.6].
- ETSI EN 301 442 [i.7].
- ETSI EN 301 443 [i.8].
- ETSI EN 301 447 [i.9].
- ETSI EN 301 721 [i.11].
- ETSI EN 302 340 [i.12].
- ETSI EN 302 448 [i.13].
- ETSI EN 302 574-3 [i.14].
- ETSI EN 302 977 [i.2].
- ETSI EN 303 984 [i.15].

Additional list of ETSI EN considered by the Proposal Team:

- ETSI EN 301 459 [i.10].
- ETSI EN 303 699 [i.1].
- ETSI EN 303 978 [i.3].
- ETSI EN 303 979 [i.4].

As can be seen, a total of 14 hENs/ENs have been subject of the study reported in the present document.

5 Methodology for WP2

5.1 Expert Input Collection

5.1.1 Expert Template and Data Structure

To ensure consistency across contributions, all experts participating were required to use a dedicated Excel-based template specifically designed for it , The template captures detailed clause-level comments for each EN and provides a structured mechanism for identifying priorities, justifications, and proposed actions. The template includes the following key fields:

- EN Identifier - The specific EN and version to which the comment applies.
- Clause Number - The exact clause, including sub-clauses up to level 3.
- Technical Justification - A detailed explanation of the issue, including references to technological evolution, regulatory changes, or operational constraints.
- Priority Level - High, Medium, or Low, based on the impact on technological relevance and urgency of update.
- Action Type - Categorized as Technology Evolution (T), Numerical Corrections (N), Regulatory Alignment (R), Clarification (C), Obsolescence (O), or Measurement & Test Methods (M).

5.1.2 Stakeholder Consultation

The expert input collection process involved a broad range of stakeholders representing the full ecosystem of satellite earth station technologies. The consultation, endorsed by ETSI, was conducted through a questionnaire accessible on the official ETSI website and targeted:

- Manufacturers of satellite terminals, including GEO, MEO, and LEO systems, with expertise in mechanically steered antennas, electronically steerable arrays, and hybrid architectures.
- Notified bodies responsible for conformity assessment under the RED, providing insights into practical challenges in applying the ENs.
- Accredited test laboratories, contributing expertise on measurement methods, test setups, and limitations of current procedures.
- Satellite operators, including GEO and NGSO operators, providing operational perspectives on link budgets, interference scenarios, and mobility patterns.
- Members of ETSI TC SES, including rapporteurs and experts involved in the maintenance of the ENs.

This multi-source approach ensured that the review captured both theoretical and practical perspectives, including real-world challenges encountered during equipment testing and certification.

5.1.3 Contribution to WP2 Results

The methodology described above directly supports the technical outcomes of WP2 by:

- Providing a comprehensive database of expert comments across all 14 ENs.
- Enabling a systematic identification of required updates across the ENs, including outdated assumptions, missing requirements, and limitations in measurement methods.
- Supporting the technology evolution analysis by linking expert observations to emerging trends.
- Informing the prioritization of EN updates, ensuring that the most critical issues are addressed first.
- Feeding into the recommendations presented in clause 10, which form the basis for the revision activities in WP3 and WP4.

The methodology for expert input collection ensures that WP2 is grounded in a robust, traceable, and technically rigorous evidence base, enabling a comprehensive and forward-looking assessment of the ENs under review.

5.2 Data Processing and Database Construction

5.2.0 General

The analysis performed in WP2 relies on a structured and traceable process for transforming raw expert contributions into a consolidated dataset. Given the volume, heterogeneity, and technical depth of the comments received across the 14 ENs under review, a dedicated extraction and database construction workflow was developed to ensure consistency, accuracy, and full traceability of all inputs.

This workflow enables WP2 to move from individual expert observations to a coherent analytical foundation, supporting the technology evolution analysis (clause 7), the identification of required updates across the ENs (clause 8), and the activities carried out through the automated semantic consolidation workflow (clause 9). The extraction process ensures that every comment - regardless of its origin, priority, or level of detail - is captured, normalized, and linked to the corresponding EN, clause, expert, and version.

The extraction and database construction process is built on three principles:

- Uniformity, ensuring that all comments follow a consistent structure.
- Traceability, enabling full reconstruction of the origin and evolution of each comment.
- Scalability, allowing the system to handle large volumes of comments across multiple ENs and multiple experts.

5.2.1 Extractor Tool

To support the systematic processing of expert contributions, WP2 developed a dedicated software module referred to as the EXTRACTOR tool. This tool automates the ingestion, parsing, and structuring of the Excel-based expert templates- Its primary function is to convert heterogeneous expert inputs into a unified MASTER TABLE, which serves as the central analytical dataset for WP2.

a) Input Handling:

  - The tool performs preliminary validation to ensure that mandatory fields (EN identifier, clause number, priority, justification, action type) are present and correctly formatted.

b) Parsing and Normalization:

  - The tool applies to a set of normalization rules to ensure consistency across inputs, including:

    - Standardization of EN identifiers (e.g. "EN302448", "ETSI EN 302 448 [i.13]", "EN302 448" → ETSI EN 302 448 [i.13]).
    - Normalization of clause numbering formats.

        - Harmonization of priority labels (H/M/L).
        - Conversion of free-text fields into a format suitable for the semantic analysis process.
    - This normalization step is essential for enabling cross-comparison and grouping during the semantic clustering process.

c) MASTER TABLE Generation:

    - The MASTER TABLE is the central output of the EXTRACTOR tool. It contains one row per EN identifier and clause, and up to N blocks composed of four fields per expert (Expert Identifier, Justification, Priority, Action Type). Each row includes:
        - EN identifier.
        - Clause number and title.
        - Expert Identifier 1.
        - Justification 1.
        - Priority 1.
        - Action Type 1.
        - Expert Identifier 2.
        - Justification 2.
        - Priority 2.
        - Action Type 2.
        - Expert Identifier N.
        - Justification N.
        - Priority N.
        - Action Type N.
    - The MASTER TABLE is designed to support:
        - Filtering by EN, clause, priority, or expert.
        - Preparation of inputs for the semantic clustering process (clause 8).

d) Version Control:

    - Each extraction run is time-stamped, and every comment retains its original wording and expert identifier, ensuring full traceability.

5.2.2 Database Construction

The MASTER TABLE generated by the EXTRACTOR tool is subsequently imported into a structured WP2 Comment Database. This database is designed to support the automated semantic consolidation workflow, enabling the grouping of justifications from different experts when they converge on similar proposals, overlap partially, or are duplicated. At the same time, it preserves unique justifications that provide distinct technical insights.

The extraction and database construction workflow transforms heterogeneous expert input into a structured, traceable, and analytically robust dataset. This dataset supports the identification of required updates across the ENs, the analysis of technology evolution, and the formulation of recommendations for subsequent work in WP3 and WP4.

6 Use Case Identification and Mapping to ENs

6.0 General

The identification of use cases is a fundamental analytical step within WP2, as it establishes the operational scenarios in which the 14 ENs under review are applied. Each EN was originally developed to support a specific category of satellite earth station, frequency band, orbit regime, or mobility profile. However, the rapid evolution of satellite communications - particularly the emergence of NGSO constellations, Electronically Steerable Antennas (ESAs), high-throughput payloads, and a wide range of mobility scenarios - has significantly expanded the diversity and complexity of use cases that rely on these standards. WP2 therefore performs a structured identification of use cases and maps them to the ENs that define their compliance framework.

This clause provides a comprehensive classification of use cases, followed by a detailed mapping to the 14 ENs considered in WP2. This mapping ensures that the subsequent technology evolution analysis (clause 7) and the identification of required updates across the ENs (clause 8) are grounded in real operational needs and reflect the current and emerging landscape of satellite communication systems.

6.1 Use Case Categories

The use cases identified in WP2 span a broad spectrum of satellite communication services and terminal types. They can be grouped into the following categories:

a) Fixed Earth Stations:

- Terminals operating from static locations, typically supporting broadband FSS services. They include GSO and NGSO terminals operating in Ku-, Ka-, and C-band. Relevant ENs:
    - ETSI EN 303 699 [i.1];
    - ETSI EN 303 980 [i.5];
    - ETSI EN 301 443 [i.8];
    - ETSI EN 301 459 [i.10].

b) Mobile Earth Stations (MES):

- Terminals operating under the Mobile Satellite Service (MSS), including handheld devices, vehicular terminals, and narrowband IoT-type systems. Relevant ENs:
    - ETSI EN 301 427 [i.6];
    - ETSI EN 301 442 [i.7];
    - ETSI EN 302 574-3 [i.14];
    - ETSI EN 301 721 [i.11].

- c) Earth Stations in Motion (ESIMs):

- Terminals mounted on moving platforms such as ships, aircraft, trains, and land vehicles. These terminals require continuous tracking of GSO or NGSO satellites. Relevant ENs:
    - Maritime:
        - ETSI EN 301 447 [i.9];
        - ETSI EN 302 340 [i.12].
    - Land mobile:
        - ETSI EN 302 977 [i.2];

        - ETSI EN 302 448 [i.13].
    - Aeronautical:
        - ETSI EN 303 984 [i.15].
    - ESOMP (GEO/NGSO):
        - ETSI EN 303 978 [i.3];
        - ETSI EN 303 979 [i.4].

d) Tracking Terminals for NGSO Systems:

- Terminals designed to track rapidly moving LEO/MEO satellites, often using ESAs or hybrid tracking mechanisms. Relevant ENs:
    - ETSI EN 303 699 [i.1];
    - ETSI EN 303 980 [i.5];
    - ETSI EN 303 979 [i.4];
    - ETSI EN 303 984 [i.15].

e) Narrowband and IoT-Type Terminals:

- Low-bit-rate terminals operating in LEO or MSS systems, supporting messaging, telemetry, and IoT applications. Relevant ENs:
    - ETSI EN 301 721 [i.11];
    - ETSI EN 302 574-3 [i.14];
    - ETSI EN 301 442 [i.7].

f) High-Frequency and High-Throughput Terminals:

- Terminals operating in Ka-band or higher, including SIT/SUT and NGSO FSS terminals. Relevant ENs:
    - ETSI EN 301 459 [i.10];
    - ETSI EN 303 699 [i.1];
    - ETSI EN 303 978 [i.3];
    - ETSI EN 303 979 [i.4].

6.2 Mapping Use Cases to the 14 ENs

The following mapping reflects the operational scope of each EN and the use cases it supports:

- Fixed Earth Stations:
    - ETSI EN 303 699 [i.1].
    - ETSI EN 303 980 [i.5].
    - ETSI EN 301 443 [i.8].
    - ETSI EN 301 459 [i.10].
- Mobile Earth Stations (MSS/MES):
    - ETSI EN 301 427 [i.6].
    - ETSI EN 301 442 [i.7].

   - ETSI EN 302 574-3 [i.14].
   - ETSI EN 301 721 [i.11].
- Earth Stations in Motion (ESIMs):
   - ETSI EN 301 447 [i.9].
   - ETSI EN 302 340 [i.12].
   - ETSI EN 302 448 [i.13].
   - ETSI EN 302 977 [i.2].
   - ETSI EN 303 984 [i.15].
   - ETSI EN 303 978 [i.3].
   - ETSI EN 303 979 [i.4].
- NGSO Tracking Terminals:
   - ETSI EN 303 699 [i.1].
   - ETSI EN 303 980 [i.5].
   - ETSI EN 303 979 [i.4].
   - ETSI EN 303 984 [i.15].
- Narrowband / IoT Terminals:
   - ETSI EN 301 721 [i.11].
   - ETSI EN 302 574-3 [i.14].
   - ETSI EN 301 442 [i.7].
- High-Throughput / High-Frequency Terminals:
   - ETSI EN 301 459 [i.10].
   - ETSI EN 303 699 [i.1].
   - ETSI EN 303 978 [i.3].
   - ETSI EN 303 979 [i.4].

7 Technology Evolution Analysis

7.0 General

The Technology Evolution Analysis provides a structured assessment of how recent and ongoing developments in satellite communications impact the validity and applicability of the 14 ENs under review. The ENs currently in force were developed during a period dominated by GEO-centric architectures, mechanically steered antennas, fixed transponder characteristics, and relatively stable link geometries. In contrast, today's satellite ecosystem is characterized by multi-orbit constellations, Electronically Steerable Antennas (ESAs), high-throughput and regenerative payloads, dynamic beamforming, and a wide range of mobility scenarios. These changes introduce new operational profiles, new interference conditions, and new measurement challenges that were not foreseen in the original standards.

This clause establishes the technical foundation required to determine whether the assumptions embedded in the ENs remain valid and whether the requirements and measurement methods continue to reflect the operational reality of modern satellite systems. The analysis is structured around three elements:

- Baseline assumptions of the current ENs, including antenna operating characteristics, orbit dynamics, link stability, and measurement conditions.
- Evolution of satellite technologies, covering orbit types, antenna architectures, payload capabilities, waveforms, network control mechanisms, and mobility patterns.
- Technology evolution matrices, contrasting the original assumptions with the state of the art to identify areas where the ENs require updates.

The analysis reveals that many ENs rely on assumptions that no longer hold for modern systems. For example, several ENs assume static or quasi-static pointing, single-beam operation, fixed spectral masks, or measurement setups designed for mechanically steered antennas. These assumptions are incompatible with the operating characteristics of ESAs, which may exhibit scanning losses, dynamic EIRP variations, multi-beam operation, and agile tracking. Similarly, ENs developed for GEO systems do not account for the rapid handovers, Doppler variations, and dynamic link budgets characteristic of LEO and MEO constellations.

The evolution of payload technologies also affects the validity of existing ENs. High-Throughput Satellites (HTS), Digital Transparent Processors (DTPs), regenerative payloads, and beam-hopping architectures introduce dynamic spectral characteristics that challenge measurement methods based on fixed transponder operation. In addition, modern satellite networks employ advanced resource-management techniques - such as adaptive coding and modulation, dynamic power control, and interference-mitigation algorithms - that influence emissions and performance in ways not captured by legacy requirements.

Mobility scenarios have also expanded significantly. ESIMs now operate across maritime, aeronautical, land-mobile, and hybrid environments, often using ESAs and multi-orbit connectivity. These terminals exhibit rapidly changing pointing geometries and operational conditions, requiring updated performance requirements and measurement procedures.

The Technology Evolution Analysis therefore provides the technical basis for identifying the required updates across the 14 ENs in clause 8. It ensures that the assessment of scope, requirements, and measurement methods is grounded in a clear understanding of how satellite technologies have evolved and how these changes affect the assumptions embedded in the ENs.

7.1 Baseline Assumptions of Current ENs

The current versions of the 14 ENs under review were developed over a period spanning more than two decades, during which satellite communication technologies, operational scenarios, and regulatory frameworks were significantly different from those of today. As a result, the ENs embed a set of baseline assumptions that reflect the technological and operational context of their time. These assumptions influence the scope, requirements, and measurement methods of each standard, and they form the reference point against which the evolution of satellite technologies should be assessed.

The baseline assumptions can be grouped into several thematic categories: orbit characteristics, antenna architectures, terminal operating profiles, payload and waveform characteristics, spectrum usage, and measurement conditions. Understanding these assumptions is essential for determining whether the ENs remain valid for modern systems and for identifying the updates required across the standards.

a) Orbit and System Architecture Assumptions

Most ENs were developed under the implicit assumption that satellite systems were predominantly GEO-based, with stable pointing geometries, negligible Doppler effects, and predictable link budgets. Only a subset of ENs - such as ETSI EN 301 442 [i.7], ETSI EN 301 721 [i.11], ETSI EN 303 699 [i.1], ETSI EN 303 979 [i.4], ETSI EN 303 980 [i.5], and ETSI EN 303 984 [i.15] - explicitly consider NGSO operation, and even these often assume simplified orbital dynamics.

Common assumptions include:

- Static or quasi-static pointing toward a GEO satellite.

- Negligible Doppler shift, or Doppler treated as a minor impairment.
- No rapid handovers between satellites.
- Predictable elevation angles and slow variations in link geometry.

These assumptions do not hold for modern LEO/MEO constellations, which exhibit rapid movement, frequent handovers, and significant Doppler variations.

b) Antenna Technology Assumptions

Most ENs assume the use of mechanically steered antennas, characterized by:

- Single-beam operation.
- Fixed radiation patterns.
- Predictable off-axis EIRP characteristics.
- Slow or moderate tracking dynamics.

Electronically Steerable Antennas (ESAs), phased arrays, and hybrid architectures - now widely used in ESIMs, NGSO terminals, and high-frequency systems - were not considered in the original ENs. As a result, the ENs do not account for:

- Scanning losses and angle-dependent gain variations.
- Dynamic EIRP changes during beam steering.
- Multi-beam operation or simultaneous tracking.
- Fast beam switching or agile tracking.

These characteristics challenge the validity of existing requirements and measurement methods.

c) Terminal Operating Assumptions

Many ENs assume that terminals operate under stable, predictable conditions, including:

- Constant or slowly varying EIRP.
- Fixed modulation and coding schemes.
- Limited mobility or static operation.
- Deterministic pointing performance.

However, modern terminals - especially ESIMs and NGSO user terminals - exhibit:

- Rapid pointing changes.
- Adaptive modulation and coding.
- Dynamic power control.
- Multi-orbit connectivity.

These operating profiles were not foreseen in the original ENs.

d) Payload and Waveform Assumptions

Several ENs assume fixed transponder characteristics, typical of traditional bent-pipe GEO satellites:

- Static bandwidth allocation.
- Constant gain.

- No beam hopping or dynamic resource allocation.
- No regenerative processing.

Modern payloads, including HTS, DTPs, and regenerative payloads, introduce:

- Dynamic beamforming.
- Adaptive bandwidth allocation.
- On-board signal processing.
- Beam hopping and time-division multiplexing.

These characteristics affect spectral occupancy and emissions in ways not captured by legacy ENs.

e) Spectrum and Emission Assumptions

Most ENs assume:

- Fixed spectral masks.
- Static carrier characteristics.
- Predictable off-axis emissions.
- No dynamic channelization.

Modern systems, however, may employ:

- Variable carrier bandwidths.
- Adaptive spectral shaping.
- Time-varying emissions due to beam hopping.
- Multi-carrier operation with dynamic allocation.

These differences impact the applicability of existing emission limits and measurement procedures.

f) Measurement Method Assumptions

The measurement methods in the ENs generally assume:

- Static test conditions.
- Single-beam, mechanically steered antennas.
- Stable EIRP and spectral characteristics.
- Laboratory or controlled outdoor environments.

These assumptions are incompatible with:

- ESA operating characteristics under dynamic steering.
- NGSO tracking with rapid pointing changes.
- Multi-beam operation.
- Time-varying payload characteristics.

As a result, several ENs require updated or entirely new measurement methods.

The baseline assumptions embedded in the current ENs reflect a technological environment dominated by GEO systems, mechanically steered antennas, static payloads, and predictable operational conditions. These assumptions no longer hold for modern satellite systems, particularly those involving NGSO constellations, ESAs, high-throughput payloads, and dynamic mobility scenarios. Identifying these assumptions provides the foundation for the analysis and directly informs the required updates across the 14 ENs in clause 8.

7.2 Evolution of Satellite Technologies

The evolution of satellite technologies over the past decade has fundamentally transformed the operational characteristics, performance capabilities, and regulatory expectations of satellite communication systems. These developments directly affect the assumptions embedded in the 14 ENs under review and determine whether the standards remain technically valid for modern systems. The evolution spans multiple dimensions, including orbit architectures, antenna technologies, payload capabilities, waveforms, network control mechanisms, and mobility scenarios. This clause provides a structured analysis of these developments and highlights the areas where the ENs may require updates.

a) Evolution of Orbit Architectures

Historically, most ENs were developed with GEO-centric systems in mind, characterized by stable pointing geometries, negligible Doppler, and predictable link budgets. The emergence of large LEO constellations and the expansion of MEO systems have introduced new operational characteristics:

- Rapid satellite movement requiring continuous tracking and frequent handovers.
- Significant Doppler shifts, especially in LEO systems.
- Variable elevation angles and dynamic link geometries.
- Multi-orbit connectivity, where terminals switch between GEO, MEO, and LEO networks.

These characteristics challenge ENs that assume static or quasi-static operation, particularly those defining off-axis EIRP limits, tracking performance, and measurement conditions.

b) Evolution of Antenna Technologies

A major technological shift has been the transition from mechanically steered antennas to Electronically Steerable Antennas (ESAs), including phased arrays and hybrid digital-analog architectures. ESAs introduce operating characteristics not considered in the original ENs:

- Scanning losses and angle-dependent gain variations.
- Dynamic EIRP changes during beam steering.
- Multi-beam operation enabling simultaneous tracking or multi-satellite connectivity.
- Fast beam switching and agile tracking incompatible with static measurement setups.
- Polarization agility, including electronic polarization switching.

These characteristics affect compliance with off-axis emission limits, tracking requirements, and measurement procedures across multiple ENs (e.g. ETSI EN 302 340 [i.12], ETSI EN 302 977 [i.2], ETSI EN 303 978 [i.3], ETSI EN 303 979 [i.4], ETSI EN 303 984 [i.15]).

c) Evolution of Payload and Satellite Capabilities

Modern satellites incorporate advanced payload technologies that significantly alter spectral characteristics and link behaviour:

- High-Throughput Satellites (HTS) with multi-spot beams and frequency reuse.
- Digital Transparent Processors (DTPs) enabling dynamic bandwidth allocation.
- Regenerative payloads performing on-board demodulation and routing.

- Beam hopping creating time-varying spectral occupancy.
- Adaptive power control and interference-mitigation algorithms.

These capabilities challenge ENs that assume fixed transponder characteristics, static bandwidth, and constant gain.

d) Evolution of Waveforms and Resource Management

Modern satellite systems employ advanced waveforms and resource-management techniques:

- Adaptive Coding and Modulation (ACM), dynamically adjusting link parameters.
- Carrier aggregation and multi-carrier operation.
- Dynamic channelization and flexible bandwidth allocation.
- Interference-aware scheduling and power control.
- Time-division multiplexing in beam-hopping systems.

These characteristics affect spectral masks, EIRP stability, and measurement repeatability, requiring updates to ENs that assume static waveform characteristics.

e) Evolution of Mobility Scenarios

Mobility has expanded significantly beyond traditional maritime and land-mobile terminals:

- Aeronautical ESIMs now operate with high-dynamics tracking and multi-orbit connectivity.
- Land-mobile ESIMs (e.g. VMES, ESTs) operate in dense environments with rapid pointing changes.
- NEST terminals combine fixed and in-motion operation in NGSO systems.
- Hybrid platforms (e.g. trains, UAVs, autonomous vehicles) introduce new operational constraints.

These scenarios require updated tracking requirements, off-axis emission limits, and measurement methods.

f) Evolution of Regulatory and Spectrum Environments

Recent regulatory developments also influence EN applicability:

- ITU and CEPT decisions on ESIMs, NGSO coexistence, and spectrum sharing.
- Increased emphasis on interference avoidance and dynamic coordination.
- New expectations for terminal autonomy, beam control, and fail-safe mechanisms.

These changes should be reflected in updated EN scopes and requirements.

The evolution of satellite technologies has introduced dynamic operating profiles, advanced antenna architectures, multi-orbit operation, and sophisticated payload capabilities that were not foreseen when the current ENs were developed. These developments directly impact the validity of baseline assumptions and highlight the need for updates across scope definitions, technical requirements, and measurement methods.

7.3 Technology Evolution Matrices

The Technology Evolution Matrices provide a structured comparison between the baseline assumptions embedded in the current ENs (clause 7.3) and the state-of-the-art satellite technologies described in clause 7.2. Their purpose is to identify, in a systematic and traceable manner, the areas where the ENs no longer reflect operational reality. These matrices form the analytical bridge between the technology evolution analysis and the identification of required updates across the 14 ENs in clause 8.

The matrices are organized along six key dimensions of technological evolution:

- orbit architectures;

- antenna technologies;
- payload capabilities;
- waveforms and resource management;
- mobility scenarios; and
- measurement conditions.

For each dimension, the matrices contrast the assumptions embedded in the ENs with the characteristics of modern systems, highlighting mismatches that may affect the validity of requirements, scope definitions, or measurement methods.

Table 1: Orbit Architecture Matrix

Aspect	Baseline assumption in ENs	State of the art	Impact
Orbit type	GEO-centric	GEO, MEO, LEO, multi-orbit	ENs may not capture NGSO dynamics
Doppler	Negligible	Significant in LEO/MEO	Requirements may not reflect real impairments
Handover	None or infrequent	Frequent NGSO handovers	Tracking and continuity requirements may be insufficient
Link geometry	Static	Rapidly varying	Off-axis limits and measurement setups may be invalid

Table 2: Antenna Technology Matrix

Aspect	Baseline assumption in ENs	State of the art	Impact
Antenna type	Mechanical	ESA, phased arrays, hybrid	ENs lack provisions for ESA operating characteristics
Beam operation	Single, static	Multi-beam, agile	Off-axis EIRP limits may not apply
Gain pattern	Fixed	Angle-dependent, dynamic	Measurement methods may be invalid
Tracking	Slow	Fast, electronic	Tracking requirements may be outdated

Table 3: Payload and Satellite Capability Matrix

Aspect	Baseline assumption	State of the art	Impact
Modulation	Fixed	ACM, adaptive waveforms	Requirements assume static carriers
Carrier structure	Single	Multi-carrier, aggregated	Spectral masks may be insufficient
Channelization	Static	Flexible, dynamic	Measurement repeatability affected
Interference management	None	Advanced algorithms	ENs do not account for adaptive operation

Table 4: Waveforms and Resource Management Matrix

Aspect	Baseline assumption	State of the art	Impact
Waveform dynamics	Static	Adaptive coding and modulation	ENs may not reflect time-varying link characteristics
Carrier usage	Single carrier	Carrier aggregation, multi-carrier	Existing limits may not cover aggregated operation
Resource allocation	Fixed	Dynamic, interference-aware	Measurement conditions may not match real operation
Scheduling	Deterministic	Flexible, demand-based	Test cases may not represent operational scenarios

Table 5: Mobility Scenario Matrix

Aspect	Baseline assumption	State of the art	Impact
Platform motion	Limited or slow	High-dynamics (aircraft, maritime, land mobility)	Tracking and pointing requirements may be insufficient
Terminal category	Fixed distinctions (fixed/transportable/mobile)	Hybrid, multi-mode terminals	Scope definitions may not reflect real deployments
Link continuity	Static or GEO-only	Frequent handovers, multi-orbit continuity	Requirements may not capture mobility-driven transitions
Operational environment	Controlled	Variable, obstructed, cluttered	ENs may require updated test geometries and conditions

Table 6: Measurement Conditions Matrix

Aspect	Baseline assumption	State of the art	Impact
Test conditions	Static	Dynamic, time-varying	EN methods may not capture ESA/NGSO operation
EIRP	Constant	Adaptive, variable	Limits may not reflect real emissions
Spectral occupancy	Stable	Time-varying	Measurement windows may be insufficient
Environment	Controlled	Operational variability	ENs may require new test procedures

The Technology Evolution Matrices demonstrate that many of the assumptions embedded in the current ENs no longer hold for modern satellite systems. The mismatches identified across orbit dynamics, antenna operating characteristics, payload capabilities, waveform characteristics, mobility scenarios, and measurement conditions provide the technical inputs for clause 8, where these findings are translated into the required updates.

8 Required Updates Across the 14 ENs

8.0 General

The combined findings from the use case mapping and the technology evolution analysis reveal that the 14 ENs under review no longer align uniformly with the operational and technical characteristics of contemporary satellite systems. The required updates do not stem from isolated issues but from a structural shift in how satellite networks operate, how terminals function, and how performance is managed across GEO and NGSO environments. This clause synthesizes the areas where the ENs require revision to remain technically credible, testable, and representative of real-world conditions.

A first area requiring attention concerns the scope definitions of several ENs. Many standards were drafted when the boundaries between fixed, mobile, and in-motion terminals were clearer and when GEO systems dominated the market. Today, the distinction between fixed and mobile operation is increasingly blurred, particularly for NGSO user terminals that may operate in hybrid modes or transition between static and mobile environments. Likewise, the emergence of multi-orbit connectivity challenges scope definitions that implicitly assume a single-orbit architecture. Updating the scopes is therefore essential to ensure that each EN accurately reflects the systems it intends to regulate and avoids unintended exclusions or overlaps.

A second area relates to the technical requirements themselves. Several ENs rely on performance expectations that were appropriate for mechanically steered antennas, fixed transponders, and static link geometries. Modern terminals, however, exhibit operating characteristics that fall outside these assumptions. Electronically steerable antennas introduce dynamic gain variations, agile beam steering, and multi-beam operation, none of which are explicitly addressed in most ENs. Similarly, NGSO terminals are expected to maintain performance under rapid handovers, significant Doppler shifts, and continuously changing elevation angles. Requirements that assume stable EIRP, fixed spectral occupancy, or slow tracking dynamics no longer capture the operational envelope of these terminals. Updating the requirements is therefore necessary to ensure that they remain meaningful and enforceable.

A third area requiring revision is the treatment of emissions and spectral characteristics. Several ENs define off-axis EIRP limits and spectral masks based on static carriers and predictable radiation patterns. Modern systems, however, may employ adaptive coding and modulation, dynamic bandwidth allocation, beam hopping, and interference-aware power control. These mechanisms produce emissions that vary over time, frequency, and pointing direction. Requirements that assume static operation may therefore be either overly restrictive or insufficiently protective, depending on the scenario. A more flexible and technology-neutral formulation of emission limits may be required to accommodate these behaviours while maintaining compatibility with adjacent systems.

The fourth area concerns measurement methods, which in many ENs are based on test setups that assume static conditions, single-beam operation, and stable spectral characteristics. These methods are not adequate for evaluating terminals that rely on ESAs, operate in NGSO systems, or use advanced resource-management techniques. For example, measurement windows designed for continuous carriers may not capture the time-varying emissions of beam-hopping payloads, and procedures based on fixed pointing may not reflect the dynamic operating characteristics of electronically steerable arrays. Updating the measurement methods is therefore essential to ensure that compliance testing remains representative, repeatable, and technically sound.

Finally, several ENs would benefit from greater internal consistency and clearer alignment across standards. The proliferation of ESIM-related ENs, each covering different frequency bands or mobility environments, has resulted in variations in terminology, requirement structure, and measurement philosophy. As satellite systems increasingly operate across multiple platforms and orbits, harmonization across ENs becomes more important to avoid contradictory expectations and to support manufacturers developing multi-band or multi-orbit terminals.

In summary, the required updates across the 14 ENs reflect the need to realign the standards with the operational and technological realities of modern satellite communications. These updates span scope definitions, technical requirements, emission treatments, and measurement methods, and they form the basis for the detailed analyses presented in the present document.

8.1 Scope and Requirements Updates

The review of the 14 ENs shows that several of them no longer fully reflect how satellite terminals operate today. The sector has moved toward multi-orbit architectures, agile antennas, and terminals that shift between operational modes depending on network availability or platform dynamics. As a result, some ENs describe a service environment that no longer matches the way modern user terminals, ESIMs, or NGSO systems operate in practice. Updating the scope of these standards is therefore necessary to ensure that each EN clearly identifies the systems it is intended to regulate and avoids leaving emerging terminal categories outside its coverage.

Beyond scope definitions, a number of performance-related requirements also need revision. Many ENs were drafted when mechanically steered antennas and GEO pointing dominated the market, and therefore assume stable radiation patterns, slow tracking dynamics, and predictable link geometry. Today's terminals - particularly those using electronically steerable antennas - operate with rapid beam adjustments, angle-dependent gain variations, and in some cases simultaneous multi-beam operation. Requirements based on static EIRP, fixed spectral occupancy, or single-beam operation do not capture these operational realities and may lead to ambiguous or incomplete compliance criteria.

A further area requiring attention concerns interference-related requirements, especially off-axis EIRP limits and spectral masks. Modern networks rely on adaptive coding and modulation, dynamic bandwidth allocation, and interference-aware power control. These mechanisms generate emissions that vary over time and frequency, and that depend on the terminal's instantaneous pointing direction. Requirements that assume a fixed carrier or a static radiation pattern may therefore be misaligned with the emissions produced by current systems. Updating these elements will help ensure that the ENs remain both protective and technically realistic.

Table 7: Summary of Required Scope and Requirements Updates Across the 14 ENs

Update category	Current limitation	Required update
Scope definition	Scope tied to single orbit, band, or platform	Expand to include NGSO, multi-orbit, hybrid fixed/mobile operation
Antenna behaviour	Assumes mechanical steering and static patterns	Incorporate ESA operating characteristics, scanning losses, multi-beam operation
Tracking performance	GEO-centric, slow dynamics	Include fast electronic tracking, NGSO handovers, Doppler effects
Emission limits	Static off-axis EIRP assumptions	Allow for dynamic EIRP, adaptive power control, beam agility
Spectral characteristics	Fixed carriers and bandwidth	Address dynamic channelization, beam hopping, variable bandwidth
Operational modes	Single-mode operation	Include multi-mode, multi-band, multi-platform terminals

8.2 Measurement Procedure Updates

The measurement procedures defined in the current ENs were developed for terminals and satellite networks whose operating characteristics were largely static:

- single-beam operation;
- predictable radiation patterns;
- stable carriers; and
- slow pointing dynamics.

Modern terminals - particularly those operating with electronically steerable antennas and in NGSO constellations - exhibit time-varying emissions, agile beam steering, and dynamic resource allocation. As a result, several of the existing test methods no longer capture the operational envelope of these systems. Updating the measurement methods is therefore essential to ensure that compliance assessments remain representative, repeatable, and technically meaningful.

The first area requiring revision concerns test conditions and measurement windows. Many ENs assume continuous carriers and stable EIRP, which is incompatible with systems using beam hopping, adaptive power control, or flexible channelization. Measurements based on short snapshots or fixed averaging intervals may not reflect the full range of emissions produced by these terminals. Updated procedures should therefore define measurement windows that are long enough to capture time-varying operation while still allowing reproducible results across laboratories. A second area relates to antenna-dependent measurements, particularly for terminals using electronically steerable antennas. Existing methods typically require measurements at fixed azimuth and elevation angles, assuming that the antenna pattern is static. ESAs, however, exhibit angle-dependent gain variations, scanning losses, and in some cases multi-beam operation. Static measurement geometries cannot capture these effects. Revised methods should therefore include procedures for evaluating emissions and performance across the antenna's scanning range, including dynamic steering sequences representative of real operation. Electronically steerable antennas are predominantly deployed in frequency bands with high commercial relevance, notably Ku and Ka bands, with emerging developments expected in Q/V bands. As a result, the applicability of antenna-dependent measurement limitations is particularly significant for ENs addressing terminals operating in these frequency ranges.

Table 8: Reasons for impact of technology evolution for some ENs

EN	Band	Reasons for impact
ETSI EN 303 979 [i.4]	Ka/Ku	ESA and NGSO scan-dependent EIRP
ETSI EN 303 978 [i.3]	Ku/Ka	ESA behaviour dynamic pattern
ETSI EN 303 699 [i.1]	Ka	ESA-based NGSO terminals
ETSI EN 303 984 [i.15]	Ku	Aeronautical ESA and wide scan
ETSI EN 303 980 [i.5]	Ku	Hybrid ESA / NGSO
ETSI EN 302 340 [i.12] ETSI EN 302 448 [i.13] ETSI EN 302 977 [i.2]	Ku	Transition to ESA / hybrid
ETSI EN 301 459 [i.10]	Ka	High-frequency ESA possible

The third area requiring updates concerns NGSO-specific operating dynamics, such as rapid pointing changes, Doppler variations, and frequent handovers. Current ENs rarely include test conditions that reproduce these effects. For example, off-axis EIRP measurements performed under static pointing do not reflect the transient emissions that may occur during fast tracking or satellite transitions. Updated methods should incorporate test profiles that emulate NGSO tracking dynamics, including representative slew rates and elevation changes.

This area is particularly applicable to ENs addressing NGSO operation, where GEO-based assumptions regarding static geometry and negligible Doppler no longer apply.

Table 9: Link and geometry impacts on some ENs

EN	Justification
ETSI EN 303 979 [i.4]	strongly time-varying EIRP
ETSI EN 303 699 [i.1]	Even "fixed" NGSO has time-varying geometry and power
ETSI EN 303 984 [i.15]	Aeronautical implies fast variations
ETSI EN 303 980 [i.5]	Hybrid fixed/in-motion NGSO imply variable link conditions

Although, these considerations are increasingly relevant for ENs originally defined for GEO operation (ETSI EN 303 978 [i.3], ETSI EN 302 340 [i.12], ETSI EN 302 448 [i.13], ETSI EN 302 977 [i.2]), as terminals evolve towards multi-orbit operation. The fourth area relates to multi-carrier and adaptive waveform operation. Several ENs define spectral masks and emission limits assuming a single, fixed carrier. Modern terminals may operate with aggregated carriers, variable bandwidths, or adaptive coding and modulation. Measurement methods should therefore be updated to specify how to evaluate emissions under these conditions, including how to treat instantaneous versus average spectral occupancy.

To provide a structured overview, Table 10 summarizes the main categories of measurement method updates.

Table 10: Summary of Required Measurement Method Updates

Measurement area	Current limitation	Required update
Test conditions	Static carriers, fixed EIRP	Include time-varying emissions, adaptive power control, beam hopping
Antenna-related tests	Fixed pointing, static patterns	Evaluate ESA scanning range, dynamic steering, multi-beam operation
NGSO dynamics	No tracking or handover emulation	Introduce test profiles for rapid pointing, Doppler, and handovers
Spectral measurements	Single-carrier assumptions	Support multi-carrier, variable bandwidth, adaptive waveforms
Averaging/integration	Short, fixed windows	Define windows suitable for dynamic emissions and repeatability
Mobility scenarios	Limited or no motion profiles	Include representative maritime, aeronautical, and land-mobile dynamics

a) Definition of test conditions

Measurement conditions should be clearly defined in terms of:

- Operating ranges.
- Environmental conditions.
- Terminal configuration.

Avoid leaving parameters open to interpretation by external entities.

b) Definition of test scenarios

Each EN should include:

- Clear diagrams of test setups.
- Description of Equipment Under Test (EUT).
- Applicability to reflector and ESA antennas.

c) Definition of measurement methods

Measurement procedures should:

- Follow consistent methodologies across ENs.
- Use harmonized instrumentation approaches.
- Replace outdated techniques (e.g. X-Y plotters) with:
  - Spectrum analyser sweeps.
  - Time-domain capture methods.

d) Definition of test results and compliance criteria

Each EN should:

- Clearly define expected results.
- Explicitly indicate pass/fail criteria.
- Ensure alignment with technical requirements.

e) Harmonized structure across ENs

A common structure should be adopted:

1) Test site definition.
2) Test setup.
3) Measurement procedure.
4) Results evaluation.

The review of the ENs has identified several aspects of measurement definitions and procedures that would benefit from further clarification and harmonisation. In particular, inconsistencies have been observed in the definition of test conditions, the description of measurement methods, and the specification of expected results.

Measurement definitions, including operating ranges and test conditions, should be clearly specified and unambiguous, avoiding reliance on implicit assumptions or external interpretation. Where multiple operating configurations are possible, the number of test options should be limited to ensure practical applicability. In such cases, the measurement method should explicitly define the representative or worst-case scenario to be verified for compliance.

The ENs under review address a wide range of operational scenarios, including maritime, aeronautical, and land-mobile environments. Despite these differences, a consistent structure for the definition and execution of measurement procedures should be adopted across all ENs in order to ensure harmonization and repeatability.

To achieve this objective, measurement procedures should be systematically structured according to the following elements:

a) Definition of the test site

The test environment should be clearly specified, including the type of measurement facility and its applicability. This may include, where appropriate:

- Simulation-based environments.
- Compact antenna test ranges (e.g. anechoic or semi-anechoic chambers).
- Outdoor test sites, including near-field and far-field ranges.
- Satellite link-based validation where representative of operational conditions.

The choice of test site should be justified in relation to the measurement objective and the characteristics of the equipment under test.

b) Definition of the test scenario

The test scenario should describe in a clear and unambiguous manner:

- The configuration of the Equipment Under Test (EUT).
- The associated subsystems and interfaces.
- The operational conditions under which the test is conducted.

Where applicable, illustrative diagrams should be provided. Existing ENs often include simplified or incomplete representations of test setups, which should be updated to reflect both conventional reflector-based systems and modern Electronically Steerable Antenna (ESA) configurations.

c) Definition of the measurement method

Measurement procedures should define, in a step-by-step manner, the methodology to be followed, ensuring consistency and reproducibility across different laboratories.

While most ENs already include measurement procedures, updates are required to:

- Ensure consistency in the application of measurement techniques across ENs.
- Harmonise the use of instrumentation in terms of performance and precision requirements.
- Replace outdated or insufficiently specified methods.

In particular, legacy techniques (e.g. X-Y plotter-based pattern acquisition) should be replaced or complemented by modern measurement approaches, such as:

- Spectrum analyser-based measurements using sweep-time control.
- Time-domain capture techniques where appropriate.
- Digital post-processing (e.g. marker tables or automated data acquisition).

Where different measurement methods are allowed, the EN should clearly specify the applicable conditions and expected equivalence between methods.

d) Definition of test results and compliance criteria

Measurement results and compliance criteria should be explicitly defined. This includes:

- The parameters to be measured.
- The form in which results are to be reported.
- The thresholds or limits that determine compliance or non-compliance.

Providing clear and explicit acceptance criteria is essential to avoid ambiguity in the interpretation of results.

e) Harmonisation of measurement procedure structure

A common structure for measurement procedures should be adopted across ENs, including:

1) Test site definition.
2) Test setup and configuration.
3) Measurement procedure.
4) Results evaluation and compliance criteria.

The adoption of a harmonized structure will improve clarity, facilitate comparison across ENs, and support consistent implementation by manufacturers and test laboratories.

8.3 Technical considerations for earth stations based on flat array antennas (Academic perspective)

8.3.1 General

Several ETSI SES hENs currently include antenna, pointing and test methodology clauses derived from assumptions historically associated with mechanically steered reflector antennas. These assumptions are increasingly insufficient for the certification and verification of modern satellite terminals employing Electronically Steered Antennas (ESAs), phased array antennas, flat panel terminals and adaptive multi-beam digital architectures. Furthermore, the array processing techniques impact on the antenna performance being those adaptive to the electromagnetic environment and so dynamically to the antenna specifications.

Recent SES standards already introduce concepts partially aligned with electronically controlled antenna systems, particularly for non-GSO and in-motion operation, including ETSI EN 303 699 [i.1], ETSI EN 303 978 [i.3], ETSI EN 303 979 [i.4] and ETSI EN 303 980 [i.5].

However, a significant number of clauses across the EN series still rely on fixed beam assumptions; mechanically referenced pointing concepts; static radiation pattern measurements; single-carrier operation models; and legacy OTA procedures based on antenna rotation only.

This creates inconsistencies between standards and limits the applicability of existing conformance procedures to current ESA-based satellite terminals operating in GSO, MEO and LEO systems. Besides, multi-system terminal thanks to the digital antenna array processing capabilities will impact the ground segment state of the art and it is recommended to be considered also.

The present contribution proposes a coordinated modernization of antenna-related and test-related clauses across the ETSI SES EN series in order to preserve technology neutrality; enable certification of electronically steered systems; harmonize terminology and verification methods; support adaptive and software-defined satellite terminal architectures.

The recommendations will particularly affect to several standards, including ETSI EN 301 427 [i.6], ETSI EN 301 442 [i.7], ETSI EN 301 443 [i.8], ETSI EN 301 447 [i.9], ETSI EN 301 459 [i.10], ETSI EN 302 340 [i.12], ETSI EN 302 448 [i.13], ETSI EN 302 977 [i.2], ETSI EN 303 699 [i.1], ETSI EN 303 978 [i.3], ETSI EN 303 979 [i.4], ETSI EN 303 980 [i.5] and ETSI EN 303 984 [i.15].

8.3.2 Antenna-Related Recommendations

Antenna-related clauses throughout the ETSI SES EN series should be modernized in a coordinated manner to explicitly support Electronically Steered Antennas (ESAs), phased array systems, flat panel terminals and digitally controlled multi-beam architectures. Existing antenna provisions across several ENs were primarily developed around operational assumptions associated with mechanically steered reflector antennas and static radiation patterns. While these assumptions remain applicable to conventional parabolic systems, they no longer fully represent the operational behavior, dynamic characteristics and verification requirements of modern satellite terminals employing adaptive beamforming and electronic steering technologies.

Multiple standards within the SES EN family currently contain antenna-related clauses addressing antenna pointing accuracy, beam pointing, polarization alignment, receive antenna off-axis gain pattern and antenna mechanical stability. Similar clause structures are present in ETSI EN 302 448 [i.13], ETSI EN 302 977 [i.2], ETSI EN 303 699 [i.1], ETSI EN 303 978 [i.3], ETSI EN 303 979 [i.4], ETSI EN 303 980 [i.5] and ETSI EN 303 984 [i.15], although the terminology, scope and associated verification methodologies are not always fully harmonized across the standards. This creates potential inconsistencies when assessing comparable antenna functions implemented using different technological architectures or intended for different orbital environments. A simple example is the need of using test campaign setups for full digital Radio Frequency System on Chip (RFSoC) architectures that can adapt the antenna pattern to specific environmental conditions as well as to match specific pattern mask requirements.

A coordinated modernization should therefore introduce technology-neutral antenna descriptors capable of representing both conventional reflector antennas and electronically steered flat panel arrays. In particular, the historical dependency on nominal antenna diameter as the primary antenna descriptor should be reconsidered. For phased array and ESA implementations, the effective antenna performance is strongly dependent on scan angle, active aperture utilization, beam shaping configuration and digital beamforming constraints. Consequently, antenna-related requirements should increasingly reference measurable radiated performance parameters such as scan-angle dependent gain, beamwidth, sidelobe behavior, EIRP density distribution and polarization performance rather than relying solely on reflector-equivalent geometric descriptors.

The standards should also explicitly distinguish between mechanical steering, electronic steering and hybrid steering architectures. Current pointing clauses often implicitly assume mechanically actuated antenna movement, whereas ESAs may steer beams electronically without requiring physical antenna motion. Hybrid architecture additionally combines mechanical platform stabilization with electronic fine steering. These distinct operating principles introduce different performance characteristics, response times, failure modes and verification requirements which should be reflected within the normative clauses and associated conformance procedures.

Antenna pointing-related clauses should therefore be extended beyond static pointing accuracy alone. Modern ESA terminals may exhibit scan-dependent beam distortion, steering quantization effects, dynamic tracking behavior and transient beam conditions during steering updates or beam switching operations. Updated requirements may therefore address parameters including beam steering accuracy, beam stability over the operational scan range, tracking dynamics, scan transition behavior, reacquisition performance and beam switching latency. Such parameters are particularly relevant for non-GSO systems operating in LEO and MEO constellations, where continuous satellite tracking and rapid beam updates form part of normal terminal operation and may affect the systems performance as well as the quality of service of final users.

Similarly, off-axis radiation pattern requirements should be revised to explicitly support adaptive beamforming, beam hopping and simultaneous multi-beam operation, being the patterns shaped adaptive. Existing clauses are largely based on static radiation envelopes derived from single-beam reflector antennas. However, modern phased array terminals may dynamically modify their radiation characteristics as a function of network loading, interference mitigation, satellite tracking geometry or adaptive EIRP density control mechanisms. Updated requirements should therefore accommodate time-varying radiation patterns and adaptive beam configurations while maintaining the necessary protection of adjacent satellite systems and terrestrial services.

Polarization-related clauses should also be modernized to reflect electronically controlled polarization architectures and agile polarization management techniques. In electronically steered arrays, cross-polar performance may vary as a function of scan angle, beam steering state or digital calibration conditions. Future revisions should therefore incorporate scan-dependent polarization behavior, electronically controlled polarization alignment and agile polarization switching capabilities within both the technical requirements and associated verification methodologies.

Finally, the terminology used throughout the EN series should be harmonized to ensure that equivalent antenna functions are described consistently across all applicable standards. Terms associated with beam pointing, steering accuracy, off-axis performance, beam stability and polarization alignment are currently expressed differently between standards developed for fixed, transportable and in-motion terminals. Harmonized terminology and aligned verification principles would improve consistency across the SES EN family while simplifying conformity assessment for modern satellite terminals operating across GSO, MEO, LEO and other non-GSO tracking environments.

8.3.3 Test and Measurement Recommendations

The test and measurement methodologies currently defined across several ETSI SES EN standards should be modernized to reflect the operational characteristics of Electronically Steered Antennas (ESAs), phased array terminals and software-defined satellite communication architectures. A significant number of existing verification procedures were originally developed for mechanically steered reflector antennas operating with static beam configurations and relatively stable transmission conditions. While these procedures remain applicable for conventional antenna systems, they are not always fully representative of the dynamic operational behavior associated with modern electronically controlled satellite terminals.

This limitation is particularly visible in clauses related to off-axis EIRP measurements, antenna radiation pattern acquisition, antenna pointing verification, polarization alignment testing, processor monitoring and Control and Monitoring Function (CMF) verification procedures. Similar methodologies and assumptions are present across multiple standards within the SES EN family, including ETSI EN 302 340 [i.12], ETSI EN 302 448 [i.13], ETSI EN 302 977 [i.2], ETSI EN 303 699 [i.1], ETSI EN 303 978 [i.3], ETSI EN 303 979 [i.4], ETSI EN 303 980 [i.5] and ETSI EN 303 984 [i.15]. In several cases, the associated test procedures still rely on assumptions based on static beam operation, mechanically rotated antennas, fixed measurement geometries and quasi-static transmission conditions.

A coordinated modernization of the verification methodologies should therefore replace obsolete assumptions associated with static beam operation and mechanical-only steering architectures. Electronically steered terminals may continuously modify their radiation characteristics as a function of scan angle, tracking conditions, network control commands, interference mitigation strategies or adaptive beamforming algorithms. Consequently, verification methodologies should support dynamic and time-varying antenna behavior rather than assuming fixed radiation patterns during the measurement interval.

Updated standards should therefore introduce OTA-oriented verification methodologies specifically adapted to electronically steered antenna systems. Such procedures should support scan-angle dependent radiation pattern acquisition, dynamic beam tracking, electronically controlled polarization verification and simultaneous multi-beam operation testing. In addition, verification methodologies should support operational scenarios involving rapid beam steering transitions, satellite handovers and adaptive beam management functions commonly present in non-GSO systems operating in LEO and MEO constellations.

The standards should also replace legacy analogue acquisition assumptions with fully digital and automated measurement approaches. Several historical procedures were developed around manual or semi-automated measurement systems relying on mechanically scanned antennas and sequential acquisition processes. Modern ESA testing increasingly relies on digital trace capture, automated pattern acquisition, time-correlated beam telemetry and digitally synchronized measurement systems capable of correlating radiated performance with beam steering commands, platform telemetry and modem operational states. Future revisions should therefore explicitly support digital acquisition methodologies and automated verification environments.

Additional harmonization is also required for operationally dynamic waveform configurations. Existing conformance procedures frequently assume single-carrier and quasi-continuous transmission conditions, whereas modern satellite terminals increasingly operate using Adaptive Coding and Modulation (ACM), Variable coding and Modulation (VCM), burst-mode transmissions, beam hopping strategies and aggregated multi-carrier operation. Verification methodologies should therefore include harmonized procedures capable of characterizing these dynamic operational modes while ensuring reproducibility and consistency between test facilities.

Clarification is also required regarding equivalence criteria between different OTA test environments. Current ENs often provide limited guidance regarding the equivalence between anechoic chambers, compact antenna test ranges, outdoor far-field ranges and near-field OTA systems. As ESA measurements increasingly rely on compact ranges and near-field methodologies due to antenna size, operational frequency and beam steering requirements, the standards should define harmonized equivalence criteria and acceptable uncertainty limits across alternative test environments in order to ensure comparable and reproducible conformance results.

Consistency between technical requirements and verification procedures should also be reinforced throughout the EN series. In several cases, ambiguities may arise regarding detector configurations, averaging methods, measurement bandwidths, operational states and interpretation of dynamic emissions. Future revisions should therefore ensure direct traceability between normative limits and associated measurement methodologies, particularly for adaptive and time-varying transmission scenarios.

Finally, CMF-related verification procedures should be modernized to support software-defined and terminal architectures. Modern satellite terminals increasingly incorporate distributed processing, remotely managed control functions, network-driven configuration mechanisms and autonomous fail-safe capabilities. Verification methodologies should therefore support software-defined terminals, modem architectures, remotely managed ESA systems and autonomous operational recovery functions while maintaining the required level of conformance robustness and operational safety.

8.3.4 Summary of Recommended Changes

Table 11 provides a consolidated summary of the principal antenna-related and test-related clauses identified across the ETSI SES EN series that may require revision or harmonization in order to fully support Electronically Steered Antennas (ESAs), phased array terminals and digitally controlled multi-beam architectures. The table identifies the applicable EN standard, the corresponding clause or section currently defining the requirement, the existing technical requirement and associated verification methodology, together with the proposed recommendation for modernization and its technical justification.

Where applicable, the existing requirements include references to currently defined operational parameters, measurement assumptions and normative formulations already present in the corresponding ENs. In addition, references to specific clauses and formula definitions have been included whenever these directly define the parameter or performance metric subject to the proposed update. The objective of this consolidated analysis is to facilitate traceability between the existing SES EN framework and the recommended modifications required to ensure technology-neutral applicability, harmonized verification methodologies and consistent conformity assessment procedures for modern ESA-based satellite terminals operating in GSO, MEO, LEO and other non-GSO environments.

Table 11

ID	EN standard	Clause	Existing requirement	Existing verification method	Recommended change	Technical justification
ANT-01-699	ETSI EN 303 699 [i.1]	4.1.7 Peak Pointing Accuracy 4.2.6 Antenna Pointing Accuracy	Peak pointing accuracy defined assuming a single boresight direction and static antenna geometry.	Static angular pointing verification.	Introduce separate definitions for mechanical pointing accuracy, electronic beam steering accuracy and hybrid steering accuracy. Include scan-angle dependent performance characterization.	Electronically steered antennas may maintain beam pointing accuracy while the physical antenna remains fixed.
ANT-01-977	ETSI EN 302 977 [i.2]	4.2.5 Antenna Pointing and Polarization Alignment	Pointing accuracy linked to reflector antenna tracking performance.	Static pointing verification.	Replace reflector-oriented terminology by technology-neutral steering terminology applicable to phased arrays and ESAs.	Pointing performance in ESAs depends on beam steering algorithms rather than mechanical tracking only.
ANT-01-978	ETSI EN 303 978 [i.3]	4.2.6.1 Antenna Pointing Accuracy	Pointing accuracy specified independently of scan angle.	Fixed beam OTA measurement.	Include beam steering accuracy as a function of scan angle and operational steering range.	ESA gain degradation and beam distortion vary with steering angle.
ANT-01-979	ETSI EN 303 979 [i.4]	4.2.6.1 Antenna Pointing Accuracy	Static pointing assumptions for non-GSO tracking.	Conventional OTA verification.	Introduce dynamic pointing performance metrics including tracking stability and steering response.	Non-GSO operation requires continuous beam steering.
ANT-01-980	ETSI EN 303 980 [i.5]	4.2.2 Antenna Beam Pointing	Beam pointing error defined using conventional antenna assumptions.	Static beam pointing measurement.	Extend beam pointing requirements to include electronically steered beam control.	NEST terminals increasingly employ phased-array antennas.
ANT-02-699	ETSI EN 303 699 [i.1]	4.2.6.3 On-axis Cross Polarization Isolation	Cross-polar performance evaluated only at nominal pointing direction.	Static polarization measurement.	Introduce scan-angle dependent cross-polarization characterization.	ESA polarization purity varies with steering angle.
ANT-02-977	ETSI EN 302 977 [i.2]	4.2.5 Antenna Pointing and Polarization Alignment	Polarization alignment assumes mechanically adjusted polarization.	Mechanical polarization alignment verification.	Introduce electronically controlled polarization alignment and polarization agility requirements.	Modern ESAs can dynamically control polarization.
ANT-02-978	ETSI EN 303 978 [i.3]	4.2.6.2.2 Polarization Angle Alignment	Fixed polarization alignment assumptions.	Static OTA verification.	Include polarization switching and electronically controlled polarization states.	Dual-polarized phased arrays support dynamic polarization control.
ANT-02-979	ETSI EN 303 979 [i.4]	4.2.6.2.3 Polarization Angle Alignment	Conventional polarization alignment methodology.	Static measurement procedure.	Introduce scan-dependent cross-polarization performance requirements.	Cross-polar isolation can vary significantly across steering range.

ID	EN standard	Clause	Existing requirement	Existing verification method	Recommended change	Technical justification
ANT-02-980	ETSI EN 303 980 [i.5]	Associated beam pointing clauses	No explicit consideration of electronically controlled polarization.	Conventional OTA verification.	Add requirements addressing electronic polarization control and beam/polarization coupling effects.	Polarization control is increasingly integrated into ESA beamforming networks.
ANT-03-699	ETSI EN 303 699 [i.1]	4.2.9 Receive Antenna Off-Axis Gain Pattern	Off-axis pattern based on fixed antenna geometry.	Static radiation pattern acquisition.	Introduce scan-angle dependent receive gain masks.	ESA receive patterns vary dynamically with beam steering.
ANT-03-977	ETSI EN 302 977 [i.2]	4.2.9 Receive Antenna Off-Axis Gain Pattern	Receive pattern characterized using reflector antenna assumptions.	Rotation-based pattern measurement.	Replace reflector-centric characterization with technology-neutral performance descriptors.	Flat panel arrays do not exhibit fixed reflector-like patterns.
ANT-03-978	ETSI EN 303 978 [i.3]	4.2.10 Receive Antenna Off-Axis Gain Pattern	Static off-axis receive envelope.	Fixed beam pattern acquisition.	Include adaptive beamforming and beam shaping behaviour.	Receive beams may be adaptively optimized in real time.
ANT-03-979	ETSI EN 303 979 [i.4]	4.2.10 Receive Antenna Off-Axis Gain Pattern	Single-beam receive pattern assumptions.	Conventional OTA pattern measurement.	Introduce support for simultaneous multi-beam reception.	Multi-beam ESA terminals are increasingly deployed in NGSO systems.
ANT-03-980	ETSI EN 303 980 [i.5]	4.2.9 Receive Antenna Off-Axis Gain Pattern	Conventional off-axis receive gain requirements.	Static receive pattern measurement.	Introduce beam steering dependent receive pattern characterization.	Receive pattern shape varies across scan range.
ANT-04-699	ETSI EN 303 699 [i.1]	4.2.6 Antenna Pointing Accuracy	No consideration of beam switching dynamics.	Static verification.	Introduce beam switching latency and steering transition requirements.	Beam handover performance is critical for NGSO systems.
ANT-04-977	ETSI EN 302 977 [i.2]	4.2.3 Off-axis EIRP Density	Static EIRP envelope assumptions.	Rotation-based pattern measurement.	Introduce dynamic beamforming and beam hopping operation.	ESA emissions are time varying.
ANT-04-978	ETSI EN 303 978 [i.3]	4.2.3 Off-axis EIRP Emission Density	Single active beam assumptions.	Static OTA verification.	Include simultaneous multi-beam operation.	Modern ESOMPs can generate multiple beams simultaneously.
ANT-04-979	ETSI EN 303 979 [i.4]	4.2.3 epfd Limits	Static transmission geometry assumptions.	Conventional epfd assessment.	Include adaptive beam management and dynamic steering conditions.	NGSO ESA terminals operate with continuously changing geometry.
ANT-04-980	ETSI EN 303 980 [i.5]	Antenna Beam Pointing and Radiation Requirements	Conventional beam management assumptions.	Static testing procedures.	Include beam hopping and adaptive beam shaping.	Digital beamforming architectures support dynamic pattern control.
ANT-05-699	ETSI EN 303 699 [i.1]	Antenna-related clauses	Antenna performance indirectly linked to conventional aperture concepts.	Conventional OTA measurements.	Introduce technology-neutral descriptors based on gain, beamwidth and sidelobe levels.	Applicable to both reflectors and flat panel antennas.
ANT-05-977	ETSI EN 302 977 [i.2]	Antenna-related clauses	Reflector-centric terminology.	Classical pattern measurements.	Remove implicit dependence on nominal antenna diameter.	Flat panel terminals are not adequately represented by reflector metrics.

ID	EN standard	Clause	Existing requirement	Existing verification method	Recommended change	Technical justification
ANT-05-978	ETSI EN 303 978 [i.3]	Antenna-related clauses	Antenna classification based primarily on conventional architectures.	Standard OTA measurements.	Introduce scan-angle dependent gain and EIRP descriptors.	Better representation of ESA performance.
ANT-05-979	ETSI EN 303 979 [i.4]	Antenna-related clauses	Fixed antenna performance descriptors.	Static verification.	Include steering-dependent beamwidth and sidelobe characterization.	ESA performance varies across steering range.
ANT-05-980	ETSI EN 303 980 [i.5]	Antenna-related clauses	Conventional aperture assumptions.	Existing OTA methodology.	Adopt technology-neutral radiated performance descriptors.	Enables harmonised certification of reflector and phased-array terminals.

9 Consolidation of Expert Comments

9.0 General

The review of the 14 ENs generates a large number of technical observations from different Experts, each focusing on specific aspects such as antenna performance, NGSO dynamics, emissions, or measurement methods. These inputs are valuable but heterogeneous, and a structured consolidation process is required to transform them into a coherent and actionable set of comments.

The purpose of the consolidation is to merge overlapping contributions, resolve inconsistencies, and ensure that similar issues raised across different ENs are treated in a harmonized manner. This is particularly important because many comments refer to topics such as ESA antennae or NGSO tracking that affect several standards simultaneously.

The process also ensures that terminology is aligned, that comments are technically consistent with the findings of clauses 7 and 8, and that the most impactful issues are clearly identified. By grouping related comments, validating their technical basis, and prioritizing them according to relevance and impact, WP2 produces a unified set of recommendations that can be used reliably in the subsequent stages of the work program.

The workflow used to achieve this - covering preprocessing, semantic grouping, conflict resolution, and prioritization is described in clause 9.1.

9.1 Proposed Consolidation Workflow

The consolidation of expert comments is based on a structured workflow supported by a dedicated semantic processing framework of WP2. This framework enables the efficient handling of a large volume of heterogeneous inputs while ensuring technical consistency across the 14 ENs. The workflow combines automated semantic consolidation, semantic clustering, and expert validation to produce a harmonized and traceable set of consolidated comments.

The process begins with a preprocessing stage in which all expert inputs are normalized. The semantic processing stage standardizes terminology, separates multi-topic contributions into atomic units, and aligns formatting so that each comment can be analysed independently. Each item is then indexed by EN and clause to maintain full traceability throughout the workflow.

The next stage is the semantic clustering process, which analyses the meaning of each comment rather than its literal wording. This step identifies three types of relationships:

- repeated comments (identical or near-identical inputs from different experts);
- semantically equivalent comments (different wording but addressing the same technical issue);
- partially overlapping comments (related but not identical observations).

This clustering is essential for reducing redundancy and identifying areas of convergence across expert contributions.

Once the clusters are formed, a technical reconciliation phase is performed. The automated semantic consolidation workflow generates a draft consolidated comment for each cluster, capturing the common technical substance while removing contradictions or ambiguities. WP2 reviewers then validate these drafts to ensure alignment with the findings of clauses 7 and 8 and to confirm that the consolidated output accurately reflects the experts' intent.

A prioritization layer is then applied. The semantic analysis process classifies each consolidated comment according to its technical impact, following the priority levels assigned by the experts. This prioritization ensures that the most critical updates are clearly highlighted for subsequent stages of the work programme.

Throughout the workflow, traceability is preserved. Each consolidated comment retains links to the original expert inputs, allowing reviewers to verify how each contribution was interpreted and ensuring that no information is lost during consolidation.

The result is a coherent, non-redundant, and technically validated set of comments for each EN, structured by clause and grouped by technical theme. This consolidated dataset forms the basis for the recommendations on EN updates and supports coordination with the relevant ETSI Technical Committees.

9.2 Cross-EN Consolidated Findings

9.2.1 Introduction

This clause presents the transversal consolidation of findings across the 14 ENs under review. While each EN contains its own set of comments, requirements, and technical assumptions, a cross-standard analysis reveals a consistent set of structural issues that recur across multiple documents. These issues reflect the evolution of satellite systems toward multi-orbit architectures, electronically steerable antennas, dynamic resource management, and increasingly diverse mobility environments.

The consolidation was carried out using a structured analytical workflow based on three inputs:

- expert comments collected during the review process;
- a transversal semantic mapping of all ENs; and
- a comparison of the consolidated themes with the technology evolution described in clauses 7 and 8.

The objective of this clause is to identify the common themes that affect multiple ENs simultaneously and to provide a unified basis for the recommendations presented in clause 10.

9.2.2 Methodology for Cross-EN Consolidation

The consolidation process followed a multi-stage approach designed to ensure consistency, traceability, and technical accuracy:

a) Normalization of expert inputs:

- All comments were normalized into a common structure, ensuring consistent terminology and categorization across ENs. This step enabled the identification of equivalent issues expressed differently by different contributors.

b) Cross-EN thematic clustering:

- Comments were grouped into thematic clusters covering scope, antenna operation, emissions, test methods, receiver performance, control and monitoring functions, and regulatory alignment. This allowed the identification of patterns that recur across multiple ENs.

c) Identification of systemic issues:

- Clusters were analysed to determine whether the issues were isolated to specific ENs or systemic across the entire set. Systemic issues were flagged as transversal priorities requiring coordinated updates.

d) Mapping to update categories:

- The transversal findings were mapped to the update categories defined in clauses 8.1 and 8.2, ensuring alignment between EN-level analysis and cross-standard conclusions.

e) Traceability:

- Each consolidated theme maintains a traceable link to the original expert comments and the ENs in which they appear, ensuring transparency and auditability.

9.2.3 Transversal Macro-Clusters (Level 1)

The transversal analysis identified seven macro-clusters that appear consistently across the 14 ENs. These clusters represent the main structural areas where the ENs require modernization:

1) Scope Modernization:

   - Many ENs rely on legacy assumptions regarding fixed/mobile distinctions, GEO-centric operation, and single-orbit architectures. Modern systems operate across hybrid GSO/NGSO environments, include ESIMs in multiple mobility domains, and support flat-array terminals. Key sub-clusters: ESIM inclusion, NGSO support, hybrid GSO/NGSO terminals, in-motion operation, removal of legacy VMES/ESV assumptions. ENs contributing: ETSI EN 302 340 [i.12], ETSI EN 302 448 [i.13], ETSI EN 302 977 [i.2], ETSI EN 303 978 [i.3], ETSI EN 303 979 [i.4], ETSI EN 303 980 [i.5], ETSI EN 303 984 [i.15], ETSI EN 301 459 [i.10], ETSI EN 301 447 [i.9].

2) Antenna Modernization:

   - Several ENs assume mechanically steered antennas and nominal antenna diameters. Modern terminals use electronically steerable antennas with scan-angle-dependent patterns, digital beamforming, and active polarization control. Key sub-clusters: ESA scan-angle patterns, beam hopping, multibeam operation, tracking dynamics. ENs contributing: ETSI EN 302 340 [i.12], ETSI EN 302 448 [i.13], ETSI EN 303 699 [i.1], ETSI EN 302 977 [i.2], ETSI EN 303 978 [i.3], ETSI EN 303 979 [i.4], ETSI EN 303 980 [i.5], ETSI EN 303 984 [i.15], ETSI EN 301 459 [i.10].

3) Emission Limit Modernization:

   - Off-axis and on-axis spurious limits are based on static patterns and fixed carriers. ESA terminals and NGSO systems produce time-varying emissions incompatible with current masks. Key sub-clusters: off-axis EIRP density, time-domain considerations, bandwidth definitions, alignment with ECC/DEC/(18)05. ENs contributing: ETSI EN 302 340 [i.12], ETSI EN 302 448 [i.13], ETSI EN 302 977 [i.2], ETSI EN 303 978 [i.3], ETSI EN 303 979 [i.4], ETSI EN 303 980 [i.5], ETSI EN 303 984 [i.15], ETSI EN 301 459 [i.10], ETSI EN 301 447 [i.9].

4) Test Method Modernization:

   - Many ENs rely on outdated test setups (e.g. XY plotters) and static pointing assumptions. ESA and NGSO terminals require dynamic, OTA-based, and multi-carrier test methods. Key sub-clusters: OTA testing, dynamic steering, wideband receivers, in-motion procedures, Annex C updates. ENs contributing: ETSI EN 302 340 [i.12], ETSI EN 302 448 [i.13], ETSI EN 302 977 [i.2], ETSI EN 303 978 [i.3], ETSI EN 303 979 [i.4], ETSI EN 303 980 [i.5], ETSI EN 303 699 [i.1],ETSI EN 301 447 [i.9]

5) Receiver Performance modernization:

   - Blocking, selectivity, and interference assumptions are based on legacy GEO systems. Modern wideband receivers and multi-orbit environments require updated performance criteria. ENs contributing: ETSI EN 302 340 [i.12], ETSI EN 302 977 [i.2], ETSI EN 303 978 [i.3], ETSI EN 303 979 [i.4], ETSI EN 303 980 [i.5], ETSI EN 303 984 [i.15], ETSI EN 301 459 [i.10].

6) CMF modernization:

   - Control and Monitoring Functions (CMF) in many ENs assume centralized architectures. Modern terminals use distributed, IP-based, remotely managed CMF with autonomous fail-safe logic. ENs contributing: ETSI EN 302 340 [i.12], ETSI EN 302 448 [i.13], ETSI EN 302 977 [i.2], ETSI EN 303 978 [i.3], ETSI EN 303 979 [i.4], ETSI EN 303 980 [i.5], ETSI EN 303 699 [i.1], ETSI EN 301 459 [i.10], ETSI EN 301 721 [i.11].

7) Regulatory Alignment:

   - Several ENs require alignment with updated ITU RR, CEPT/ECC decisions, RED Article 3.2, and coexistence studies. ENs contributing: ETSI EN 303 699 [i.1], ETSI EN 303 979 [i.4], ETSI EN 303 980 [i.5], ETSI EN 303 984 [i.15], ETSI EN 302 340 [i.12], ETSI EN 301 459 [i.10], ETSI EN 301 721 [i.11].

9.2.4 Technical Sub-Clusters (Level 2)

The sub-clusters provide a more granular view of the transversal issues. They include:

- ESIM applicability across mobility domains.
- Scan-angle-dependent antenna patterns.
- Time-domain emission characteristics.
- Dynamic NGSO tracking profiles.
- Multi-carrier and adaptive waveform operation.
- Distributed CMF architectures.
- Alignment with ECC/DEC/(17)04 [i.16] and ECC/DEC/(18)05 [i.17].
- Removal of legacy assumptions (e.g. VMES/ESV distinctions).

These sub-clusters appear repeatedly across ENs, confirming that the required updates are systemic rather than isolated.

9.2.5 EN-by-EN Cross-Mapping (Level 3)

Table 12 provides the full transversal mapping matrix, showing which EN contributes to which cluster. This matrix confirms that most ENs contribute to multiple macro-clusters, demonstrating the systemic nature of the required updates.

Table 12: EN-by-EN Mapping Table (Level 3)

EN	Scope	Antenna	Emissions	Tests	Receiver	CMF	Regulatory
ETSI EN 301 427 [i.6]	✓	-	✓	✓	-	-	✓
ETSI EN 301 442 [i.7]	✓	-	✓	✓	✓	✓	✓
ETSI EN 301 443 [i.8]	✓	-	✓	✓	✓	-	✓
ETSI EN 301 447 [i.9]	✓	✓	✓	✓	-	-	✓
ETSI EN 301 459 [i.10]	✓	✓	✓	✓	✓	✓	✓
ETSI EN 301 721 [i.11]	✓	-	✓	✓	✓	✓	✓
ETSI EN 302 340 [i.12]	✓	✓	✓	✓	✓	✓	✓
ETSI EN 302 448 [i.13]	✓	✓	✓	✓	✓	✓	✓
ETSI EN 302 574-3 [i.14]	✓	-	✓	✓	✓	✓	✓
ETSI EN 302 977 [i.2]	✓	✓	✓	✓	✓	✓	✓
ETSI EN 303 699 [i.1]	✓	✓	✓	✓	✓	✓	✓
ETSI EN 303 978 [i.3]	✓	✓	✓	✓	✓	✓	✓
ETSI EN 303 979 [i.4]	✓	✓	✓	✓	✓	✓	✓
ETSI EN 303 980 [i.5]	✓	✓	✓	✓	✓	✓	✓
ETSI EN 303 984 [i.15]	✓	✓	✓	✓	✓	✓	✓

9.2.6 Cross-EN Consolidation Matrix

Table 13

Update category	Current limitation	Required update
Scope definition	Scope tied to single orbit, band, or platform	Expand to include NGSO, multi-orbit, hybrid fixed/mobile operation
Antenna operation	Assumes mechanical steering and static patterns	Incorporate ESA operating characteristics, scanning losses, multi-beam operation
Tracking performance	GEO-centric, slow dynamics	Include fast electronic tracking, NGSO handovers, Doppler effects
Emission limits	Static off-axis EIRP assumptions	Allow for dynamic EIRP, adaptive power control, beam agility
Spectral characteristics	Fixed carriers and bandwidth	Address dynamic channelization, beam hopping, variable bandwidth
Operational modes	Single-mode operation	Include multi-mode, multi-band, multi-platform terminals

The transversal consolidation demonstrates that the 14 ENs share a common set of structural gaps related to scope, antenna assumptions, emissions, test methods, receiver performance, CMF architecture, and regulatory alignment. These gaps reflect the evolution of satellite systems toward multi-orbit operation, electronically steerable antennas, dynamic resource management, and diverse mobility environments.

The findings of this clause provide the analytical foundation for clause 10, where the required updates are translated into structured, actionable recommendations derived from high-priority and medium-priority comments.

10 Recommendations for EN Updates

10.0 General

The recommendations presented in this clause translate the consolidated expert input and the transversal analysis of the 14 ENs into a structured set of updates aimed at ensuring technical relevance, regulatory alignment, and long-term coherence across the standards portfolio. They reflect both the immediate needs identified through high-priority comments and the broader improvements emerging from medium-priority contributions. Together, these recommendations provide a clear and coordinated roadmap for updating the ENs in line with current satellite system architectures, evolving antenna technologies, and international coordination requirements.

10.1 Recommendations Derived from High Priority Comments

10.1.1 General

The high-priority recommendations in this clause address the most urgent updates required to preserve the technical validity and regulatory alignment of the ENs. They reflect areas where expert consensus identified immediate action as essential to avoid inconsistencies with modern satellite architectures and antenna technologies. These items therefore constitute the core revisions that should be prioritized in the upcoming EN update cycle.

10.1.2 Recommendations on alignment and harmonization of structure and concepts related to the "Terms" clauses

The "Terms" clauses of the EN series present significant inconsistencies in terminology, scope, structure and conceptual hierarchy. These discrepancies arise from the progressive evolution of satellite terminal technologies, the introduction of Electronically Steered Antennas (ESAs), the coexistence of GSO and NGSO systems, and the incorporation of wideband and software-defined architectures. Expert comments highlight that the current definition clauses do not provide a coherent foundation for the technical requirements that follow, and that harmonization is essential to ensure clarity, interoperability and regulatory alignment.

General Need for Harmonization

A unified approach to definitions is required to ensure that all ENs use consistent terminology and conceptual structures. Several standards include overlapping or partially conflicting definitions for key terms such as antenna gain, beam pointing, EIRP density, control and monitoring functions, spurious emissions, blocking, nominal antenna diameter, off-axis angles, polarization, and terminal states. These inconsistencies complicate interpretation and may lead to divergent compliance assessments. A harmonized definitions framework should therefore be established and referenced uniformly across all ENs.

Technology-Neutral and Future-Proof Terminology

Terms should be updated to reflect the full range of antenna and terminal technologies currently deployed or expected soon ensuring that the definitions remain valid as technologies evolve and prevents the need for repeated revisions. In particular, the definitions should:

- Avoid assumptions tied to reflector-based antennas.
- Incorporate terminology applicable to flat-panel and ESA architectures.
- Clarify the term "nominal antenna diameter" when addressing flat array antennas.
- Include concepts relevant to digital and hybrid beamforming.
- Reflect multi-beam, multi-carrier and adaptive transmission modes.
- Support both GSO and NGSO operational profiles.

Alignment with ITU-R and CEPT/ECC Vocabulary

To ensure regulatory consistency, the terms should be aligned with the terminology used in ITU-R S-series and SM-series Recommendations, as well as CEPT/ECC deliverables. This includes harmonized terms for off-axis angles and reference patterns, unwanted emissions domains, antenna reference parameters, polarization descriptors, and interference-related concepts such as blocking, selectivity and coexistence.

Where ETSI-specific terms are required, they should be clearly distinguished from ITU-R terms to avoid ambiguity.

Clear Conceptual Hierarchy and Clause Structure

The structure of the terms clause should follow a consistent hierarchy across all ENs. At minimum, the clause should distinguish between:

- Fundamental physical quantities (e.g. gain, EIRP, bandwidth).
- Antenna-related parameters (e.g. scan angle, sidelobe envelope, XPD).
- System-level concepts (e.g. terminal states, control functions, operational modes).
- Regulatory concepts (e.g. spurious domain, out-of-band domain, protection criteria).

This hierarchical structure ensures that definitions are logically grouped and facilitates cross-reference within the standard.

Inclusion of ESA-Specific and NGSO-Relevant Concepts

Modern terminals increasingly rely on electronically steered antennas and operate in NGSO constellations. The terms clause should therefore include terms that capture:

- scan-angle-dependent gain and pattern variation;
- dynamic pointing and tracking states;
- Doppler-related effects relevant to NGSO systems;
- electronically controlled polarization;
- multi-beam and sub-array configurations.

Consistency Across Requirements and Test Methods

Terms should be fully aligned with the terminology used in both the requirements (clause 4) and the test methods (clause 6). Experts noted several cases where terms do not match the terms used in the corresponding requirements, leading to ambiguity in compliance assessment. A harmonized terms clause should therefore be used as the authoritative reference for all subsequent clauses.

10.1.3 Recommendation to address the ambiguities and technology and regulatory updates of the Scope of the ENs

The scope clause should always include information on frequency bands, services affected, type of earth stations as well as any relevant provision in force at the time of adopting the hEN.

Scope: Frequency bands

Each hEN should include in its "Scope" clause a clear identification of the frequency bands and whether the Earth Station can claim conformity if operating in the whole range of the frequency bands or in part of them. For each frequency band, there should be an identification of any general or specific regulatory provision which affects the operation of the hEN and which has to be considered when defining requirements in clause 4 of the ENs.

Table 14 with the operating frequency bands should be provided in the "Scope" clause.

Table 14

Frequency band		Radio service	Relevant provisions of the Radio Regulations or CEPT/ECC Decisions or EC Decisions
Uplink (GHz)	Downlink (GHz)		
14,0 - 14,5	10,7 - 10,95	FSS	ECC/DEC/(09)01 [i.18]

When a limit is specified, one should take into account that it might have already been defined in a piece of legislation (e.g. an EC regulation or decision), or there could be minimum requirements already defined in international benchmarks (e.g. ITU Radio Regulations or IEC standards) and/or ECC Decisions. Relevant Recommendations ITU-R and ECC Reports/Decisions should be also considered when defining limits. Examples (article 3.2 of the RED [i.37]):

- The frequency tolerance is defined in the ITU Radio Regulations [i.21].
- The spurious emissions limits are defined in the ITU Radio Regulations [i.21] and ERC/REC 74-01 [i.20].
- Unwanted emissions in the OOB domain are typically defined in Recommendation ITU-R SM.1541 [i.19].

In general, all the relevant ITU-R Recommendations and ECC Decisions/Reports should be taken into account as well as IEC (very important for EMC HS) and ISO standards. The defined limits:

- should represent the state-of-the-art;
- will be applicable independently from the environmental conditions without any exception;
- "*shall not be exceeded*" or "*shall be at least*" in any case;
- cannot have a tolerance expressed as "±". If it is important that a minimum value is specified, this needs to be considered as a limit associated to a separate technical requirement.

Scope: Use case

Explanation of the use of the earth station:

- the intended use;
- which type of characteristics are associated to the intended use (freedom from designer);
- fixed;
- stationary;

- in motion;
- etc.

Scope: Operation of the earth station as part of a satellite network

References to the control centre (CMF) without specifying the control centre characteristics clearly indicating that the requirements are defined for the earth station capability to receive or transmit command and control signals which can be processed by the earth station.

Scope: Maximum power level

The maximum power level should be included in the Scope clause, if there is no regulatory limit.

Scope: Equipment associated with the earth station

If the deliverable intends to cover different classes/types of equipment, that should be specified in the scope as well. It should be taken into account that a hEN applies to what is placed on the market, and, therefore, the mandatory usage of specific accessories to perform the tests is not allowed if these same accessories are not part of what is placed on the market (in which case they would be considered as an integral part of the equipment and therefore subject to the same "declaration of conformity"). However, if the equipment is intended to be used with specific accessories (e.g. a particular type of antenna) and is delivered without them, the scope needs to mention them explicitly if they have an influence on the conformity of the radio equipment and its intended usage. In general, the user is responsible for operating the radio equipment and the accessories as intended and according to the description provided by the manufacturer. The technical features of the accessories (e.g. an antenna) should, therefore, be mentioned in the Declaration of Conformity in order to enable the user to operate compliant radio equipment. This information could be the generic characteristics of a given antenna type or a reference to a specific antenna available on the market.

If some equipment types and/or class of equipment is excluded from the hEN, the scope should also include a statement regarding the excluded equipment types and/or class of equipment unless this is clear from the hEN title and/or the scope itself. This is also the case for other "limitations" although this could imply a restriction in the OJEU and so needs to be carefully considered.

The scope should not include any requirement (no "*shall*") while descriptive information, if any, should be added elsewhere (e.g. in the introduction).

Scope: other considerations

When revising a hEN already listed in the OJEU, it is in general not allowed to relax a given limit, unless a valid technical justification is provided.

Since the technical requirements for conformance apply to the equipment covered by the hEN and not the equipment under test only, "EUT" or similar acronyms should not be used in the technical requirements clause (normally clause 4 of the hEN).

10.1.4 Recommendations on review consistency of spurious emissions

Spurious emission provisions of the EN series agreed for WP2 present some inconsistencies in terminology, limit structures, reference bandwidths, measurement conditions and operational assumptions. These differences originate from legacy text inherited from earlier versions of the standards, incremental revisions carried out at different times, and the introduction of new antenna and terminal technologies, wideband front-ends and NGSO-capable architectures. Expert comments indicate that the current framework lacks internal coherence and requires a structured review to ensure clarity, regulatory compatibility and consistent application across all ENs.

A unified conceptual framework for spurious emissions is required to avoid divergent interpretations and to support reproducible compliance assessments. Several ENs use overlapping or partially conflicting terminology for spurious domain, out-of-band domain, unwanted emissions, wideband spurious and receiver spurious response. These inconsistencies risk uncertainties on the application of limits and test methods. A single, standardized terminology set should therefore be adopted, aligned with Recommendation ITU-R SM.329 [i.22] and CEPT/ECC definitions, and applied uniformly across the EN series.

Reference bandwidths and detector specifications also vary significantly between ENs. Some standards retain legacy bandwidths such as 4 kHz or 40 kHz, or detector types that no longer reflect current measurement practice or ITU-R guidance. Updated requirements should adopt reference bandwidths and detector settings that match the bandwidth used in the corresponding test method, reflect the capabilities of modern measurement equipment, support wideband and time-varying signals, and remain consistent with Recommendations ITU-R SM.329 [i.22] and SM.1541 [i.19]. This alignment will improve reproducibility and ensure that limits remain technically meaningful for contemporary satellite terminals.

Measurement conditions for spurious emissions differ across ENs in terms of operational states, antenna configurations, modulation settings and transmit power levels. A unified set of measurement conditions should be introduced, covering operational transmit states representative of modern terminals, including multi-carrier and burst-mode operation; antenna configurations applicable to flat-panel and ESA architectures; conditions for NGSO terminals subject to dynamic pointing, Doppler shifts and time-varying off-axis geometries; and provisions for terminals employing adaptive power control or beam hopping. These consolidated conditions will ensure that spurious emission measurements are representative of real operational scenarios and comparable across standards.

As part of the consistency review, all spurious emission definitions, limit structures and measurement conditions should be systematically compared against ERC/REC 74-01 [i.20] and Appendix 3 of the ITU Radio Regulations [i.21] (RR). These documents provide internationally recognized reference criteria for unwanted emissions domains and associated limit structures, antenna reference patterns and angular definitions relevant to spurious emission assessment, coordination parameters for satellite networks, spectral density definitions and measurement bandwidths, protection criteria applicable to GSO and NGSO systems, and cross-polar and co-polar reference envelopes. Ensuring alignment with ERC/REC 74-01 [i.20] and RR Appendix 3 will reinforce regulatory compatibility, reduce ambiguity in cross-border coordination and ensure that ETSI spurious emission requirements remain consistent with international satellite regulatory frameworks. Any discrepancies identified during this review should be resolved either by adopting the international definition directly or by providing a clear justification for ETSI-specific terminology. Current ENs use different limit structures, including absolute power limits, power spectral density limits and EIRP-based formulations.

No Electromagnetic requirements (EMC) should be included in the definition of requirements for the spurious emissions (some ENs includes these requirements for lower frequency bands).

A unified approach should be adopted to ensure that limits are applicable to both reflector-based and electronically steered antennas, suitable for wideband, multi-carrier and software-defined radio architectures, compatible with coexistence studies conducted under CEPT/ECC and ITU-R frameworks and expressed in a form that supports reproducible measurement across different test setups. Where appropriate, limits should be aligned with Recommendation ITU-R SM.1541 [i.19] and related recommendations.

Test methods for spurious emissions should also be revised to reflect current measurement practice. Traditional swept-spectrum techniques may not be adequate for wideband or time-varying signals. Updated procedures should include digital trace capture and time-domain analysis for burst-mode emissions, measurement techniques suitable for multi-carrier and adaptive waveforms, OTA-based methods where antenna configuration influences spurious levels, and clear pass/fail criteria linked to the consolidated limit structure. Alignment between clause 4 requirements and clause 6 test methods is essential to address inconsistencies noted by experts.

10.1.5 Recommendations on EIRP Emissions Off-Axis, Particularly for Flat Antennas

Modern satellite terminals - especially those incorporating Electronically Steerable Antennas (ESAs) and flat-panel arrays - operate with dynamic beam steering, adaptive power control and multi-beam capabilities that are not reflected in the legacy off-axis EIRP provisions of the current ENs. The existing reflector-based assumptions and simplified angular masks are no longer adequate for ensuring compatibility with GSO and NGSO systems. The ENs directly affected include: ETSI EN 301 427 [i.6], ETSI EN 301 442 [i.7], ETSI EN 301 443 [i.8], ETSI EN 301 447 [i.9], ETSI EN 301 459 [i.10], ETSI EN 302 340 [i.12], ETSI EN 302 448 [i.13], ETSI EN 302 977 [i.2], ETSI EN 303 699 [i.1], ETSI EN 303 978 [i.3], ETSI EN 303 979 [i.4], ETSI EN 303 980 [i.5] and ETSI EN 303 984 [i.15].

To ensure that off-axis EIRP emission density requirements remain technically robust and internationally aligned, the updated clauses should incorporate the following elements:

- Use ITU-R reference material: Adopt the latest versions of Recommendations ITU-R S.465 [i.23], S.580 [i.24], S.524 [i.25] and Reports S.2278 [i.26] and S.2223 [i.27] as the baseline for off-axis EIRP masks and coexistence criteria.

- Harmonize angular definitions: Replace inconsistent φ-ranges with ITU-aligned definitions for near-boresight, intermediate and far off-axis regions.
- Include ESA-specific characteristics: Reflect scan-angle-dependent gain, dynamic sidelobe behaviour and adaptive beam shaping in the off-axis limits.
- Align transmit/receive assumptions: Ensure that off-axis EIRP limits are coherent with receive pattern definitions and ITU-R protection criteria.
- Update reference bandwidths: Replace legacy 40 kHz/4 kHz bandwidths with ITU-consistent definitions.
- Clarify GSO/NGSO applicability: Distinguish between GSO protection requirements, NGSO dynamic aspects and hybrid/multi-orbit terminals.
- Ensure test-method traceability: Align emission limits with OTA measurement methods and ESA-appropriate test procedures.

Additional Requirements for Flat-Panel and Electronically Steerable Antennas

Flat-panel array antennas introduce configurable radiation patterns, electronic steering and integrated control units that should be explicitly reflected in the ENs. The following standards require updates to incorporate these antenna characteristics: ETSI EN 303 979 [i.4], ETSI EN 303 978 [i.3], ETSI EN 303 699 [i.1], ETSI EN 301 459 [i.10], ETSI EN 301 427 [i.6], ETSI EN 302 448 [i.13], ETSI EN 302 977 [i.2], ETSI EN 302 340 [i.12], ETSI EN 301 443 [i.8], ETSI EN 301 447 [i.9], ETSI EN 303 984 [i.15].

Required specification updates:

1) Scope definition including antenna control. The scope should explicitly cover the full terminal chain: antenna elements, electronic steering mechanisms and the antenna control unit, including its capability to configure test profiles.
2) Off-axis pattern definition for configurable antennas. Off-axis EIRP patterns should reflect the configurable nature of ESA radiation patterns across the full range of operational steering angles.
3) Gain characterization. On-axis and off-axis gain regions should be defined considering pointing accuracy tolerances and polarization adjustment tolerances.
4) Pointing accuracy requirements. Specifications should define the relationship between declared pointing accuracy and the resulting on-axis and off-axis EIRP, ensuring that pointing performance is maintained under operational conditions.
5) Control accuracy and power management. Terminals should be capable of controlling EIRP and EPFD through power control and beam-shape control. A nominal power-setting concept - similar to that used in ETSI EN 301 459 [i.10] - should be applied for evaluating antenna patterns.
6) Blocking capability. Antennas should demonstrate the ability to meet blocking requirements in the direction of adjacent satellites.

Antenna Characterization for System-Level Evaluation

System-level evaluation relies on methodologies defined in Recommendations ITU-R S.524 [i.25], S.1503 [i.28], S.1717 [i.29] and S.1855 [i.30], which assess interference between constellations and terminal populations. EN updates should ensure that the outputs of EN-specified test procedures provide the necessary inputs for these ITU-R methodologies.

For electronically steerable antennas, specifications should reflect the reconfigurable nature of the radiation pattern across fixed, mobile and stabilized operational modes. This requires defining minimum, expected and maximum values for off-axis EIRP and EPFD, consistent with operational tolerances.

Testing of Flat-Panel Antennas

Electronically steerable antennas should be tested in their operational context using the integrated antenna control unit as part of the equipment under test. The operational context should define the parameters that influence off-axis pattern accuracy, including:

- pointing accuracy;

- polarization control;
- discrimination capability toward adjacent satellites;
- on-axis and off-axis gain as a function of pointing angle and frequency.

These parameters should be incorporated into the test procedures to ensure that measured EIRP and EPFD values reflect real operational performance.

10.1.6 Recommendations on updated requirements for receive radiation patterns applicable to flat antennas

Receiving radiation pattern requirements should be updated to reflect the performance characteristics of flat antennas employing electronic steering, digital or hybrid beamforming, wideband front-ends and multi-beam operation. These antennas exhibit pattern variations that depend on scan angle, frequency, operational mode, and control configuration. The revised requirements should therefore adopt a parameterization that is independent of antenna implementation and suitable for both GSO and NGSO systems. The following aspects for updates are recommended:

Scope of the Receive Radiation pattern requirements for the flat antennas

The flat panel antennas are specified and under test consisting of the antenna elements for the receive antenna and including the control unit for the control of the antenna system.

Harmonized Definition of Angular Regions

The current ENs apply different definitions for near-boresight, intermediate and far-off-axis angular regions. To avoid inconsistent interpretations, a harmonized set of angular regions should be introduced. These regions should be defined using clear and uniform reference angles and should, where appropriate, be aligned with ITU-R S-series terminology. The receive pattern envelope should be expressed as a function of these harmonized angular regions. The angular regions should be covered by the steering angular range of the flat panel antennas.

Scan-Angle-Dependent Receive Pattern Envelope

Flat antennas and ESAs exhibit scan-angle-dependent variations in main-beam gain, sidelobe levels and cross-polar performance. This approach ensures that the requirements remain applicable to antennas operating over wide steering ranges, including those used for NGSO tracking. The receive pattern envelope should therefore be defined as a function of scan angle. The envelope should specify among others, the maximum allowable reduction of main-beam gain with increasing scan angle, the permissible sidelobe levels for each angular region, the expected variation of Cross-Polar Discrimination (XPD) under electronic steering.

Consideration of Dynamic and Multi-Orbit Operation

Terminals operating with NGSO systems experience time-varying geometries, Doppler shifts and rapid pointing transitions. The receive pattern requirements should explicitly address conditions such as specify acceptable receive pattern performance during tracking transitions, define the conditions under which temporary pattern degradation is permissible, and ensure that the receive pattern envelope remains valid for hybrid GSO/NGSO terminals.

Technology-Neutral Performance Metrics

To ensure applicability across different antenna technologies, receive pattern requirements should be expressed using technology-neutral metrics, Examples of such aspects are receiving gain envelope as a function of angle and frequency, Effective Isotropic Sensitivity (EIS) or equivalent indicators, cross-polar discrimination envelopes, pattern stability across the operational bandwidth. Such metrics avoid assumptions tied to specific antenna architectures and support consistent evaluation across different implementations.

Polarization-Related Requirements

Flat antennas may support electronically controlled polarization, dual-linear or circular modes, and agile polarization switching. The receive pattern requirements should therefore include definitions of polarization alignment and cross-polar performance applicable to electronically steered antennas, provisions for polarization-agile operation, XPD envelopes that account for scan-angle-dependent variations. These requirements should be aligned with ITU-R definitions and terminology.

Interference and Coexistence Considerations

Receive radiation pattern requirements should be coherent with the interference protection criteria applicable to the relevant frequency bands. In particular, the requirements should ensure that receive patterns do not increase susceptibility to adjacent-band emissions, cross-polar sidelobe levels remain within acceptable limits, and the receive pattern envelope is compatible with coexistence studies conducted under CEPT/ECC and ITU-R frameworks. This alignment is necessary to ensure that flat antennas do not adversely affect coexistence with terrestrial services or adjacent satellite systems. The interference and coexistence considerations should consider the flat panel antenna capability to spatially filter and block directions from interfering satellites.

Test Method Alignment

Test methods for receiving radiation patterns should be updated to support ESA-specific characteristics. Traditional rotation-based far-field measurements are not sufficient for electronically steered antennas. Updated test methods are needed.

Harmonized Framework Across ENs

To ensure uniform application, all ENs addressing receive radiation patterns should reference a common framework. This may be implemented through a harmonized clause or a shared normative annex.

10.1.7 Recommendations on Updating Requirements Involving Blocking Performance

Blocking performance requirements should be updated to reflect current receiver architectures and realistic interference conditions. Existing clauses rely on legacy assumptions that no longer represent modern wideband, digitally processed, or dynamically steered terminals. Updated requirements should ensure technical relevance, clarity, and consistent application across all ENs.

Consolidated Definitions

A harmonized set of definitions should be adopted for blocking, narrowband blocking, wideband blocking, adjacent-band interference, and overload. Terminology should be aligned with ITU-R usage and applied uniformly across all ENs.

Interferer Characteristics

Interferer models should be updated to represent operational conditions, including multi-carrier signals, burst-mode transmissions, beam-hopping patterns, aggregated emissions, dynamic power variations, and NGSO-specific geometries and Doppler effects.

Receiver Performance Metrics

Blocking requirements should be expressed using architecture-neutral metrics, including demodulation degradation thresholds, SINR margins, error-vector stability, effective isotropic sensitivity under blocking, and robustness of digital processing chains.

Test Methods and Configurations

Test procedures should define representative interferer bandwidths, modulation formats, spectral densities, and dynamic profiles. OTA methods should be used where antenna characteristics influence susceptibility. Requirement clauses and test methods should be fully aligned, with explicit pass/fail criteria.

Coexistence Scenarios

Blocking requirements should consider coexistence with terrestrial systems (e.g. 5G/IMT) and adjacent satellite networks. Thresholds should be consistent with CEPT/ECC and ITU-R studies to ensure resilience in mixed-service environments.

Regulatory Cross-Checking

Definitions, interferer models, and performance criteria should be reviewed against ERC/REC 74-01 [i.20] and ITU-R Appendix 3 to reinforce regulatory alignment and reduce ambiguity.

Framework for Consistency

Updated blocking concepts and test principles should be captured in a common reference clause or shared annex to ensure long-term consistency across all ENs.

10.1.8 Recommendations on updating requirements for adjacent band selectivity

The Adjacent Signal Selectivity requirements in ETSI EN 301 442 [i.7], ETSI EN 302 574-3 [i.14], ETSI EN 301 721 [i.11], ETSI EN 301 443 [i.8] and ETSI EN 303 980 [i.5] share a common technical basis.

In all cases:

- the frequency offset is equal to the wanted signal occupied Bandwidth (BW);
- receiver performance is evaluated through the degradation caused by the adjacent signal;
- the maximum permitted degradation is limited to 0,5 dB.

The principal difference identified between the analysed ENs concerns the relative power level assigned to the adjacent signal. ETSI EN 301 442 [i.7], ETSI EN 302 574-3 [i.14] and ETSI EN 301 721 [i.11] specify a value of 12 dB relative to the wanted signal, whereas ETSI EN 301 443 [i.8] and ETSI EN 303 980 [i.5] specify a value of 7 dB.

The comparison also shows differences in terminology, drafting structure and description of the associated test methods. However, the underlying technical objective and measurement principle remain substantially equivalent across all reviewed standards.

The reviewed ENs share the same Adjacent Signal Selectivity concept, i.e. the ability of a receiver to maintain reception of a wanted signal in the presence of an adjacent interfering signal. The associated measurement methodologies also share a common architecture based on a wanted signal source, an adjacent signal source, a combining network, the EUT and a receiver performance measurement function.

This common approach supports the definition of a harmonized requirement for the development of a harmonized Adjacent Signal Selectivity requirement and test method applicable across multiple SES Harmonised Standards.

Proposed Harmonized Technical Requirement Adjacent Signal Selectivity (in the clause 4 of the ENs).

Justification

Adjacent Signal Selectivity is required to ensure reception of a wanted signal in the presence of signals occupying adjacent channels or adjacent frequencies.

The requirement defines the minimum receiver performance necessary to maintain reception under adjacent-channel interference conditions and provides a common basis for conformity assessment across different categories of satellite earth stations.

Technical Requirement

Adjacent Signal Selectivity should be defined as the ability of a receiver to receive a wanted signal at its assigned channel frequency in the presence of an adjacent signal at a specified frequency offset from the centre frequency of the assigned channel.

The adjacent signal should occupy the same bandwidth as the wanted signal, where BW is the wanted signal occupied bandwidth.

Table 15: Adjacent Signal Frequency and Power Level

Signal	Centre Frequency Offset from Wanted Signal	Power Level Relative to Wanted Signal
Adjacent Signal	BW	7 dB

The decrease in the measured signal-to-noise ratio in the presence of the stated adjacent signal should be no more than 0,5 dB.

Proposed Harmonized Test Method (clause 5/clause 6)

General

This test verifies compliance with the Adjacent Signal Selectivity requirement.

Where the EUT provides access to the receiver input, the test should be performed using a conducted arrangement. Where the antenna is integrated and cannot be disconnected, an equivalent radiated arrangement may be used.

The adjacent signal parameters should be those specified in the Adjacent Signal Selectivity requirement.

Harmonized Measuring System Set-up

The measuring system should include:

- a wanted signal generator;
- an adjacent signal generator;
- a combiner or equivalent coupling arrangement;
- the EUT;
- a receiver performance measurement function (e.g. SNR, BER or equivalent metric);
- optional monitoring equipment such as a spectrum analyser.

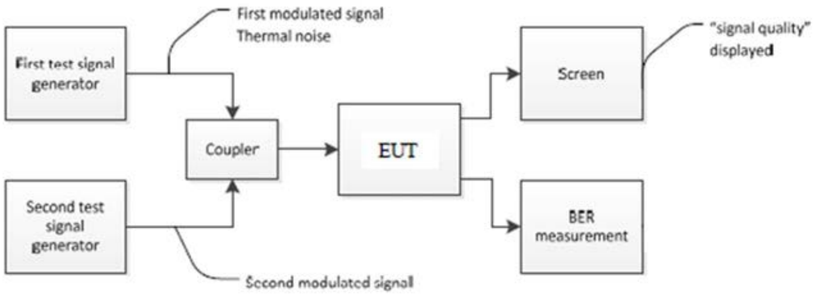

Figure 1: Harmonized Adjacent Signal Selectivity Test Arrangement

The measuring system shown in Figure 1 represents the minimum test configuration. Additional monitoring equipment, including spectrum analysers, may be used where required. For EUTs with integrated antennas, an equivalent radiated test arrangement may be employed.

Test Procedure

1) Configure the EUT to receive the wanted signal at its assigned channel frequency.

2) With the adjacent signal disabled, establish the reference receiver performance condition. The reference receiver performance condition should correspond to the minimum acceptable receiver performance specified for the EUT under normal operating conditions. The applicable receiver performance metric may be based on threshold sensitivity, Signal-to-Noise Ratio (SNR), Bit Error Rate (BER), Packet Error Rate (PER) or another equivalent receiver quality parameter defined for the system under test.

3) Record the reference receiver performance with the adjacent signal disabled.

4) Configure the adjacent signal according to the frequency offset, bandwidth and relative power level specified in the Adjacent Signal Selectivity requirement.

5) Apply the adjacent signal to the EUT using the measuring system set-up described above.

6) Measure the receiver performance in the presence of the adjacent signal.

7) Determine the degradation between the reference receiver performance and the receiver performance measured with the adjacent signal present.

8) Repeat the measurement for all relevant adjacent frequency positions, operating modes and receiver configurations applicable to the EUT.

9) Record the highest degradation measured.

10) Verify compliance against the Adjacent Signal Selectivity requirement

Compliance should be demonstrated by verifying that the degradation determined during the test does not exceed the limit specified in the Adjacent Signal Selectivity requirement.

Harmonization Rationale

A comparison of ETSI EN 301 442 [i.7], ETSI EN 302 574-3 [i.14], ETSI EN 301 721 [i.11], ETSI EN 301 443 [i.8] and ETSI EN 303 980 [i.5] demonstrates that Adjacent Signal Selectivity is already based on a common technical concept across the reviewed SES Harmonised Standards. All analysed ENs assess the ability of a receiver to maintain reception of a wanted signal in the presence of an adjacent interfering signal while limiting receiver performance degradation to a maximum value of 0,5 dB.

By preserving the 0,5 dB degradation criterion and the matching bandwidth offset common to all analysed ENs, the proposed requirement maintains technical continuity.

The only significant technical disparity identified concerns the relative power level assigned to the adjacent signal. A value of 7 dB is proposed as the harmonized reference level because it is already implemented in ETSI EN 301 443 [i.8] and ETSI EN 303 980 [i.5] and represents the more stringent receiver performance condition. Operating successfully with a lower power margin between the wanted and interfering signals requires higher receiver selectivity, thereby providing a robust and conservative criterion applicable across different categories of satellite earth stations.

The comparison also shows that the associated test methods are technically equivalent despite differences in terminology, drafting style and level of detail. All reviewed ENs use substantially equivalent measuring system configurations consisting of a wanted signal source, an adjacent signal source, a combining network, the EUT and a receiver performance measurement function.

Harmonizing the test arrangement, test procedure and associated figure would improve consistency between SES Harmonised Standards, facilitate implementation by test laboratories and reduce unnecessary variations in conformity assessment procedures.

The proposed harmonization therefore aims to:

- improve consistency between SES Harmonised Standards;
- simplify interpretation and implementation of Adjacent Signal Selectivity requirements;
- facilitate conformity assessment activities;
- maintain appropriate protection against adjacent-channel interference;
- support efficient use of radio spectrum under the Radio Equipment Directive framework.

The proposed common requirement and associated test method provide a suitable basis for future revisions of SES Harmonised Standards while maintaining technical continuity with the requirements currently implemented across the analysed ENs.

10.1.9 Recommendation on addressing uniformly the references to Control and Monitoring Functions

Control and Monitoring Functions (CMF) references in the ENs are defined and implemented inconsistently across the EN series, reflecting legacy architectures based on mechanically steered antennas, centralized control processors and static operational states. Modern satellite terminals - particularly those employing Electronically Steered Antennas (ESAs), software-defined radio chains, virtualized control layers and multi-orbit connectivity - require a harmonized and technology-neutral CMF-related framework. It is noted that the requirements for the CMF are not part of the ENs, but the capability of the earth stations to receive, transmit and interpret the commands and telemetry provided by the CMF.

To ensure coherence, traceability and regulatory alignment, all references to CMF across the ENs should be updated and standardized according to the following aspects:

- CMF terminology should be unified. Current ENs use heterogeneous expressions such as control channel, -response channel, network control commands, transmission inhibit, initial burst control and radio state transitions. These should be consolidated under a single, consistent CMF vocabulary, with clear definitions of CMF signals which the earth station should be capable of properly interpret. A harmonized set of CMF terms should apply equally to GSO, NGSO, transportable, fixed and in-motion terminals.

- Earth station requirements to communicate with CMF should be updated to reflect contemporary terminal functionalities. This includes support for autonomous tracking, dynamic beam steering, adaptive EIRP control, multi-carrier operation, software-defined configuration changes, remote management and secure command execution. Earth station CMF-related requirements should explicitly cover ESA-specific characteristics such as scan-angle-dependent performance, electronic polarization control and rapid beam reconfiguration. The communications with the CMF framework should also distinguish between safety-critical functions (e.g. cessation of emissions, loss-of-tracking protection) and operation functionalities (e.g. network-driven configuration updates).

- Radio states should be harmonized across ENs. Several standards define different initialization phases, inhibit states, safe modes and operational states. A unified state model should be adopted, with consistent naming, transitions and triggers. This model should support both reflector-based and ESA-based terminals, and should be applicable to GSO and NGSO systems, including multi-orbit handover scenarios.

- Communications with CMF should be aligned with modern security and reliability expectations. Definitions should incorporate secure command authentication, integrity protection, fail-safe functions, watchdog mechanisms, redundancy of control paths and resilience against erroneous or malicious commands. This is essential for terminals operating in-motion or in autonomous configurations.

- Test methods for communications requirements with CMF should be updated to match the harmonized requirements. Current ENs contain heterogeneous and sometimes obsolete test procedures. Updated test methods should comply:

    - correct execution of network control commands;
    - timely cessation of emissions under fault or mis-pointing conditions;
    - correct reporting of location, configuration and operational status;
    - robustness of processor and subsystem monitoring;
    - correct operation during initial access, burst transmission and reauthorization;
    - compliance under dynamic operational scenarios (beam hopping, adaptive modulation, multi-carrier operation).

Test methods should also support ESA-specific performances and OTA-based verification where appropriate, and all ENs should reference a common CMF communications framework, either through a harmonized clause or a shared normative Annex. This ensures that communications with CMF requirements are interpreted uniformly across standards and that future updates can be applied consistently, providing coherent communications with CMF framework across the EN series, ensuring that control and monitoring functions remain robust, secure and technically aligned with modern satellite terminal architectures.

10.1.10 Recommendations addressing environmental requirements

The lack of clear organization of the requirements for environmental conditions is a general and frequent issue in ETSI TC SES hENs. Sometimes, environmental conditions are defined in the body of the hEN (clauses 4 and/or 5), other times they are defined in an Annex which becomes normative, and very frequently the specific parameters are discretional not following a harmonized scheme. Therefore, it is recommended that each hEN should incorporate a clause of requirements for environmental conditions. This clause may include no requirements (then, clear statement should be made in this clause) basic parameters, optional additional parameters, site-specific parameters, etc. Therefore, it will be crystal clear whether an environmental profile is specified or not and if it specified it clearly state the associated requirements.

The following structure of the environmental profile requirements is recommended:

Clause X: Environmental Conditions

X.1 Scope

The present clause specifies the environmental conditions applicable to the test methods defined in the present document.

It defines the requirements for the establishment, control, and documentation of environmental conditions in order to ensure the validity, repeatability, and reproducibility of measurement results.

X.2 General requirements

Environmental conditions during measurements should be such that they do not adversely affect the:

- performance of the Equipment Under Test (EUT);
- performance of the measuring equipment;
- validity of the measurement results.

Environmental conditions should be:

- defined, where they can influence the measurement results;
- controlled and maintained within specified limits;
- monitored and, where appropriate, recorded during the measurement.

Where environmental conditions are not explicitly specified in the present document, there should be a clear statement that those requirements do not exist, although the test conditions will be provided in the report of the test laboratory and documented consequently.

X.3 Environmental profile

An environmental profile should be established for each requirement, or group of requirements or for all requirements of the hEN.

The environmental profile should include:

- reference (nominal) environmental conditions;
- permissible ranges or tolerances;
- stability requirements during measurement;
- where applicable, conditions for normal and extreme environments.

X.4 Climatic conditions

X.4.1 General

Unless otherwise specified, measurements should be carried out under defined climatic conditions.

X.4.2 Temperature

The ambient temperature should be specified.

- nominal temperature or temperature range;
- permissible tolerances;
- stabilization conditions prior to measurement.

X.4.3 Relative humidity

The relative humidity should be specified where it can influence the measurement results. The following should be defined:

- nominal humidity or humidity range;
- permissible tolerances.

X.4.4 Atmospheric pressure

Atmospheric pressure or the corresponding altitude should be specified where it is relevant to the measurement method.

X.5 Electromagnetic environment

The electromagnetic environment should be such that it does not affect the validity of the measurements. In particular:

- ambient electromagnetic noise and interference should be sufficiently low not to influence the results;
- the measurement site should comply with the requirements applicable to the relevant test site (e.g. open area test site, semi-anechoic chamber, anechoic chamber);
- background signals should be below the levels to be measured.
- limits for ambient interference should be specified.

X.6 Environmental stability

During the measurement:

- environmental parameters should remain within the specified limits;
- variations in environmental conditions should not introduce additional measurement uncertainty.

Where deviations occur, their impact on the measurement results should be assessed and recorded.

X.7 Additional environmental conditions

X.7.1 Outdoor test sites

For outdoor measurements (e.g. open area test sites), the following conditions should be considered where relevant:

- wind speed;
- precipitation (e.g. rain, snow);
- solar radiation;
- ground conditions.

Measurements should not be performed under environmental conditions that can affect the validity of the results.

X.7.2 Mechanical conditions

Where applicable for a given hEN:

- vibration and mechanical instability of the test arrangement should be minimized;
- movement of the EUT, antennas, or measurement equipment should be avoided.

X.8 Pre-conditioning and operational conditions

Prior to measurements:

- the EUT should be conditioned to reach thermal and operational stability;
- the duration and conditions of pre-conditioning should be defined where necessary.

The operational state of the EUT during measurement should be consistent with the requirements defined in the applicable measurement procedures.

X.9 Documentation

The following environmental parameters should be recorded in the test report:

- ambient temperature;
- relative humidity;
- atmospheric pressure (if applicable);
- any additional environmental conditions that may influence the measurement.

Any deviation from the specified environmental conditions should be:

- clearly documented;
- justified with respect to its impact on measurement validity.

With all the above clarifications the two options offered by the HS skeleton would be undoubtedly established:

For Harmonised Standards not specifying a normative environmental profile should use the following text:

- The technical requirements of the present document apply under the environmental profile for operation of the equipment, which should be in accordance with its intended use. The equipment should always comply with all the technical requirements of the present document when operating within the boundary limits of the operational environmental profile defined by its intended use.

For Harmonised Standards specifying a normative environmental profile (such as those ones related to Marine Radio Equipment) should use the following alternative text:

- "*The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be in accordance with its intended use, but as a minimum, shall be that specified in the test conditions contained in the present document. The equipment shall always comply with all the technical requirements of the present document when operating within the boundary limits of the operational environmental profile defined by its intended use.*"

10.1.11 Recommendations to unify and harmonize the concepts of test methods, test sites, measurement methods and test set-ups

In telecommunications radio standards, testing and measurement are essential to ensure that radio equipment complies with regulatory and performance requirements, such as spectral efficiency, emissions, immunity, and coexistence. Standards bodies such as ETSI define harmonized approaches to testing, ensuring reproducibility, comparability, and traceability of results. In the context of telecommunications radio hENs, the overarching concept is the Test Method, which encapsulates all elements required to perform a standardized measurement.

The Test Method represents all components of the tests and can be decomposed into three fundamental components:

- Test site (environment).
- Measurement method and procedures (execution logic).
- Test set-up (equipment and configuration).

Although these concepts are sometimes used interchangeably in practice, they represent distinct layers of abstraction within the overall test method.

Test Site (Measurement Environment)

The test site refers to the physical environment in which measurements are carried out. It defines the electromagnetic conditions under which the device under test (DUT) operates during testing.

Common Types of Test Sites:

- Open Area Test Site (OATS):
  - An outdoor environment with minimal reflections, traditionally used for radiated emission measurements. It relies on natural free-space propagation conditions.
- Semi-Anechoic Chamber (SAC):
  - An indoor shielded enclosure with absorbers on walls and ceiling but often reflecting ground plane. It simulates free-space conditions while providing controlled repeatability.
- Fully Anechoic Chamber (FAR):
  - A fully absorber-lined enclosure (including the floor), designed to minimize reflections and emulate ideal free-space conditions.

The test site:

- Controls environmental variables (reflections, interference).
- Ensures reproducibility.
- Defines calibration constraints (e.g. normalized site attenuation in OATS).

The test site does not define how to measure, but where under which physical conditions measurements are valid.

Test Measurement Methods and Procedures

The test measurement method defines the overall strategy and technical logic used to evaluate a parameter (e.g. radiated power, spurious emissions). It typically includes the underlying principles and calculation models.

The test procedure, on the other hand, is the step-by-step implementation of the measurement method.

Measurement Methods

Examples in radio telecom standards include:

- Radiated versus conducted measurement methods.
- Substitution method (replacing DUT emission with known source).
- Direct measurement using calibrated antennas and receivers.

These methods define:

- Measurement geometry (distance, orientation).
- Signal processing approach (detector type, bandwidth).
- Reference levels and normalization.

Measurement Procedures

Procedures translate methods into actionable steps, such as:

1) Configure the DUT in a specified operating mode.
2) Position antennas and adjust height.
3) Perform frequency sweeps.
4) Record peak and average values.
5) Apply correction factors.

It is important to distinguish between:

- Method, which is a conceptual and theoretical framework.
- Procedure, which includes operational execution instructions.

Test Set-up (Test Arrangement)

The test set-up (also called test arrangement) refers to the specific configuration of measurement equipment and EUT interconnections used to perform the test.

Components of a Test Set-up are:

- Equipment Under Test (EUT).
- Measurement instruments (spectrum analyser, EMI receiver).
- Antennas or probes.
- Cables, attenuators, couplers.
- Positioning systems (turntables, antenna masts).
- Control and acquisition systems.

The test set-up:

- Implements the measurement method physically.
- Ensures traceability and calibration.
- Minimizes measurement uncertainty.

It is usually illustrated in hENs through block diagrams, specifying:

- Equipment types.
- Signal flow.
- Interconnections.

Relationship Between the Concepts

These three concepts are hierarchical and complementary:

- Test site defines the environmental boundary conditions.
- Measurement methods and procedures define the measurement logic and execution steps.
- Test set-up defines the hardware configuration implementing the test.

Together, they ensure:

- Reproducibility across laboratories.

- Compliance with regulatory requirements.
- Reliability of measurement results.

In summary, a conceptual Consolidation of the concepts is crucial to ensure a clear separation of these three concepts for:

- Interpreting standards correctly.
- Designing compliant test campaigns.
- Ensuring consistency across different testing laboratories.

Their integration under the unified concept of Test Method provides a complete and robust framework for radio equipment verification in modern telecommunications systems.

In the context of telecommunications radio standards, the overarching concept is the Test Method, which encapsulates all elements required to perform a standardized measurement.

This Test Method can be decomposed into three fundamental components:

Test Site

The measurement environment, which defines the electromagnetic conditions under which tests are performed. Examples include:

- Open Area Test Site (OATS).
- Semi-anechoic chamber.
- Anechoic chamber.

Table 16: Test Measurement Method (and Procedures)

Aspect	Test Site	Test Measurement Procedures	Test Set-up (Test Arrangement)
Definition	The environment in which measurements are performed	The step-by-step process used to execute the measurement	The equipment configuration used to perform the measurement
Focus	Electromagnetic conditions (reflections, shielding, interference)	Execution logic and sequence of actions	Hardware, instruments, and interconnections
Nature	Physical environment / facility	Operational process / instructions	Technical implementation
Purpose	Ensure controlled and reproducible measurement conditions	Ensure consistent and repeatable execution of the method	Enable physical realization of the measurement
Typical Elements	OATS, semi-anechoic chamber, anechoic chamber	DUT configuration steps, antenna positioning sequence, measurement sweep steps	Spectrum analyser, antennas, cables, turntable, DUT placement
Level of Detail	High-level boundary conditions	Medium-level (procedural steps)	Detailed practical implementation
Variability	Usually fixed or standardized	Defined per measurement type, relatively stable	Can change depending on test case or equipment used
What it answers	"Where is the test performed?"	"How is the test executed step-by-step?"	"With what equipment and configuration?"
Relation to Test Method	Defines the environmental context	Defines the execution of the method	Defines the physical implementation of the method

The logical and procedural framework used to perform the measurement. It includes:

- Theoretical measurement approach (method).
- Step-by-step execution (procedure).

Test Set-up (Test Arrangement)

The practical implementation, including all measurement equipment and configuration required to conduct the test.

A simplified table is provided here as a concise comparison table for the three concepts, aligned with the previous definitions and typical usage in hENs

A comparison of Key Concepts in Radio Test Methods is provided in Figure 2.

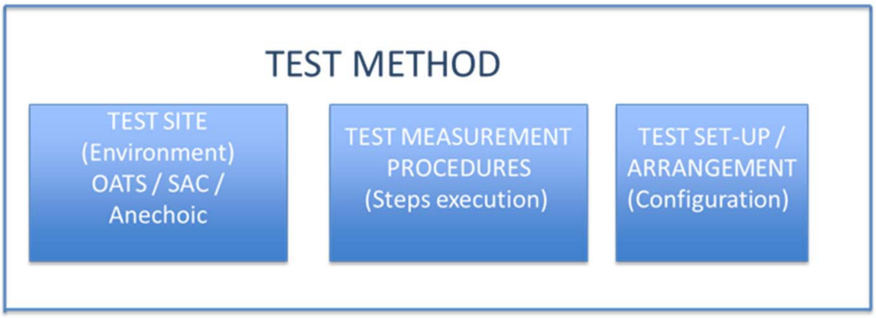

Figure 2

10.1.12 Recommendations on specific measurement procedures and test set-ups (test arrangements)

Across the reviewed ENs, there are 3 main common recommendations for most of them:

- A first common recommendation is to strengthen consistency, traceability, and unambiguous terminology in the description of measurements. In particular, several experts´ contributions highlight the need to clearly distinguish (and use consistently) the notions of test site, measurement method, test arrangement/set-up, and test procedure, ideally by introducing harmonised terminology upfront and then applying it systematically throughout the present document. In parallel, requirements should remain precisely coupled to their corresponding test methods so that each conformance statement is demonstrably verifiable (including explicit identification of the EUT operational configuration/state used during the test). Finally, method descriptions should begin with short explanatory text (purpose, applicability, constraints) before listing step-by-step actions to avoid inconsistent interpretations. This specific recommendation is addressed above in clause 10.1.10.

- A second recurring recommendation is to modernize and normalize test arrangements and acceptable test sites, ensuring they remain feasible with today's instrumentation and antenna technologies. Multiple inputs call for updating legacy arrangements (e.g. replacing "X-Y plotter" concepts with a generic recording system/digital trace capture) and for clarifying how alternative test sites (open-area test site, anechoic chamber, semi-anechoic chamber, compact range, or in specific cases far-field satellite-based measurements) can be considered equivalent for compliance purposes, including the conditions under which results are comparable. Where radiated measurements are performed, several comments converge on requiring explicit site-quality constraints (e.g. avoiding reflecting objects) and ensuring ambient noise is sufficiently below the applicable limits so that margin-to-limit is meaningful and repeatable across facilities.

- A third common topic is the need to remove ambiguity in "edge cases" and in the parameterization of procedures, which is increasingly critical for integrated terminals, Electronically Steered Antennas (ESA), and multi-carrier operation. The ENs repeatedly flag that procedures should state what to do when access to the antenna flange, LNB/downconverter, or internal subsystems is not possible, and how compliance is then demonstrated (e.g. OTA approaches, defined substitution methods, or validated alternative arrangements). They also highlight that key test parameters should be explicitly defined (measurement bandwidth choices, detector assumptions, modulation and frequency-offset conditions for blocking/selectivity tests, and the handling of multi-carrier or time-varying emissions/patterns) because leaving these open leads to non-comparable results. Where terminals require reception of a satellite carrier to enable transmission, the EN should define the necessary "satellite simulation" arrangement to allow reproducible lab testing, and where ESAs are involved, methods should acknowledge scan-angle dependence and avoid procedures that only make sense for mechanically rotated feeds/polarizers.

10.1.13 Recommendations when allowing several test sites to carry out measurements

An important element is related to the possibility to carry out the measurements to check conformity by using different test sites (different environments). It is common in the Satellite Earth stations hENs that several test sites are possible. In the case of TC SES, the hENs assume that measurements can be carried out in Open Area Test Site (AOTS), Semi-anechoic chamber of full anechoic chamber. This flexibility is allowed on the assumption that the measurement method and the test set up are unique to avoid divergence of results.

This test site flexibility is only possible if the measurements conducted in any of the alternative test sites lead to comparable test results. The difference of results could be indeed parametrized by computing the tolerances and measurement uncertainties associated to each test site.

In general, the tolerances and measurement uncertainties is independent of the radio equipment technology or its technical parameters defined in the Harmonised Standards in support of the RED.

Tolerances in the technical requirement for conformance specified in hENs could allow manufacturers to overcome the limits if used as a variation of the limit by means of a margin and, therefore, are not allowed. All other tolerances present in the standard (e.g. on the test setup) should not substantially impact the compliance and should be in line with the accuracy of the common, economically viable, best practices.

Measurement uncertainties are linked to the testing equipment and the overall test setup and therefore can have an impact on the measurements. Measurement uncertainties are usually defined in the informative part of the hENs (e.g. an informative annex). However, it is also possible that, for some technical requirements, a maximum allowed measurement uncertainty should be specified, since otherwise it would not be possible to perform a measurement in the correct way. As an example, when measuring the frequency deviation with a spectrum analyser, the frequency error of the measurement instrument should not exceed the corresponding limit and, therefore, it needs to be specified in the hEN unless there is the certainty that there is no problem with any of the measurement instruments available on the market.

A market surveillance authority will interpret the measurements as in Figure 3 (the measured value should be "better than" the limit independently from the measurement uncertainty).

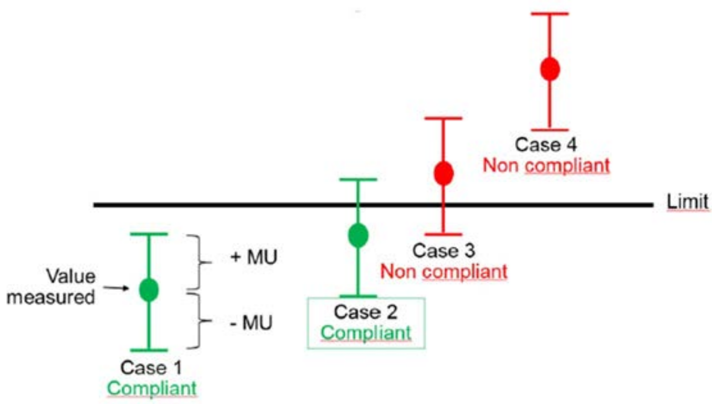

Figure 3: Market Surveillance interpretation of measurements

When defining the maximum measurement uncertainties in hENs, it is expected that state-of-the-art is considered and a value is specified for all the technical requirements for conformance defined in the hENs and requiring a measurement procedure.

Consequently, if the alternative test site, assuming they contribute to the overall tolerance and measurement uncertainty of the test method, can quantify its specific tolerance and measurement uncertainty for each allowed test site, the results can indeed be comparable and therefore, clear statement can be made on whether the Equipment meets its limits (case 1 depicted in the figure above). Should tolerances and measurement uncertainties provoke results as per cases 2, 3, 4 depicted above, the test site should be carried out in one specific test site, defined as the preferred test site. This statement should be included in the description of the test methods, when addressing the test site.

10.2 General Guidelines from Medium Priority Comments and Medium Priority Recommendations

10.2.0 General

Medium-priority comments provide a complementary layer of guidance to the high-priority recommendations addressed in clause 10.1. While they do not typically identify immediate technical shortcomings, they highlight structural refinements, clarifications, and harmonization needs that are essential for ensuring long-term coherence across the EN portfolio. These comments also reflect areas where experts identified opportunities to improve clarity, strengthen alignment with international frameworks, and modernize the standards in anticipation of future system evolution.

The following clauses consolidate the transversal themes emerging from the Medium Priority (MP) contributions and translate them into general recommendations applicable across multiple ENs.

10.2.1 Enhancing Terminology Consistency

A significant portion of MP comments emphasizes the need to refine and harmonize terminology across the ENs. Several standards still rely on legacy definitions or inconsistent wording when describing terminal categories, operational modes, or antenna configurations. These inconsistencies can lead to divergent interpretations during compliance assessment and complicate cross-standard alignment.

Experts highlighted the need to:

- Clarify definitions of fixed terminals, transportable terminals and ESIMs to ensure uniform application across ENs.
- Align terminology related to GSO and NGSO operation, particularly in standards where hybrid or multi-orbit terminals may be deployed.
- Update references to legacy categories such as VMES/ESV to reflect modern operational contexts.
- Harmonize definitions of antenna types, including flat-panel arrays and electronically steerable antennas.

Medium Priority Recommendation: Introduce a harmonized terminology (possible as an annex) applicable across all ENs, ensuring that definitions are consistent, up to date, and aligned with ITU-R and CEPT/ECC terminology.

10.2.2 Improving Cross-Standard Alignment of Antenna-Related Provisions

Medium-priority comments consistently highlight the need to align antenna-related provisions across ENs addressing similar frequency bands or mobility environments. While high-priority comments focus on the technical modernization of off-axis EIRP limits and ESA-specific requirements, MP contributions emphasize structural harmonization.

Key areas identified include:

- Ensuring consistent definitions of on-axis gain and off-axis regions.
- Harmonizing the treatment of polarization control and pointing accuracy.
- Aligning the structure of antenna-related clauses to facilitate cross-EN comparison.

Medium Priority Recommendation: Develop a unified antenna-related clause structure applicable across ENs, ensuring that antenna pattern definitions, control requirements, and performance parameters follow a consistent format.

10.2.3 Refining the Structure and Clarity of Emission-Related Clauses

Medium-priority comments frequently point to the need for clearer structuring of emission-related clauses, especially in ENs where legacy text has accumulated over multiple revisions. While high-priority recommendations address the technical modernization of emission masks, MP guidance focuses on editorial and structural improvements.

Experts recommend:

- Reorganizing emission clauses to clearly distinguish between on-axis EIRP, off-axis EIRP, spurious emissions, and out-of-band emissions.
- Updating references to outdated bandwidth definitions.
- Clarifying applicability to different operational modes (fixed, mobile, stabilized, NGSO tracking).
- Ensuring explicit cross-referencing between emission limits and test methods.

Medium Priority Recommendation: Introduce a harmonized emission-clause template across ENs, ensuring consistent structure, terminology, and cross-referencing.

10.2.4 Strengthening Test Method Descriptions and Cross-Referencing

Medium-priority comments highlight the need to improve the clarity and internal consistency of test method descriptions. While high-priority updates focus on dynamic and ESA-specific test procedures, MP guidance emphasizes structural improvements.

Experts identified the need to:

- Clearly reference measurement windows, averaging intervals, and test geometries.
- Harmonize the structure of test method sections across ENs.
- Clarify the relationship between emission limits and measurement procedures.
- Update diagrams, tables, and annexes to reflect modern equipment.

Medium Priority Recommendation: Develop a unified test-method framework applicable across ENs, ensuring consistent structure, terminology, and cross-referencing.

10.2.5 Updating Receiver-Related Provisions for Modern Operating Conditions

Medium-priority comments also address receiver-related aspects such as adjacent-channel performance. While these issues are not always critical, they are important for long-term alignment with evolving satellite system architectures.

Experts recommend:

- Reviewing definitions of blocking performance and selectivity.
- Clarifying applicability to hybrid GSO/NGSO terminals.
- Ensuring alignment with modern wideband architectures.

Medium Priority Recommendation: Update receiver-related clauses to reflect modern architectures and ensure consistency across ENs.

10.2.6 Improving CMF-Related Clauses for Modern Terminal Architectures

Medium-priority comments highlight the need to update references for communications with the Control and Monitoring Functions (CMF) provisions to reflect modern terminal architectures, including distributed control, remote management, and autonomous fail-safe logic.

Experts recommend:

- Clarifying functional boundaries between terminal equipment, antenna control units, and network-side management systems.
- Updating terminology to reflect IP-based and virtualized CMF architectures.

- Ensuring consistency across ENs addressing similar terminal categories.

Medium Priority Recommendation: Introduce a harmonized CMF clause structure across ENs, reflecting modern distributed and virtualized architectures.

10.2.7 Consolidated Medium Priority Recommendations

Based on the consolidation of MP comments, the following general recommendations apply across the EN portfolio:

- Align antenna-related provisions to ensure consistent treatment of gain, pointing accuracy, polarization, and pattern definitions.
- Restructure emission-related clauses to improve clarity and cross-referencing.
- Modernize test-method descriptions and ensure alignment with updated measurement practices.
- Update receiver-related provisions to reflect wideband and multi-orbit architectures.
- Revise CMF-related clauses to reflect distributed, IP-based, and virtualized control architectures.

10.2.8 Summary on medium-lower priority comments

Medium-priority comments provide essential guidance for improving the clarity, consistency, and long-term maintainability of the ENs. While they do not typically identify immediate technical shortcomings, they highlight structural refinements that will support the implementation of high-priority updates and ensure coherence across the standards portfolio.

The themes identified (scope clarity, antenna alignment, emission structuring, test-method refinement, receiver performance, CMF communication with earth station, and regulatory alignment) form a complementary layer of recommendations that will guide the detailed revision work in subsequent phases of the program.

10.3 Implications for WP3 and Subsequent Phases

The recommendations formulated in WP2 have direct implications for the activities planned under WP3 and WP4, shaping both the analytical framework for deployment-scenario assessment and the technical foundations for the revision of the Harmonised European Norms (hENs). As WP2 identifies technological evolution, operational trends, and regulatory drivers affecting satellite earth stations, the resulting findings provide the baseline against which WP3 will evaluate overlaps between standards, assess the feasibility of consolidation, and map use cases to the most appropriate hENs. The structured set of updates proposed in clause 10 therefore acts as a bridge between the diagnostic role of WP2 and the normative development tasks of WP4.

For WP3, the implications are twofold. First, the identification of transversal themes (such as the need to modernize antenna assumptions, harmonize emission-related clauses, and clarify scope definitions) enables WP3 to determine where multiple ENs address similar technologies or operational scenarios. This supports the analysis of potential merging opportunities, particularly in areas where legacy distinctions (e.g. VMES/ESV, fixed vs. transportable) no longer reflect current system architectures. Second, the refined mapping of use cases and technology categories emerging from WP2 provides WP3 with a coherent framework for evaluating deployment scenarios across GSO, NGSO, and hybrid systems. This ensures that any proposed consolidation of hENs is grounded in a clear understanding of the operational environments and performance requirements identified during the WP2 review.

The implications for WP4 are equally significant. The technical updates recommended in WP2 (covering antenna performance, off-axis EIRP limits, receiver characteristics, communications with CMF, and test-method modernization) form the core input for the drafting of revised hENs. WP4 will rely on these recommendations to ensure that the updated standards are technically robust, aligned with RED Article 3.2, and suitable for citation in the Official Journal of the European Union (OJEU). Furthermore, the harmonized terminology, clarified scope definitions, and improved clause structures proposed in WP2 will facilitate a more consistent and efficient drafting process within WP4, reducing ambiguities and ensuring coherence across the set of revised hENs.

Overall, the outputs of WP2 provide the analytical foundation upon which WP3 will build its consolidation and prioritization of hENs, and they supply the technical direction required for WP4 to elaborate updated and future-proof hENs. The alignment between these work packages ensures a coherent progression from analysis to consolidation and finally to standard revision, supporting the overarching objective of maintaining a modern, consistent, and internationally aligned EN framework for satellite earth stations.

Annex A: Stakeholder questionnaire

SURVEY / CONSULTATION WITH STAKEHOLDERS

Standards Certification and Compliance in Antenna Manufacturing

In the context of the Special Task Force, Experts Group, which ETSI has launched to update several Harmonised European Standards, mostly from the technology updates and measurement methods and test arrangements, a survey to stakeholders was considered necessary to collect actual data which can help focus on the work of the Experts Group.

An introductory letter from ETSI accompanies this survey.

Purpose:
This survey aims to consult with relevant stakeholders on their views regarding the requirements of the Harmonised European standards (hENs) produced by ETSI, as well as the issues which may be encountered by manufacturers, operators, and service providers on claiming compliance against the requirements of the hENs.

Confidentiality:
All responses will be treated as confidential and used only for analysis purposes.

Section 1 - Company Information

Company Name: ______________________________

Contact Person: ______________________________

Position/Title: ______________________________

Email: ______________________________

Country: ______________________________

Primary Market Segment (check all that apply):

- ☐ Defence
- ☐ Aerospace
- ☐ Satellite Communications (SATCOM) Fixed terminals
- ☐ Satellite Communications (SATCOM) Mobile terminals
- ☐ Satellite Communications (SATCOM) On the move for land terminals
- ☐ Satellite Communications (SATCOM) On the move for aircraft terminals
- ☐ Satellite Communications (SATCOM) On the move for maritime terminals
- ☐ Telecommunications (5G/6G)
- ☐ Other: ______________________________

Section 2 - Relevance of Certification and Qualification

2.1 Does your company consider certification and qualification under Harmonised European Standards relevant?

- ☐ Highly relevant
- ☐ Moderately relevant
- ☐ Slightly relevant

☐ Not relevant

☐ Not applicable

2.2 Please inform whether your company uses the self-declaration route for compliance against hENs or follows the certification process with the assistance of Notified Bodies.

____

____

____

____

2.3 Are declarations of compliance (self-declaration or declaration by a notified body) against hENs required by your customers?

☐ Yes - Always

☐ Yes - In most projects

☐ Occasionally

☐ Rarely

☐ Never

If yes, please specify the type of customers requiring certification:

____

____

Section 3 - Harmonised European Norms Used by your company for Declaration of Compliance.

3.2 Which standards does your company work with for certification or qualification? (Check all that apply and specify version/year if possible.)

Military & Defense Standards

☐ MIL-STD-810

☐ MIL-STD-461

☐ MIL-STD-464

☐ Other MIL-STD: ____

Telecommunications & EMC Standards

☐ ETSI Standards

☐ Harmonised European Standards

☐ FCC Regulations

☐ Recommendations ITU

☐ 3GPP Specifications

☐ Other: ____

Environmental & Reliability standards

- ☐ IEC Standards
- ☐ ISO Standards (please specify): ____________________________
- ☐ DO-160 (Aerospace)
- ☐ Other: ____

3.3 Is declaration of compliance performed:

- ☐ Internally (in-house testing). Self-declaration
- ☐ Through accredited external laboratories (Notified Bodies)
- ☐ Both
- ☐ Not applicable

Section 4 - Harmonised European Standard (hEN) Compliance

4.1 Does your company follow Harmonised European Standards (hEN) for earth stations?

- ☐ Yes
- ☐ No
- ☐ Only when required by customer
- ☐ Not applicable

4.2 Which Harmonised European standards are applied to your earth stations? (Please specify exact hEN numbers and titles if possible.)

hEN/Standard	Title/Description	Applied To (any subset foreseen in the hEN)

4.3 Are compliance against hEN verified through testing on:

- ☐ Final product only
- ☐ Subsystems/modules
- ☐ Components level
- ☐ Full environmental qualification campaign

4.4 With respect to the hENs of interest, do you have any problem interpreting the requirements of the hEN?

Please, explain the reasons for each hEN of interest:

____

____

____

____

4.5 With respect to the hENs of your interest, do you consider there are requirements which should be revised or that have been outdated from the technology point of view?

Please explain the reasons and your proposals for the revision of technical requirements to each hEN of your interest:

____

____

____

____

4.6 With respect to the hENs of interest, do you find difficulties interpreting the measurement methods or measurement procedures or test arrangements of the hENs?

Please explain the reasons for each hEN of interest:

____

____

____

____

4.7 With respect to the hENs of interest, do you consider some measurement procedures or measurement methods, or test arrangements be updated or modified?

Please explain the reasons and your proposals for the revision of measurement methods/measurement procedures requirements to each hEN of interest:

____

____

____

____

Section 5 - Testing and Validation

5.1 What types of testing are conducted on your earth stations? (Check all that apply)

☐ EMC/EMI Testing

☐ Environmental Testing (temperature, humidity, vibration)

☐ Mechanical Shock & Vibration

☐ RF Performance Validation

☐ Radiation Pattern Characterization

☐ Thermal Vacuum Testing

☐ Salt Fog/Corrosion

☐ Other: ____

5.2 Are compliance tests repeated periodically after design changes?

☐ Yes - Always

☐ Yes - Major changes only

☐ Rarely

☐ No

Section 6 - Future Outlook

6.1 Do you have any plan to adopt additional hENs in the next 3-5 years?

☐ Yes

☐ No

☐ Under evaluation

Section 7 - Additional Comments

Annex B: Expert individual reports

B.1 Analysis Expert "AA"

Overview of ETSI EN 301 459

1. Introduction

ETSI EN 301 459 [i.10] specifies technical requirements for Fixed Satellite Service (FSS) satellite terminals transmitting in Ka-band frequencies. It has historically played a key role in harmonizing equipment compliance across Europe under the Radio Equipment Directive framework.

2. Purpose and Scope

ETSI EN 301 459 [i.10] defines:

- Essential radiofrequency GEO characteristics of satellite terminals.
- Limits on unwanted emissions and spurious radiation.
- Requirements to ensure coexistence with other radio services.

Its scope is focused on:

- satellite networks.
- Fixed satellite service (FSS) earth stations.
- 29,5 GHz - 30 GHz uplink operations.

The standard is designed to provide presumption of conformity with European regulatory requirements, particularly under the Radio Equipment Directive.

Assessment of Scope Adequacy

While still valid for legacy systems, the scope shows limitations:

- It does not explicitly address electronically steerable antennas.
- It assumes relatively static operational conditions, not dynamic spectrum environments.
- There is limited consideration of advanced interference mitigation techniques (e.g. adaptive coding/modulation tied to interference conditions or AI-based coordination).
- The scope does not fully capture dense deployment scenarios of user terminals, where aggregate interference and coordination become critical.

3. Commercial Applications Covered by the Standard

ETSI EN 301 459 [i.10] applies to a range of commercial satellite services:

- VSAT networks for enterprise connectivity.
- Broadcast contribution and distribution.
- Government and defence communications.
- Fixed broadband access via GEO satellites.

Gaps in Emerging Applications

Modern applications not fully addressed include flat-panel antennas and phased arrays.

4. Operators Whose Systems Fall Within the Scope

Although operators do not typically declare explicit use of ETSI EN 301 459 [i.10], systems operating in Europe should comply with harmonized standards.

GEO Satellite Operators (within scope): SES, Eutelsat, Hispasat… These operators deploy Ku-band FSS systems that align with the technical assumptions of ETSI EN 301 459 [i.10].

Manufacturers of Satellite Earth Stations

Key manufacturers whose products may be designed to comply (directly or indirectly) and include Hughes Network Systems, Viasat Inc., Gilat Satellite Networks, Intellian Technologies, Cobham Satcom…

5. CEPT / ECC Framework

The standard ETSI EN 301 459 [i.10] is closely linked to the regulatory work of CEPT and ECC. Relevant ECC studies related with the standard include ECC Report 152 [i.31] and ECC Report 184 [i.32], and ECC/DEC/(05)01 [i.33], ECC/DEC/(05)08 [i.34], ECC/DEC/(06)03 [i.35] and ECC/DEC/(13)01 [i.36].

Identified Gaps

ETSI EN 301 459 [i.10] does not fully incorporate:

- The results and conclusions of the ECC Reports and ECC Decisions above mentioned.
- Aggregate interference modelling for dense constellations.
- Time-varying interference scenarios.
- Validation methods for electronically steered antennas.

6. Conclusions

Key Areas Requiring Update

1) Antenna Technologies:
    - Inclusion of Electronically Steered Antennas (ESAs).
    - Beamforming and dynamic pointing validation.
2) Interference Methodology:
    - Aggregate interference models.
    - Statistical and simulation-based compliance.
3) Measurement Methods:
    - Move from static lab testing to dynamic scenarios.
    - Inclusion of real-time and software-defined testing.

Alignment with the regulatory framework

The standard is linked to the framework of the ITU and the CEPT, particularly:

- Article 21 (interference limits).
- Coordination procedures for satellite networks.

- Conclusions of ECC Report 152 [i.31] and ECC Report 184 [i.32], and ECC/DEC/(05)01 [i.33], ECC/DEC/(05)08 [i.34], ECC/DEC/(06)03 [i.35] and ECC/DEC/(13)01 [i.36].

Final Assessment

ETSI EN 301 459 [i.10] remains a relevant but legacy-oriented standard suitable for traditional Ku-band GEO systems, but maybe insufficient for ESIMs and advanced antenna systems.

To remain effective, the standard should evolve towards:

- Alignment with ECC regulatory framework.
- Dynamic, system-level compliance approaches.
- Covering new antenna technologies.

B.2 Analysis Expert "FM"

Report for ETSI EN 301 442

1. The recently updated title of the EN

ETSI EN 301 442 [i.7]: "Satellite Earth Stations and Systems (SES); NGSO Mobile Earth Stations (MES) including handheld earth stations, for Satellite Personal Communications Networks (S-PCN) operating in the 1 980 MHz to 2 010 MHz (earth-to-space) and 2 170 MHz to 2 200 MHz (space-to-earth) frequency bands under the Mobile Satellite Service (MSS); Harmonised Standard for access to radio spectrum".

2. Scope of the EN

The present document applies to Mobile Earth Station (MES) radio equipment which have the following characteristics:

- the MES operates in a Non-Geostationary Orbit (NGSO) mobile-satellite system;
- the MES has both transmit and receive capabilities and operate in a Satellite-Personal Communications Network (S-PCN). An S-PCN MES can be handheld, portable, vehicle-mounted, host connected, semi-fixed or fixed equipment, or can be an element in a multi-mode terminal. It consists of a number of modules with associated connections and user interface, or can be a self-contained single unit;
- the MESs are controlled and monitored by a Network Control Facility (NCF). The NCF is outside the scope of the present document;
- if the MES is an element in a multi-mode terminal, unless otherwise stated in the present document, its requirements apply only to the S-PCN MES element of the terminal operating in the MSS frequency bands given in Table 1;
- the MES is capable in operating in all or part of the frequency bands shown in Table 1.

Table 1: Mobile Satellite Service (MSS) frequency bands

MES	MSS frequency bands
Transmit	1 980 MHz to 2 010 MHz (Earth to space)
Receive	2 170 MHz to 2 200 MHz (space to Earth)

3. Requirements for update/revision

ETSI EN 301 442 [i.7] is not yet updated to meet the requirements of the Radio Equipment Directive. Following are the required action points to achieve conformity with the Directive:

- Terms and definitions clauses should be updated.

- Self monitoring functions clause (4.2.4.1) should be deleted.
- "Special Test Equipment (STE)" should be replaced by "simulator" in clause 5.2.1.4. The clause should be updated accordingly.
- Clause 5.2.1.5.5.1.1 (Test site) should be amended to cover the test sites other than OATS.
- Clause 5.2.1.5.7 (Interpretation of the measurement results) should be deleted.
- Clause 5.2.5.1 (Self-monitoring functions/Processor Monitoring), should be deleted.
- Clause 5.2.5.2 (Self-monitoring functions/Transmit frequency generation sub-system monitoring) should be deleted.
- Clause 5.2.5.4 should be revisited to introduce CMF.
- Clause 5.2.5.4.1 title should be changed to "Transmission disable/enable".
- First two paragraphs in clause 5.2.5.4.1.2 should be deleted.
- Clause 5.2.5.4.1.3 (Test requirement) should be revisited and updated.
- A new clause (5.2.5.4.2) should be added "transmit frequency control", covering "method of test", "test procedure" and "test requirement".

Report for ETSI EN 303 980

1. The recently updated title of the EN

ETSI EN 303 980 [i.5]: "Satellite Earth Stations and Systems (SES); Fixed and in-motion Earth Stations communicating with non-geostationary satellite systems (NEST) in the 11 GHz to 14 GHz frequency bands; Harmonised Standard for access to radio spectrum".

2. Scope of the EN

ETSI EN 303 980 [i.5] specifies technical characteristics and methods of measurements for fixed and in-motion Earth Stations communicating with non-geostationary satellite systems (NEST) in the 11 GHz to 14 GHz FSS frequency bands, which have the following characteristics:

The NEST is designed for both in-motion and stationary operation.

The NEST operates in-motion on various platforms such as trains, maritime vessels, aircraft and other vehicles and, therefore, may be subject to occasional disturbances and interruptions in the satellite link.

The NEST is operating as part of a satellite system used for the provision of broadband communications.

The NEST is comprised of all the equipment, electrical and mechanical, from the antenna itself to the interface with other communications equipment on a mobile platform.

The NEST comprises one or more emitters and the system overview as given in Figure 1 should be interpreted accordingly.

The transmit and receive frequencies are shown in Table 1.

Table 1: Frequency bands

	Frequency Bands
Transmit (Earth-to-space)	14,0 GHz to 14,50 GHz
Receive (space-to-Earth)	10,70 GHz to 12,75 GHz

The NEST transmits within the frequency range from 14,0 GHz to 14,50 GHz. The NEST transmits at elevation angles of 35° or greater, relative to the horizontal plane.

The NEST receives within the range from 10,70 GHz to 12,75 GHz.

The NEST uses linear or circular polarization.

The NEST communicates with non-geostationary satellites.

The NEST is designed for unattended operation.

The NEST is controlled and monitored by a Network Control Facility (NCF). The NCF is outside the scope of the present document.

ETSI EN 303 980 [i.5] applies to the NEST 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 manufacturer and when installed as required by the manufacturer's declaration or in the user documentation.

3. Requirements for update/revision

ETSI EN 303 980 [i.5] is not yet updated to meet the requirements of the Radio Equipment Directive. Following are the required action points to achieve conformity with the Directive:

- National transposition dates should be revised.
- Introduction should be deleted.
- Terms and definitions clauses should be updated.
- All references to "declaration of the manufacturer" should be deleted.
- Objective clause should be deleted.
- Sub-clauses related to Test site should be amended to cover the test sites other than OATS.
- Text for the conformance tests should be amended throughout the document. The new text should read *"This test shall be performed using the test procedure specified in the following clause. The tests can be carried out in an open-area test site, or in an anechoic chamber or in a semi-anechoic chamber as they lead to comparable test results for establishing compliance. Ambient noise levels shall be at least 6 dB below the applicable unwanted emissions limit."*.
- Annex A, Table A.1 should be reviewed and revised to align with the already approved similar standards (e.g. ETSI EN 303 699 [i.1]).
- Annex B should be reviewed and revised to align with the already approved similar standards (e.g. ETSI EN 303 699 [i.1]).
- In Annex E, Table E.1: Waveguide bands and associated waveguides may not be needed.
- Annex F should be reviewed and revised to align with the already approved similar standards (e.g. ETSI EN 303 699 [i.1]).
- The information given in Annex G, Table G.1 should be combined with Table A.1 and Annex G should be deleted.

B.3 Analysis Expert "HA"

Assessment Report on ETSI EN 301 442

ETSI EN 301 442 [i.7]: "Satellite Earth Stations and Systems (SES); NGSO Mobile Earth Stations (MES) including handheld earth stations, for Satellite Personal Communications Networks (S-PCN) operating in the 1 980 MHz to 2 010 MHz (earth-to-space) and 2 170 MHz to 2 200 MHz (space-to-earth) frequency bands under the Mobile Satellite Service (MSS); Harmonised Standard for access to radio spectrum".

Current edition: ETSI EN 301 442 V2.1.1 (2016-06)

1. Scope and Purpose of the Standard

ETSI EN 301 442 [i.7] is a Harmonised European Standard developed by ETSI TC SES to support presumption of conformity with Article 3.2 (effective and efficient use of radio spectrum) of the Radio Equipment Directive (RED) 2014/53/EU [i.37].

1.1 Technical scope

The standard applies to Mobile Earth Stations (MES) operating in:

- Non-Geostationary Orbit (NGSO) mobile-satellite systems.
- Satellite Personal Communications Networks (S-PCN) under the Mobile-Satellite Service (MSS).
- Frequency bands:
  - Earth-to-space: 1 980 MHz - 2 010 MHz.
  - Space-to-Earth: 2 170 MHz - 2 200 MHz.

The scope explicitly includes a wide range of MES form factors:

- handheld terminals;
- portable and vehicle-mounted terminals;
- host-connected, semi-fixed or fixed terminals;
- S-PCN modules embedded within multi-mode terminals;

provided they are controlled and monitored by a Network Control Facility (NCF), which is outside the scope of the standard.

1.2 Purpose within the ETSI framework

ETSI EN 301 442 [i.7] was originally developed to:

- Replace earlier TBR-based specifications under the R&TTE Directive.
- Provide a technology-neutral compliance route for 2 GHz MSS S-PCN terminals.
- Harmonise technical requirements across EU administrations for NGSO MSS terminals.

2. Regulatory Context and Consistency

2.1 ITU Radio Regulations

The frequency bands covered by ETSI EN 301 442 [i.7] correspond to the globally harmonized MSS allocations at 2 GHz, as defined in the ITU Radio Regulations for NGSO mobile-satellite systems.

Historically, these bands were identified for Satellite Personal Communications Networks, forming the regulatory basis for systems such as:

- Iridium (initially).
- Globalstar.
- ICO/Teledesic (historic concepts).
- Later evolution of MSS personal terminals.

The standard remains fully consistent with the ITU RR frequency allocations and basic MSS concepts, but it reflects regulatory and system assumptions of the late 1990s and early 2000s, particularly:

- narrowband or low-to-moderate data-rate services;

- circuit-oriented or simple packet data models;
- relatively static interference assumptions.

2.2 CEPT/ECC framework

ETSI EN 301 442 [i.7] does not directly reference a single dedicated ECC Decision equivalent to modern ESIM frameworks. Instead, it aligns with earlier CEPT/ERC decisions and reports related to:

- the introduction of 2 GHz MSS;
- harmonized use of spectrum for satellite personal communications.

ECC/DEC/(06)09

ECC/DEC/(06)09 [i.38] designates:

- 1 980 MHz - 2 010 MHz/2 170 MHz - 2 200 MHz for MSS including Complementary Ground Components (CGC) across CEPT.

Later ECC technical studies (e.g. ECC Report 197 [i.39], ECC Report 233 [i.40]) analyse MES interference and CGC coexistence in the same bands.

ETSI EN 301 442 [i.7] covers MES radio characteristics consistent with these CEPT studies, although CGC base stations themselves are outside the scope of the EN.

2.3 EU regulatory framework (RED)

ETSI EN 301 442 [i.7] is still listed as a harmonized standard under RED in national and EU databases and continues to provide presumption of conformity for Article 3.2.

Decision 626/2008/EC [i.41] establishes:

- a pan-European selection and authorisation procedure for Mobile Satellite Services (MSS);
- exclusive use of the 2 GHz MSS bands:
  - 1 980 MHz - 2 010 MHz (Earth-to-space).
  - 2 170 MHz - 2 200 MHz (Space-to-Earth).
- harmonized authorisation conditions across all EU Member States.

The Decision explicitly defines MSS systems providing communications between mobile earth stations and satellites in these band.

Commission Decision 2007/98/EC (spectrum harmonisation)

Decision 2007/98/EC [i.42] designated the 2 GHz MSS bands for MSS in the EU. Decision 626/2008/EC explicitly builds on it, referring to the same frequency ranges.

EN 301 442's scope aligns fully with the frequencies and service definition of Decision 2007/98/EC + 626/2008/EC.

Commission Decision 2009/449/EC (operator selection)

Decision 2009/449/EC [i.43] selected MSS operators (e.g. Inmarsat, Solaris/EchoStar) under the framework of Decision 626/2008/EC [i.41].

CEPT and ECC technical foundations for ETSI EN 301 442 [i.7].

CEPT Report 013 - technical basis for EU MSS harmonisation

CEPT Report 013 [i.44] was produced in response to a European Commission mandate on harmonized technical conditions for 2 GHz MSS.

This report:

- analyses MSS system characteristics;
- defines interference and coexistence assumptions;
- explicitly addresses Mobile Earth Stations and NGSO MSS systems.

Is ETSI EN 301 442 [i.7] part of an "ongoing" EU harmonized framework?

Yes, it is.

Evidence:

- The EU 2 GHz MSS band framework is still active today, with licences expiring in May 2027 and being actively reviewed by the Commission and RSPG.
- The Commission launched consultations in 2024-2025 on future use of the EU 2 GHz MSS band, discussing new MSS and Direct-to-Device scenarios.
- ETSI EN 301 442 [i.7] remains listed as a harmonized standard under RED for MSS terminals in this band.

Therefore:

- ETSI EN 301 442 [i.7] is not a legacy orphan standard; it is structurally tied to one of the EU's few pan-European, centrally authorized spectrum regimes.

2.4 ITU Radio Regulations alignment

At ITU level:

- The 2 GHz MSS bands are allocated globally to the Mobile-Satellite Service.
- NGSO MSS user terminals are explicitly foreseen.

Decision 626/2008/EC [i.41] adopts those ITU allocations verbatim, and EN 301 442 implements equipment-level compliance within that internationally harmonized band.

3. Technology Evolution vs. Standard Requirements

3.1 Technology assumptions in ETSI EN 301 442

The standard implicitly assumes:

- dedicated MSS S-PCN terminals;
- relatively narrow bandwidth channels;
- centralised network control via NCF;
- simple power control and emission masks;
- limited multi-mode coexistence, despite allowing modules in hybrid terminals.

3.2 Current technology landscape (technical assessment)

Since 2016, satellite communications technology has shifted significantly:

- User expectations align with broadband-like services, even for mobility.
- Modern terminals integrate:
  - software-defined radios;
  - adaptive waveforms;

- IP-native protocols.

- NGSO systems now focus on:
  - seamless integration with terrestrial networks (5G/IoT).

ETSI EN 301 442 [i.7] is well aligned with legacy MSS personal communication systems, but not much aligned with current NGSO system architectures and user-terminal technology.

4. Market Use: Manufacturers and Satellite Operators

4.1 Manufacturers (historical and current relevance)

Based on the original ecosystem that motivated the standard and public MSS deployments:

- Terminal manufacturers historically aligned with ETSI EN 301 442 [i.7] include:
  - Thales.
  - Hughes Network Systems.
  - Globalstar.
  - Echostar.
  - ICO terminal suppliers.
  - Specialized MSS handheld manufacturers.

4.2 Satellite operators

Systems historically or conceptually aligned with ETSI EN 301 442 [i.7]:

- Globalstar (voice and data handheld MSS).
- Echostar.
- Planned European S-PCN initiatives (now discontinued).
- Market activity in this band is stable focused on:
  - niche MSS services;
  - safety, emergency, and specialised professional applications.

5. Measurement Methods and Potential Obsolescence

ETSI EN 301 442 [i.7] relies on:

- classical conducted and radiated measurements;
- static emission masks;
- worst-case power and spectral constraints;
- assumptions of single-system, controlled operation.

Assessment of obsolescence

- The methods are technically valid for legacy MSS terminals.
- They are not well suited for:
  - adaptive modulation and coding;
  - dynamic spectrum access;

- SDR-based terminals;
- coexistence scenarios involving dense NGSO deployments.

6. Conclusion: Should ETSI EN 301 442 be Reviewed?

Yes, from a strategic and technical standpoint.

Recommended options:

1) Review and modernize , to:
   - clearly defined legacy MSS use cases; or
   - performance-based requirements aligned with modern SDR terminals.
2) Update measurement methodologies to reflect:
   - adaptive emissions;
   - multi-mode operation;
   - dynamic network control.

Assessment Report on ETSI EN 301 447

ETSI EN 301 447 [i.9]: "Satellite Earth Stations and Systems (SES); Satellite Earth Stations on board Vessels (ESVs) operating in the 4/6 GHz frequency bands allocated to the Fixed Satellite Service (FSS); Harmonised Standard for access to radio spectrum".

Current edition: ETSI EN 301 447 V2.1.1 (2016-05).

1. Scope and Purpose of the Standard

ETSI EN 301 447 [i.9] is a Harmonised European Standard intended to provide presumption of conformity with Article 3.2 (effective use of radio spectrum) of the Radio Equipment Directive (RED) 2014/53/EU for Earth Stations on board Vessels (ESVs) operating in the C-band (4/6 GHz) Fixed-Satellite Service (FSS) via GSO satellites.

The scope:

- ESVs on maritime platforms (ships),
- Uplink: 5 925 MHz - 6 425 MHz (Earth-to-space).
- Downlink: 3,7 GHz - 4,2 GHz (space-to-Earth; region-dependent).
- Single-carrier operation.
- Linear or circular polarization.
- Large antennas (minimum 2,4 m diameter).
- Operation under a Network Control Facility (NCF).
- GSO operation with ≥ 2° - 3° satellite spacing and declared minimum elevation angle.
- Unattended professional operation in managed satellite networks.

Implication: The standard targets professional, high-power, large-aperture maritime C-band terminals, not modern low-profile or consumer VSATs.

2. Regulatory Context and Consistency

2.1 Alignment with ITU Radio Regulations

- The frequency ranges covered (C-band FSS) are consistent with ITU-R Radio Regulations allocations for the Fixed-Satellite Service.
- The standard's protection logic (antenna size, sidelobe control, pointing accuracy) reflects classic ITU-R interference-management assumptions developed during the era of dense GSO C-band deployments.

While formally consistent with the ITU RR, the standard does not reflect subsequent ITU-R developments related to:

- aggregate interference modelling;
- dynamic spectrum access;
- coexistence with evolving terrestrial services in C-band (e.g. IMT in parts of 3,4 GHz - 3,8 GHz, region-dependent).

2.2 CEPT / ECC framework

ETSI EN 301 447 [i.9] predates and is not directly mapped to modern CEPT ECC Decisions for ESIMs. In particular:

- ECC/DEC/(05)11 [i.45] (Aircraft Earth Stations) and later ESIM decisions in Ku/Ka-band introduced dynamic control, network-managed transmission constraints, and aggregate interference concepts, which are absent or implicit in ETSI EN 301 447 [i.9]. Although they may not be applicable for C band
- No dedicated, recent ECC Decision or CEPT Report has updated the regulatory framework for C-band maritime ESVs post-2016.

The standard remains regulatorily acceptable, but structurally outdated compared with the technology-neutral, ESIM-centric approach adopted later by CEPT in higher bands.

2.3 EU (RED) considerations

- ETSI EN 301 447 [i.9] remains cited in the Official Journal as a harmonized standard for RED Article 3.2 for this equipment class.

3. Technology Evolution vs. Standard Requirements

3.1 Technology assumptions embedded in ETSI EN 301 447

The standard assumes:

- Large mechanically-steered parabolic antennas (≥ 2,4 m).
- Single-carrier analog or classic digital carriers.
- Static spectral masks.
- GSO-only operation.
- Limited automation beyond basic NCF supervision.

3.2 Current maritime satellite technology (contextual assessment)

Since 2016, maritime satellite communications have evolved toward:

- Electronically Steered Antennas (ESA) and hybrid flat-panel solutions in higher bands.
- Multi-carrier and adaptive waveforms.
- Dynamic power control and beam shaping.

- Ku- and Ka-band dominance, with C-band declining to niche or legacy uses.
- Network-centric interference management aligned with ESIM frameworks.

ETSI EN 301 447 [i.9] does not reflect current state-of-the-art maritime terminal technology, even within C-band, particularly regarding:

- adaptive emissions;
- integration with modern network management systems.

4. Market Use: Manufacturers and Operators (High-level Assessment)

Based on publicly available industry positioning (not explicit ETSI adoption lists):

- Historically relevant manufacturers for C-band maritime ESVs include:
  - Harris CapRock.
  - Cobham / Sea Tel (legacy large-antenna systems).
  - Intellian (earlier C-band products).
  - Orbit Communications (large maritime antennas).
- Satellite operators historically serving this segment:
  - Intelsat.
  - SES.
  - Eutelsat (limited C-band maritime coverage).
  - Regional operators in ITU Regions 1 and 3.

Current market reality (assessment):

- Most new maritime deployments focus on Ku-band and Ka-band ESIMs (and increasingly NGSO systems).
- C-band ESVs persist mainly for legacy fleets, high-availability links, or specific regional constraints.

No recent evidence suggests active innovation driven by ETSI EN 301 447 [i.9].

5. Measurement Methods and Potential Obsolescence

ETSI EN 301 447 [i.9] relies on:

- Conventional conducted and radiated measurement techniques.
- Static antenna patterns and sidelobe envelopes.
- Worst-case emission measurements.

Measurement methods are technically valid, but:

- Not suitable for dynamic or adaptive systems.
- Do not address time-varying emissions.
- Do not support modern aggregate interference assessment methodologies increasingly used in CEPT/ITU studies.

6. Overall Assessment and Recommendation

6.1 Consistency with regulations

- Consistent with ITU RR allocations.
- Acceptable under RED Article 3.2.
- Weak alignment with post-2016 CEPT/ECC regulatory philosophy.

6.2 Technology relevance

- Does not reflect modern maritime satellite technologies.
- Assumes declining C-band professional ESV architectures.

6.3 Market relevance

- Limited largely to legacy installations.
- Minimal influence on current ESIM or NGSO maritime deployments.

7. Conclusion: Should ETSI EN 301 447 be Reviewed? Recommended actions

1) Strategic review within ETSI TC SES to decide whether:
    - to revise and modernize ETSI EN 301 447 [i.9]; or
    - to progressively withdraw it in favour of technology-neutral ESIM standards.
2) If revised:
    - Introduce performance-based requirements.
3) If withdrawn:
    - Clearly position ETSI EN 301 447 [i.9] as a legacy harmonized standard for existing installations only.

ETSI EN 301 447 [i.9] remains regulatorily valid but technologically obsolete and no longer representative of the state of maritime satellite communications. A formal review would improve coherence with modern CEPT/ECC regulation and contemporary satellite terminal technologies.

Review of ETSI EN 301 427

Mobile satellite Earth Stations (MESs) 11/12/14 GHz.

1. Introduction

ETSI EN 301 427 [i.6] is the European harmonized standard providing presumption of conformity with Article 3.2 of the Radio Equipment Directive (RED) for non-aeronautical, low data rate Mobile Earth Stations (MES) operating in the 11/12/14 GHz bands with geostationary Fixed Satellite Service (FSS) systems. It defines equipment-level radio-frequency requirements and test methods to ensure efficient spectrum use and avoidance of harmful interference.

The standard is based on low data rate operation and for fixed or mechanically steered antennas, while aggregate interference, broadband operation, ESIM and NGSO scenarios are explicitly outside its scope.

2. Purpose of ETSI EN 301 427

ETSI EN 301 427 [i.6] specifies radio-frequency requirements and associated measurement methods that allow demonstrate compliance with RED Article 3.2, namely efficient use of the radio spectrum and avoidance of harmful interference.

The standard:

- applies exclusively at the individual terminal level;
- does not regulate satellite operators or network operation;
- does not assign spectrum or define coordination mechanisms;
- does not establish system-level or aggregate interference criteria.

It translates long-established regulatory assumptions, derived primarily from the ITU Radio Regulations and long-standing European practice for Ku-band GSO FSS operation, into objective and reproducible conformity-assessment criteria suitable for harmonized testing and CE marking.

3. Technical Scope

ETSI EN 301 427 [i.6] applies to low data rate Mobile Earth Stations (MES), excluding aeronautical earth stations, characterised by:

- Operation exclusively with geostationary FSS systems.
- Operation in one or more of the following frequency bands:
  - 10,70 GHz - 11,70 GHz and 12,50 GHz - 12,75 GHz (space-to-Earth).
  - 14,00 GHz - 14,25 GHz (Earth-to-space), subject to secondary allocation under the ITU Radio Regulations.
- Equipment categories limited to:
  - Land Mobile Earth Stations (LMES).
  - Maritime Mobile Earth Stations (MMES), excluding GMDSS functionality.

The standard assumes operation with a minimum 3° orbital separation from adjacent GSO satellites and integration into a managed satellite network under a Network Control Facility (NCF), which lies outside its normative scope.

4. Technological Relevance

It provides effective control of:

- maximum EIRP and spectral power density;
- antenna off-axis radiation characteristics;
- unwanted and spurious emissions;
- basic control, monitoring and disabling functions.

The standard is limited by design. It does not address dense terminal deployments, broadband or high-throughput systems, electronically steered antennas, aggregate interference effects or dynamic multi-satellite operation. These exclusions are deliberate and ensure alignment with the low data rate MES use cases for which the standard was developed.

5. Use by Industry

ETSI EN 301 427 [i.6] is mainly used by manufacturers of legacy, niche or specialized low data rate Ku-band mobile terminals, particularly for land and maritime applications with limited traffic demand and stable operational profiles. It provides a recognized and harmonized basis for RF conformity assessment and CE marking.

Satellite operators do not generally reference the standard explicitly, but compliance with ETSI EN 301 427 [i.6] is implicitly relied upon for the legal operation of low data rate MES on GSO FSS networks in Europe. The standard is not applied to modern Ku-band broadband terminals, ESIM platforms or NGSO user equipment.

6. Relationship with CEPT and ITU

ETSI EN 301 427 [i.6] is firmly anchored in:

- The ITU Radio Regulations [i.21), notably the secondary status of Earth-to-space emissions in the 14,0 GHz - 14,25 GHz band.
- Long-established CEPT assumptions regarding GSO FSS spectrum sharing and orbital separation in the Ku band.

The standard does not implement recent CEPT/ECC frameworks for ESIM or NGSO systems, nor regulatory concepts such as aggregate interference management or dynamic spectrum sharing, which apply to different equipment categories.

7. Areas for potential update

Limited updates could be considered to:

- clarify the boundary between ETSI EN 301 427 [i.6] and newer Ku-band regulatory frameworks;
- align terminology and references with current RED and ETSI drafting practice;
- ensure editorial consistency with the latest editions of the ITU Radio Regulations.

Any update should remain strictly confined to low data rate MES, preserving the original technical intent of the standard.

8. Conclusions

ETSI EN 301 427 [i.6] remains a valid and fit-for-purpose harmonized standard enabling compliance with RED Article 3.2 for low data rate Ku-band Mobile Earth Stations operating with geostationary FSS systems.

Experts Group review of ETSI EN 303 699

Fixed Earth Stations for NGSO Systems.

1. Introduction

ETSI EN 303 699 [i.1] is a European Harmonized Standard defining essential technical requirements for Fixed Earth Stations (FES) operating with NGSO satellite systems in the Ka band. It supports conformity with Article 3.2 of the Radio Equipment Directive (RED) 2014/53/EU [i.37], ensuring efficient spectrum use and avoidance of harmful interference. However, the EN has not yet been cited in the OJ EU.

The standard was developed before the large-scale deployment of high-density NGSO constellations. The evolution of satellite architectures and earth station deployments motivated a review through on certain technical and regulatory relevance.

2. Objective of ETSI EN 303 699

The standard aims to:

- Define harmonized requirements for fixed NGSO earth stations.
- Ensure protection of other services, particularly GSO satellite systems.
- Implement relevant provisions of the ITU Radio Regulations, notably EPFD limits.

3. Technical Scope

ETSI EN 303 699 [i.1] applies to:

- Permanently installed fixed earth stations, under centralised network control (NCF).

- NGSO operation in:
    - 17,3 GHz - 20,2 GHz (space-to-Earth).
    - 27,5 GHz - 30 GHz (Earth-to-space).
- Highly directive antennas with dynamic satellite tracking.
- Requirements on transmit power, unwanted emissions, and NGSO/GSO coexistence, including EPFD compliance.

The current scope does not fully address electronically steerable antennas (ESA) or high-density deployment scenarios.

4. Technological Relevance

The standard has enabled early NGSO deployments in Europe by providing regulatory certainty and supporting coexistence in congested Ka-band spectrum. However, its assumptions are partially outdated, given the widespread adoption of:

- Electronically steerable antennas.
- Dynamic spectrum and power control.
- Large numbers of simultaneously active earth stations.

5. Industry usage

Industry uses ETSI EN 303 699 [i.1] as:

- The primary RED conformity reference for fixed NGSO earth stations.
- A means to achieve harmonized market access for NGSO infrastructure in Europe.

6. Relationship with CEPT and ITU

The standard is aligned with the ITU Radio Regulations, including Article 22 (EPFD) and relevant coordination principles. It is also consistent with CEPT/ECC Decisions and Reports under the ETSI-CEPT cooperation framework, ensuring regulatory coherence at European and global level.

7. Areas for possible STF update

An STF review is justified to address:

- Explicit treatment of Electronically Steerable Antennas (ESA).
- High-density fixed NGSO earth station scenarios.
- Aggregate interference effects.
- Advanced dynamic spectrum management mechanisms.
- Alignment with recent CEPT/ECC developments, WRC outcomes, and newer ETSI NGSO standards.
- Consider possible inclusion of in motion terminals following ESIM operations and in accordance with ITU provisions.

8. Conclusions

ETSI EN 303 699 [i.1] remains a key harmonized standard, but the evolution of NGSO systems has created a gap with current deployments (inclusion of flat array antennas and their corresponding measurement methods).

Experts Group - Review ETSI EN 303 980

ETSI EN 303 980 [i.5] - NGSO Ku band Satellite Earth Stations

1. Introduction

Non Geostationary Satellite Orbit (NGSO) systems operating in the Ku band are now widely deployed in Europe, supporting fixed and in motion connectivity through large populations of earth stations. In this context, ETSI EN 303 980 [i.5] is the European harmonized standard enabling compliance with Article 3.2 of the Radio Equipment Directive (RED) for NGSO Ku band satellite earth stations, thereby supporting CE marking and market access.

Since the standard was adopted, NGSO deployments have become denser, more dynamic and increasingly reliant on electronically steered antennas, while regulatory focus at CEPT and ITU level has shifted towards aggregate interference and multi system coexistence. This review assesses whether ETSI EN 303 980 [i.5] remains aligned with current technological and regulatory assumptions and identifies whether targeted technical updates may be appropriate.

2. Purpose of ETSI EN 303 980

The purpose of ETSI EN 303 980 [i.5] is strictly technical and market enabling. It defines radio frequency requirements and measurement methods that allow manufacturers to demonstrate efficient spectrum use and avoidance of harmful interference in accordance with RED [i.37] Article 3.2.

The standard does not regulate operators, assign spectrum, or establish system level coordination rules. Its role is limited to implementing higher level regulatory assumptions at equipment level, in line with the established European regulatory framework.

3. Technical Scope

The standard applies to fixed earth stations and Earth Stations in Motion (ESIM) associated with NGSO Fixed Satellite Service systems operating in the Ku band, typically:

- 10,7 GHz - 12,75 GHz (space to Earth).
- 14,0 GHz - 14,5 GHz (Earth to space).

It focuses on individual equipment performance, addressing EIRP and spectral density limits, out of band and spurious emissions, basic control and disabling functions, and classical RF conformity assessment methods. Aggregate or system level behaviour is outside its normative scope.

However, no clear reference is found whether the EN meets the ESIM concepts of the ITU.

4. Technological Relevance

ETSI EN 303 980 [i.5] remains valid for individual terminals and for supporting reproducible conformity assessment. However, it does not explicitly address features that now dominate NGSO deployments, such as aggregate interference from large terminal populations, widespread use of electronically steered antennas, and highly dynamic time domain operation.

ETSI EN 303 980 [i.5] is therefore not obsolete, but reflects assumptions originating from earlier NGSO deployment models.

5. Use by Industry

Manufacturers of NGSO Ku band terminals and ESIM solutions widely rely on ETSI EN 303 980 [i.5] for RF design, testing and preparation of CE marking documentation. Its role is essential for market access but largely invisible in public materials.

Satellite operators use ETSI EN 303 980 [i.5], for example, Oneweb system.

6. Relationship with CEPT and ITU

CEPT/ECC defines spectrum access conditions and coexistence assumptions, while the ITU Radio Regulations provide the global framework for NGSO operation. ETSI EN 303 980 [i.5] translates these higher level rules into verifiable equipment level requirements.

Recent regulatory work has increasingly focused on aggregate and dynamic effects, elements that are only partially reflected in ETSI EN 303 980 [i.5].

ECC/DEC/(18)05 [i.17] establishes the regulatory conditions that ETSI EN 303 980 [i.5] converts into measurable technical requirements, including:

Protection of:

- Fixed Service (FS) in 14,25 GHz - 14,5 GHz
- Radio Astronomy Service (RAS) in 14,47 GHz - 14,5 GHz

Non-interference measures through:

- EIRP and power density limits.
- Control of antenna pointing and tracking.
- Emission limits and out-of-band constraints.

Requirement that ESIMs operate under network control, but not referring yet to the ITU Concept of ESIM.

The Decision explicitly states that it is based on:

- ECC Report 279 [i.47] (regulatory conclusions).
- ECC Report 271 [i.48] (technical compatibility studies).
- ECC/DEC/(18)04 [i.46] Harmonized use, exemption from individual licensing and free circulation and use of land-based ESIM operating with GSO FSS satellite systems in the frequency bands 10.7-12.75 GHz and 14.0-14.5 GHz.

Although ECC/DEC/(18)04 [i.46] addresses GSO FSS rather than NGSO, it is important because it:

- Applies to the same Ku band frequencies.
- Protects the same services (FS and RAS).
- Introduces core ESIM principles:
  - Licence exemption.
  - Free circulation.
  - Interference mitigation through terminal design.

These principles are reused in ECC/DEC/(18)05 [i.17] and therefore reflected indirectly in ETSI EN 303 980 [i.5], ensuring regulatory coherence for ESIMs regardless of orbit type.

ECC/DEC/(17)04 [i.16] Harmonized use and exemption from individual licensing of fixed earth stations operating with NGSO FSS systems in the frequency bands 10,7 GHz - 12,75 GHz and 14,0 GHz - 14,5 GHz.

ECC/DEC/(17)04 [i.16]:

- Established the baseline regulatory framework for NGSO FSS user terminals in Ku band.
- Defined early emission limits and protection mechanisms for FS and RAS.
- Served as the starting point for later ESIM specific studies (ECC Reports 271 [i.48] and 279 [i.47]).

ETSI EN 303 980 [i.5] inherits these principles, extending them from fixed terminals to terminals in motion.

7. Areas for potential update

ETSI EN 303 980 [i.5] adequately covers power limits, spectral emissions, classical RF testing and basic control functions. Potential candidates for targeted technical update include:

1) Multi operator NGSO coexistence.
2) Aggregate interference assessment using statistical approaches.
3) Explicit consideration of Electronically Steered Antenna (ESA) behaviour.
4) Dynamic and time domain measurement methodologies.
5) Among everything, update the language of the EN to the RED requirements.

8. Conclusions

ETSI EN 303 980 [i.5] remains an essential and valid harmonized standard enabling EU market access for Ku band NGSO satellite earth stations. At the same time, the evolution towards dense and dynamic NGSO deployments has created a growing gap between current regulatory assumptions and the equipment centric verification framework of the standard.

B.4 Analysis Expert "JJ"

Explanatory notes on ETSI EN 302 574-3

ETSI EN 302 574-3 [i.14] was revised in January 2026 to correct editorial mistakes. This latest revision is identified as version 2.1.9.

Found some more corrections to be made to align with the latest version of the skeleton (dated June 2025).

The only element which seems important to look at is how the receiver blocking performance is specified and measured: the notion of "in-band signals" extends out up to 10 MHz from both edges of the receive operating band (2 170 - 2 200 MHz) (see clause 3.1 Terms); at the same time the interfering CW signal is located at an offset of 5 MHz from the wanted carrier (see clause 4.2.7.2 and Table 7), which is at most 1 MHz wide. There do not seem any reason to extend the "in-band signals" further out than 5 MHz and up to 10 MHz from the operating band edges.

However, this extension of 10 MHz does not seem to have an impact on the way the blocking is measured according to clause 5.3.7.

Altogether the need for a revision of ETSI EN 302 574-3 [i.14] is considered as fairly low.

Explanatory notes on ETSI EN 303 978

The reference version is version 2.1.1 as published in December 2024 and listed in the OJEU.

A few editorial mistakes are to be corrected, in particular in line with recent comments received from the HAS consultant.

The only major points seem to be the following:

- To take into consideration phased array antenna (in particular of nominal antenna diameter definition and in clause 6.4.1.2.1.
- Concerning the value of EIRP density limit in clause 4.2.3 (Off axis EIRP emission density within the band) for off axis angle greater than 48 degrees, there is a discontinuity for this off-axis angle:
    - 22 - 25 log 48 = -20 dBW while a value of -10 dBW is indicated for angles greater than 48 degrees. However, this discontinuity is in line with Recommendation ITU-R S.524 [i.25].

Altogether the need for a revision of ETSI EN 303 978 [i.3] is considered as medium.

B.5 Analysis Expert "JA"

Experts Group - Review ETSI EN 301 442

ETSI EN 301 442 [i.7] - Satellite Personal Communication Networks (S-PCN) in the 2,0 GHz Bands.

1. Introduction

ETSI EN 301 442 [i.7] is a Harmonized Standard developed by ETSI Technical Committee Satellite Earth Stations and Systems (SES). It applies to Mobile Earth Stations (MES), including handheld earth stations, operating as part of Satellite Personal Communication Networks (S-PCN) in the 2 GHz Mobile-Satellite Service (MSS) bands. The standard covers equipment operating in the 1 980 MHz to 2 010 MHz band in the Earth-to-space direction and in the 2 170 MHz to 2 200 MHz band in the space-to-Earth direction. Its current published version is ETSI EN 301 442 [i.7] (V2.1.1), dated June 2016. The standard is intended to support compliance with Article 3.2 of Directive 2014/53/EU, the Radio Equipment Directive (RED), which requires radio equipment to effectively use and support the efficient use of radio spectrum so as to avoid harmful interference. ETSI EN 301 442 [i.7] (V2.1.1) has been cited in the Official Journal of the European Union under the RED, giving it regulatory relevance for conformity assessment of applicable satellite user terminals.

Within the Experts Group, ETSI EN 301 442 [i.7] is relevant because it belongs to the family of ETSI Harmonised Standards for satellite earth stations and user terminals. Although the specific S-PCN market in the 2 GHz MSS bands is relatively narrow compared with current broadband NGSO systems, the standard remains important as a reference for radio spectrum access requirements, unwanted emissions, network control, terminal behaviour and protection of other radio services.

The bands covered by ETSI EN 301 442 [i.7] are part of a wider European and international regulatory framework for MSS. At CEPT level, ECC/DEC/(06)09 [i.38] designates the 1 980 - 2 010 MHz and 2 170 - 2 200 MHz bands for use by MSS systems, including systems supplemented by Complementary Ground Components (CGC). At ITU level, these bands are allocated to the Mobile-Satellite Service under Article 5 of the Radio Regulations [i.37] and are subject to coordination procedures under Article 9.

2. Purpose of ETSI EN 301 442

The main purpose of ETSI EN 301 442 [i.7] is to define the technical requirements and test methods that allow Mobile Earth Stations, including handheld terminals, to demonstrate conformity with the essential spectrum-access requirements of the RED. The standard focuses on ensuring that terminals operating in the 2 GHz MSS bands do not create harmful interference to other radio services, to other satellite systems, or to the network with which they communicate. It does so by defining requirements relating to transmitter behaviour, unwanted emissions, carrier control, network control and the prevention of uncontrolled transmissions.

In regulatory terms, the standard provides a bridge between the general legal obligation established by the RED and the specific technical behaviour expected from MSS user terminals. Manufacturers may use the standard to demonstrate a presumption of conformity with Article 3.2 of the RED for equipment falling within its scope.

The standard is therefore not a system design specification and does not define the complete architecture of a satellite network. Rather, it is a radio equipment standard focused on the terminal side. It does not assign spectrum, license networks, or replace ITU and CEPT regulatory procedures. Its purpose is to define measurable equipment requirements that support efficient spectrum use and coexistence.

3. Technical Scope

ETSI EN 301 442 [i.7] applies to Mobile Earth Stations operating in NGSO MSS systems within the paired 2 GHz bands.

Direction	Frequency band	Service context
Earth-to-space	1 980 MHz - 2 010 MHz	MSS uplink from MES to satellite
Space-to-Earth	2 170 MHz - 2 200 MHz	MSS downlink from satellite to MES

The standard covers MES equipment, including handheld earth stations, used for Satellite Personal Communication Networks. These terminals are typically low-power or portable devices intended to communicate with NGSO satellite systems. The scope is therefore different from VSAT, ESIM, fixed earth station, or broadband satellite terminal standards.

From a technical perspective, the standard addresses requirements such as:

- unwanted emissions;
- spurious emissions;
- carrier-on and carrier-off behaviour;
- network control and monitoring functions;
- avoidance of uncontrolled RF transmissions;
- behaviour of dual-mode or multi-mode terminals;
- test methods for verifying compliance.

A key principle behind the standard is that a terminal should only be transmitted when properly authorized and controlled by the satellite network. This is particularly relevant for mobile or handheld terminals, where large numbers of devices may operate across wide geographic areas and where uncontrolled transmissions could affect adjacent services or other satellite systems. The standard also defines test arrangements and measurement procedures, allowing manufacturers and test laboratories to verify compliance. This ensures that conformity assessment under the RED is based on repeatable and well-defined methods.

4. Technological Relevance

The technological relevance of ETSI EN 301 442 [i.7] has evolved since its first versions. The standard was originally linked to the development of Satellite Personal Communication Networks and the use of the 2 GHz MSS bands for mobile satellite communications. At the time, the main technological scenario involved NGSO mobile satellite systems providing personal communication services through handheld or portable terminals. The satellite communications market has changed significantly. Current NGSO developments are largely driven by broadband mega-constellations, direct-to-device initiatives, IoT/M2M connectivity, hybrid satellite-terrestrial networks, and multi-orbit architectures. In this new environment, the traditional S-PCN concept may appear less central than in the early 2000s. Nevertheless, ETSI EN 301 442 [i.7] remains technologically relevant for several reasons:

1) TI addresses terminal control and prevention of unwanted emissions, which remain essential for any modern satellite user equipment. The principle that a terminal should not transmit unless correctly controlled by the network is still valid, especially in mobile and handheld use cases.

2) The 2 GHz MSS bands continue to be strategically important in Europe. CEPT has maintained a harmonized framework for MSS in 1 980-2 010 MHz and 2 170-2 200 MHz, including the possibility of Complementary Ground Components. This makes the standard relevant not only for satellite-only systems but also for hybrid MSS/CGC architectures.

3) There is renewed interest in direct-to-device satellite communications and integration between satellite and terrestrial mobile networks. Although ETSI EN 301 442 [i.7] was not originally written for current 5G NTN or direct-to-smartphone architectures, some of its underlying concepts remain useful, particularly in relation to mobile terminal behaviour, network control, spectrum access discipline, and protection of adjacent services.

However, the standard may not fully reflect the latest technological developments. It predates the most recent 3GPP NTN work, modern software-defined terminals, advanced beamforming, dynamic spectrum management, and large-scale hybrid satellite-terrestrial service models. This creates a strong case for review under the Experts Group.

5. Use by Industry

ETSI EN 301 442 [i.7] is mainly used by manufacturers, test laboratories, satellite operators, and notified bodies involved in the conformity assessment of NGSO MSS mobile terminals in the 2 GHz bands.

- For manufacturers, the standard provides a route to demonstrate compliance with Article 3.2 of RED. By designing and testing equipment according to ETSI EN 301 442 [i.7], manufacturers can support CE marking and access to the European market.
- For test laboratories, the standard provides technical requirements and measurement procedures. This helps ensure consistency between different conformity assessment processes.
- For satellite operators, ETSI EN 301 442 [i.7] supports the safe deployment of user terminals by ensuring that terminals behave predictably and remain under network control. This is particularly important in MSS systems where a large number of devices may be deployed.
- For regulators and market surveillance authorities, the standard provides a recognised benchmark for assessing whether equipment operating in the 2 GHz MSS bands uses spectrum efficiently and avoids harmful interference.

In practice, the industrial use of ETSI EN 301 442 [i.7] is likely narrower than that of more widely used satellite terminal standards, such as those covering VSAT, ESIM, or broadband satellite earth stations. This is due to the limited number of MSS systems operating in the 2 GHz bands and the specific historical development of S-PCN services. However, the standard remains important where equipment falls within its scope.

6. Relationship with CEPT and ITU

ETSI EN 301 442 [i.7] operates within a broader regulatory ecosystem:

- At CEPT level, the most relevant instrument is ECC/DEC/(06)09 [i.38], which designates the bands 1 980 MHz - 2 010 MHz and 2 170 MHz - 2 200 MHz for MSS systems, including systems supplemented by CGC. ECC/DEC/(06)10 [i.49] is also relevant because it addresses the transition of terrestrial service operations from these bands to facilitate the harmonized introduction and development of MSS systems, including CGC. Additional technical and regulatory considerations, including sharing and compatibility aspects between MSS and terrestrial systems, are further addressed in CEPT studies such as ECC Report 273 [i.57]. These CEPT decisions define the spectrum environment in which ETSI EN 301 442 [i.7] terminals operate. While CEPT decisions address frequency designation, harmonisation, and coexistence at regulatory level, ETSI EN 301 442 [i.7] translates part of that framework into equipment-level technical requirements.
- At ITU level, the 1 980-2 010 MHz and 2 170-2 200 MHz bands are part of the international MSS allocation framework defined in Article 5 of the Radio Regulations. The operation of MSS systems in these bands is subject to coordination procedures under Article 9, particularly in relation to coexistence with other satellite networks and terrestrial services. These bands have also been associated with the satellite component of IMT-2000, as reflected in Resolution 212 (WRC). In addition, Recommendation ITU-R M.1036 [i.50] and Recommendation ITU-R S.1428 [i.51] provide technical guidance on coexistence between MSS and terrestrial mobile systems operating in adjacent or overlapping frequency bands. These recommendations are relevant to the technical requirements defined in ETSI EN 301 442 [i.7], particularly regarding controlled terminal operation and the avoidance of harmful interference.

The relationship can therefore be summarised as follows.

Layer	Role
ITU Radio Regulations	International allocation and coordination framework
ITU-R Recommendations	Technical guidance for coexistence
CEPT/ECC Decisions	European harmonisation and spectrum designation
ETSI EN 301 442 [i.7]	Equipment-level technical requirements and test methods
RED 2014/53/EU [i.37]	Legal conformity framework for radio equipment placed on the EU market

ETSI EN 301 442 [i.7] does not replace ITU filing, coordination, notification, or national licensing obligations. It is concerned with the conformity of radio equipment. Network operators should still ensure that their satellite systems comply with ITU, CEPT, EU and national regulatory obligations.

7. Areas for potential update

Several areas may justify updating ETSI EN 301 442 [i.7] under the Experts Group.

1) The standard should be reviewed against current RED drafting practices. ETSI EN 301 442 [i.7] (V2.1.1) dates from 2016, and ETSI has an active work item for ETSI EN 301 442 [i.7]. The ETSI work programme indicates that a draft version 2.1.10 reached a mature draft stage in February 2026. This suggests that the standard is already under active review.

2) The terminology should be checked. The concept of S-PCN may require clarification in light of modern MSS, NTN and direct-to-device systems. The standard should make clear whether it remains limited to traditional NGSO S-PCN terminals or whether any aspects are relevant to newer service models.

3) The interaction with Complementary Ground Components should be reviewed. The CEPT framework explicitly recognises MSS systems supplemented by CGC. The standard should be checked to ensure that terminal requirements remain appropriate where satellite and terrestrial components coexist.

4) Test methods may need modernisation. Since 2016, terminals have become more software-defined, more integrated, and more capable of operating in multi-mode environments. Test methods should remain repeatable but also realistic for modern equipment.

5) The standard should be assessed against current coexistence requirements. The 2 GHz range is adjacent to important terrestrial mobile allocations. Protection of adjacent services, unwanted emissions, and terminal control requirements should be reviewed against current spectrum use and receiver environments.

6) Dual-mode and multi-mode terminal requirements may need expansion. Modern devices may support satellite, terrestrial cellular, Wi-Fi®, Bluetooth®, GNSS, and other radio interfaces. The standard should ensure that fellow radio stations in a multi-radio device cannot trigger harmful or uncontrolled satellite transmissions.

7) The standard may need clearer alignment with market surveillance expectations. Requirements should be testable, unambiguous and linked clearly to Article 3.2 of the RED.

8. Conclusions

ETSI EN 301 442 [i.7] is a specialised but important Harmonized Standard for NGSO Mobile Earth Stations, including handheld terminals, operating in the 2 GHz MSS bands. Its main function is to support conformity with Article 3.2 of the Radio Equipment Directive by defining technical requirements and test methods for efficient spectrum use and avoidance of harmful interference.

The standard is closely linked to the European harmonized framework for MSS in the 1 980 - 2 010 MHz and 2 170 - 2 200 MHz bands, particularly ECC/DEC/(06)09 [i.38] and ECC/DEC/(06)10 [i.49]. It also sits within the wider ITU framework for MSS allocations and satellite system coordination.

Although the original S-PCN market is relatively narrow, the standard remains relevant because the technical principles it contains - terminal control, unwanted emission limits, prevention of uncontrolled transmissions, and protection of other services - remain central to modern satellite communications.

However, the satellite sector has changed substantially since the publication of ETSI EN 301 442 [i.7] (V2.1.1) in 2016. New developments such as 5G NTN, direct-to-device satellite services, hybrid MSS/CGC networks, software-defined terminals and multi-radio user equipment create a strong justification for review. The ongoing ETSI Experts Group work item provides an opportunity to update the standard, clarify its scope, modernize terminology and ensure continued regulatory relevance.

ETSI EN 301 442 [i.7] should be maintained as a Harmonized Standard, but it should be reviewed carefully to ensure that its technical requirements, test methods and references remain aligned with current RED requirements, CEPT harmonisation measures, ITU regulatory provisions and modern MSS industry practice.

Experts Group - Review ETSI EN 301 443

ETSI EN 301 443 [i.8] - C-band VSAT 4 GHz and 6 GHz

1. Introduction

ETSI EN 301 443 [i.8] is a Harmonized Standard developed by ETSI Technical Committee Satellite Earth Stations and Systems (SES). It applies to Very Small Aperture Terminals (VSATs), including transmit-only, transmit-and-receive and receive-only earth stations operating in the 4 GHz and 6 GHz frequency bands within the Fixed-Satellite Service (FSS). The standard supports compliance with Article 3.2 of Directive 2014/53/EU [i.37] (Radio Equipment Directive - RED), which requires radio equipment to effectively use radio spectrum and avoid causing harmful interference.

C-band remains widely used for professional and high-reliability communications, particularly in environments where robustness against atmospheric attenuation is required.

2. Purpose of ETSI EN 301 443 [i.8]

The purpose of ETSI EN 301 443 [i.8] is to define technical requirements and corresponding test methods that ensure compliance with the essential spectrum usage requirements under Article 3.2 of the RED. The standard focuses on ensuring that VSAT terminals:

- Limit unwanted and spurious emissions.
- Control off-axis radiation.
- Maintain proper antenna performance.
- Operate under controlled transmission conditions.

It provides a harmonized framework for manufacturers to demonstrate conformity while ensuring efficient spectrum use and protection of other services.

3. Technical Scope

ETSI EN 301 443 [i.8] applies to VSAT earth stations operating in the 4 GHz and 6 GHz bands within the FSS.

It covers:

- Transmit-only VSATs.
- Transmit-and-receive VSATs.
- Receive-only VSAT.

The main focus is on transmitting terminals, as these are responsible for potential interference.

Key technical areas include:

- Off-axis e.i.r.p. density limits.
- Antenna radiation characteristics.
- Antenna pointing accuracy.
- Unwanted and spurious emissions.
- Transmission control and emission states.
- Test methods for conformity assessment.

These requirements are essential to ensure compatibility with other satellite systems, particularly in geostationary environments.

4. Technological Relevance

ETSI EN 301 443 [i.8] remains highly relevant for professional satellite communications.

C-band continues to provide robust performance, particularly in high-rainfall regions. Despite the emergence of higher frequency bands, C-band remains critical for high-availability services, particularly in regions with challenging propagation conditions.

VSAT systems operating in C-band are widely used in sectors such as energy, maritime, emergency communications, and remote enterprise connectivity.

The standard remains essential for ensuring that terminals operate in a controlled manner and do not cause harmful interference, particularly in densely populated geostationary orbital environments.

5. Use by Industry

ETSI EN 301 443 [i.8] is used by:

- VSAT equipment manufacturers (for CE marking).
- Satellite operators.
- Service providers.
- Test laboratories.
- Regulators and market surveillance authorities.

It supports the deployment of professional satellite communication networks, including:

- Enterprise and corporate networks.
- Energy, mining and offshore operations.
- Maritime and transport communications.
- Emergency and disaster recovery systems.
- Cellular backhaul infrastructure.

The standard ensures that VSAT terminals can be deployed safely and efficiently within the regulatory framework.

6. Relationship with CEPT and ITU

ETSI EN 301 443 [i.8] operates within a broader regulatory ecosystem.

- At CEPT level, the regulatory framework for VSAT operation in the 4 GHz and 6 GHz bands includes ERC/DEC/(00)08 [i.52], which supports the harmonized use of VSAT earth stations in Europe, and ERC/REC/(25)01 [i.53], which provides guidance on the use of satellite earth stations within the Fixed-Satellite Service (FSS). In addition, CEPT studies addressing coexistence between FSS and terrestrial fixed services in C-band provide further technical background for spectrum sharing conditions in certain frequency ranges.

These CEPT instruments define the European regulatory environment in which VSAT terminals operate. While CEPT focuses on spectrum harmonisation, coexistence and regulatory conditions, ETSI EN 301 443 [i.8] translates these principles into equipment-level technical requirements applicable to VSAT terminals.

- At ITU level, the 4 GHz and 6 GHz bands are allocated to the Fixed-Satellite Service (FSS) under Article 5 of the Radio Regulations. The operation of satellite networks in these bands is subject to coordination procedures defined in Article 9, particularly in geostationary environments where adjacent satellite interference should be carefully managed. In addition, Article 21 establishes limits on emissions in order to protect other satellite and terrestrial services.

Furthermore, Recommendation ITU-R S.465 [i.23] (reference antenna radiation patterns), Recommendation ITU-R S.524 [i.25] (off-axis e.i.r.p. limits) and Recommendation ITU-R S.728 [i.54] (antenna pointing accuracy) provide the technical basis for controlling interference between satellite networks. These technical references are particularly relevant in geostationary satellite environments, where strict control of off-axis emissions is required to protect adjacent satellite networks.

In this context, the Harmonized Standard provides a practical implementation of international and regional regulatory requirements at equipment level, ensuring that terminals operate within controlled and predictable conditions.

7. Areas for potential update

Potential areas for update include:

- Alignment with the latest RED harmonized standard requirements.
- Modernisation of test methods for software-defined VSAT terminals.
- Consideration of advanced antenna technologies.
- Improved consistency with other ETSI satellite earth station standards.
- Clarification of requirements for automated and remotely managed terminals.

8. Conclusions

ETSI EN 301 443 [i.8] is an important Harmonized Standard for C-band VSAT terminals operating in the 4 GHz and 6 GHz frequency bands. It supports compliance with Article 3.2 of the Radio Equipment Directive by defining technical requirements and conformance tests related to efficient spectrum use and the avoidance of harmful interference. The standard is particularly relevant for professional satellite communications, where C-band remains valuable due to its reliability, propagation robustness and suitability for critical connectivity. C-band VSATs continue to support a wide range of applications, including enterprise networks, government communications, energy sector operations, maritime connectivity, emergency services and remote-site communications.

The most important technical elements of the standard include the control of unwanted emissions, spurious emissions, off-axis e.i.r.p. density, antenna pointing accuracy and terminal transmission control states. These requirements are essential to protect adjacent satellite systems, other FSS networks and, where applicable, terrestrial services operating in adjacent or shared frequency bands. Although the standard remains valid and effective, the satellite sector has evolved significantly since the publication of ETSI EN 301 443 [i.8] (V2.1.1). Modern VSAT systems are increasingly software-controlled, remotely managed and integrated into more complex and dynamic network environments. In addition, evolving regulatory and technological developments continue to shape the use of C-band spectrum at both European and global levels.

For these reasons, the review of ETSI EN 301 443 [i.8] is fully justified. The standard should be maintained as a Harmonized Standard, but updated where necessary to reflect current RED requirements, modern VSAT technologies, updated ETSI drafting practices and the continued need for robust interference protection in C-band satellite operations.

ETSI EN 301 443 [i.8] remains a key element within the European regulatory framework for satellite communications, providing a clear and effective link between international spectrum management principles and practical equipment-level implementation.

Experts Group- Review ETSI EN 302 574-3

ETSI EN 302 574-3 [i.14] - Mobile Earth Stations operating in the 1 980 MHz to 2 010 MHz and 2 170 MHz to 2 200 MHz bands - Part 3: User Equipment for narrowband systems

1. Introduction

ETSI EN 302 574-3 [i.14] is a Harmonized Standard developed by ETSI Technical Committee Satellite Earth Stations and Systems (SES). It applies to Mobile Earth Stations (MES), also referred to as User Equipment (UE), operating in the Mobile-Satellite Service (MSS) frequency bands 1 980 MHz to 2 010 MHz in the Earth-to-space direction and 2 170 MHz to 2 200 MHz in the space-to-Earth direction. The standard forms part of the ETSI EN 302 574 series, which addresses satellite earth stations for MSS systems operating in the 2 GHz MSS bands. Within that series, Part 3 specifically covers User Equipment for narrowband systems, distinguishing it from Part 2, which addresses User Equipment for wideband systems, and Part 1, which addresses Complementary Ground Components (CGC) for wideband systems.

ETSI EN 302 574-3 [i.14] supports compliance with Article 3.2 of Directive 2014/53/EU [i.37], the Radio Equipment Directive (RED), which requires radio equipment to effectively use and support the efficient use of radio spectrum in order to avoid harmful interference. Its role is therefore to translate regulatory spectrum-access requirements into measurable technical requirements and test methods applicable to narrowband MSS user equipment. The standard is particularly relevant in the context of MSS systems using the 2 GHz bands for low data-rate, narrowband or specialised mobile satellite services. These may include messaging, telemetry, tracking, safety-related services, machine-type communications or other applications where spectrum-efficient narrowband operation is preferred over broadband connectivity.

Within the Experts Group, ETSI EN 302 574-3 [i.14] is relevant because it belongs to a set of Harmonised Standards that require review to ensure continued alignment with RED requirements, ETSI drafting rules, CEPT harmonisation measures and current MSS technological developments.

2. Purpose of ETSI EN 302 574-3

The purpose of ETSI EN 302 574-3 [i.14] is to define technical requirements and test methods for MSS User Equipment operating in the 1 980 MHz to 2 010 MHz and 2 170 MHz to 2 200 MHz bands when used for narrowband systems. The standard focuses on ensuring that narrowband MSS terminals operate in a controlled and predictable manner. This is essential because MSS user terminals may be widely distributed, mobile, portable or installed in operational environments where direct technical supervision is limited. The terminal should therefore comply with defined emission limits and should not transmit in a way that could cause harmful interference to other MSS systems, terrestrial services, adjacent-band systems or the MSS network itself. The standard provides a harmonized route for manufacturers to demonstrate conformity with Article 3.2 of the RED. It does not assign spectrum, authorize satellite networks or replace ITU and national licensing obligations. Instead, it defines the radio characteristics and operational behaviour expected from the equipment.

The main objectives of the standard include:

- Ensuring efficient use of the 2 GHz MSS spectrum.
- Limiting unwanted and spurious emissions.
- Ensuring controlled access to the MSS network.
- Avoiding uncontrolled or unauthorized transmissions.
- Supporting coexistence with terrestrial mobile systems and other services.
- Providing repeatable test methods for conformity assessment.

In this sense, ETSI EN 302 574-3 [i.14] provides the equipment-level implementation of broader spectrum management requirements applicable to narrowband MSS user terminals.

3. Technical Scope

ETSI EN 302 574-3 [i.14] applies to User Equipment operating in the following MSS bands:

Direction Earth-to-space 1 980 MHz - 2 010 MHz, direction Space-to-Earth 2 170 MHz - 2 200 MHz. The standard is focused on narrowband systems. This distinction is important because narrowband MSS user equipment generally has different operational characteristics from wideband terminals. Narrowband systems may use lower bandwidth channels, lower data rates and more specialized applications, but they still require strict control of emissions and network access.

The technical requirements typically address:

- Transmitter unwanted emissions.
- Spurious emissions.
- Emissions outside the assigned channel.
- Carrier-on and carrier-off conditions.
- Terminal control and monitoring functions.
- Network-controlled operation.
- Behaviour in abnormal or failure conditions.
- Test procedures for verifying compliance.

A key technical concept is that the UE should transmit only when properly authorized by the network. This prevents uncontrolled emissions and supports coexistence with other systems using or adjacent to the 2 GHz MSS bands.

The definition of unwanted and spurious emissions is particularly important for narrowband systems. ETSI EN 302 574-3 [i.14] defines spurious emissions by reference to frequency separation from the UE center carrier frequency, reflecting the narrowband nature of the equipment and the need for precise emission control close to the wanted channel.

4. Technological Relevance

ETSI EN 302 574-3 [i.14] remains technologically relevant because narrowband MSS continues to have a clear role within the satellite communications ecosystem.

While much of the current satellite market is focused on broadband NGSO connectivity and direct-to-device services, narrowband MSS remains important for applications where low data rate, wide-area coverage, resilience and terminal simplicity are more important than high throughput. These applications may include asset tracking, remote monitoring, emergency messaging, maritime or aeronautical support functions, telemetry, IoT-type services and other machine-to-machine communications.

The 2 GHz MSS bands are especially relevant because they are internationally and regionally recognised for mobile satellite use. They provide a regulatory framework suitable for mobile and portable satellite terminals, including services requiring reliable connectivity over wide geographic areas. The standard is also relevant because narrowband systems can be highly spectrum-efficient. In environments where spectrum is scarce and adjacent-band coexistence is complex, narrowband technologies can provide useful connectivity while limiting bandwidth occupation. However, this advantage depends on strict control of emissions and terminal behaviour, which is precisely the function of ETSI EN 302 574-3 [i.14].

The technological environment has evolved since the publication of ETSI EN 302 574-3 [i.14] (V2.1.1). Modern narrowband terminals may include software-defined radio functions, integrated multi-radio platforms, remote provisioning, adaptive transmission parameters, embedded SIM or authentication functions, and integration with IoT platforms. These developments justify a review of the standard to ensure that test methods and technical requirements remain appropriate.

The increasing interest in satellite IoT and direct-to-device narrowband connectivity reinforces the relevance of the standard. Even if the standard was not originally drafted for the latest NTN ecosystem, its underlying principles remain important: spectrum-efficient operation, network control, emission limitation and protection of adjacent services.

5. Use by Industry

ETSI EN 302 574-3 [i.14] is used by manufacturers, MSS operators, test laboratories, notified bodies, regulators and market surveillance authorities.

- For manufacturers, the standard provides a route to demonstrate conformity with Article 3.2 of the RED for narrowband MSS user equipment placed on the European market. This is relevant for CE marking and for ensuring that devices can be deployed in Europe under the applicable equipment conformity framework.

- For MSS operators, the standard supports the safe deployment of user terminals by ensuring predictable radio behaviour. This is particularly important where a large number of terminals may be deployed over wide areas, including mobile, remote or unattended environments.
- For test laboratories and notified bodies, ETSI EN 302 574-3 [i.14] provides technical requirements and test methods that allow consistent conformity assessment. This is important because narrowband equipment may require precise measurement of emissions close to the wanted carrier and in adjacent frequency ranges.
- For regulators and market surveillance authorities, the standard provides a recognised technical reference for assessing whether narrowband MSS terminals use spectrum efficiently and avoid causing harmful interference.

Typical industry use cases may include:

- Satellite messaging services.
- Asset tracking and fleet monitoring.
- Maritime or aeronautical narrowband applications.
- Remote telemetry and monitoring.
- Emergency and safety-related communications.
- Narrowband IoT/M2M satellite services.
- Low-data-rate mobile satellite applications.

Compared with wideband MSS or broadband satellite terminals, ETSI EN 302 574-3 [i.14] applies to a more specialised equipment category. However, this does not reduce its regulatory relevance. Narrowband systems may involve very large numbers of terminals, and therefore robust equipment-level requirements are essential.

6. Relationship with CEPT and ITU

ETSI EN 302 574-3 [i.14] operates within a broader regulatory ecosystem.

- At CEPT level, the most relevant regulatory framework includes ECC/DEC/(06)09 [i.38], which designates the bands 1 980 MHz to 2 010 MHz and 2 170 MHz to 2 200 MHz for MSS systems, including systems supplemented by Complementary Ground Components. ECC/DEC/(06)10 [i.49] is also relevant because it addresses the transition of terrestrial services from these bands in order to support the harmonized introduction and development of MSS systems. These CEPT decisions define the European spectrum environment in which ETSI EN 302 574-3 [i.14] user equipment operates. While CEPT instruments address spectrum designation, harmonisation and coexistence conditions at regulatory level, ETSI EN 302 574-3 [i.14] translates part of that framework into equipment-level requirements for narrowband MSS terminals.

Additional CEPT studies are also relevant. ECC Report 197 [i.39] addresses compatibility between MSS/CGC systems and adjacent-band terrestrial mobile systems in the 2 GHz range. This is particularly important because the 1 980 MHz to 2 010 MHz and 2 170 MHz to 2 200 MHz MSS bands are adjacent to frequency ranges used for terrestrial mobile services. ECC Report 233 is also relevant in relation to adjacent-band compatibility studies for aeronautical CGC systems operating in the same 2 GHz MSS bands.

- At ITU level, the 1 980 MHz to 2 010 MHz and 2 170 MHz to 2 200 MHz bands are part of the international MSS allocation framework defined in Article 5 of the Radio Regulations. MSS systems operating in these bands are subject to the coordination procedures of Article 9, particularly where coexistence with other satellite networks and terrestrial services should be ensured. These bands have also been associated with the satellite component of IMT-2000, as reflected in Resolution 212 (WRC). This is relevant because the 2 GHz MSS framework has historically been linked to the integration of satellite and terrestrial mobile communications.

Recommendation ITU-R M.1036 [i.50] and Recommendation ITU-R S.1428 [i.51] provide technical guidance on mobile systems and sharing considerations between MSS and terrestrial services. In addition, ITU-R Recommendations on unwanted emissions, such as Recommendation ITU-R SM.329 [i.22] and Recommendation ITU-R SM.1539 [i.55], are relevant to the distinction between out-of-band and spurious emissions, which is a key aspect of narrowband terminal compliance.

The relationship can therefore be summarised as follows:

Layer	Role
ITU Radio Regulations	International MSS allocation, coordination and interference management framework
ITU-R Recommendations	Technical basis for sharing, emission control and coexistence studies
CEPT/ECC Decisions and Reports	European harmonisation, designation and adjacent-band compatibility framework
ETSI EN 302 574-3 [i.14]	Equipment-level requirements and test methods for narrowband MSS UE
RED 2014/53/EU [i.37]	Legal conformity framework for radio equipment placed on the EU market

ETSI EN 302 574-3 [i.14] does not replace ITU filing, coordination, notification or national licensing obligations. It is concerned with the conformity of radio equipment. Network operators should still ensure that their satellite systems comply with ITU, CEPT, EU and national regulatory obligations.

In this context, the Harmonized Standard provides a practical implementation of international and regional regulatory requirements at equipment level, ensuring that narrowband MSS terminals operate within controlled and predictable conditions.

7. Areas for potential update

Several areas may justify updating ETSI EN 302 574-3 [i.14].

1) The standard should be reviewed against the latest RED harmonized standard drafting requirements. Since the current published version dates from 2016, the normative structure, terminology and Annex ZA should be checked to ensure alignment with current European Commission expectations for Harmonised Standards.

2) The distinction between narrowband and wideband user equipment should be kept clear. The ETSI EN 302 574 series includes different parts for wideband systems, narrowband systems and CGC. ETSI EN 302 574-3 [i.14] should clearly define its own scope and avoid ambiguity with ETSI EN 302 574-2 [i.14].

3) The treatment of modern narrowband satellite IoT and M2M terminals should be reviewed. Many current systems use compact, embedded or remotely managed terminals that may not resemble traditional mobile satellite user equipment. The standard should remain applicable to these new deployment models where they fall within the scope.

4) Test methods for software-defined and remotely configurable terminals should be reviewed. Modern UE may support remote firmware updates, adaptive channel selection, configurable output power and dynamic network access control. The standard should ensure that conformity testing remains meaningful for such equipment.

5) Unwanted emission and spurious emission requirements should be reviewed in light of adjacent-band terrestrial mobile deployments. The 2 GHz MSS bands are located close to frequency ranges used for terrestrial mobile networks, and compatibility with adjacent services remains a key regulatory issue.

6) The relationship with CGC should be clarified. Even though ETSI EN 302 574-3 [i.14] applies to UE for narrowband systems rather than CGC base stations, user equipment may operate in system environments where satellite and terrestrial components coexist. The standard should ensure that terminal behaviour remains controlled in such scenarios.

7) Consistency with other ETSI SES Harmonised Standards should be improved where appropriate. Ther is an opportunity to harmonise terminology, structure, test method presentation and RED-related wording across the broader satellite earth station standards family.

8. Conclusions

ETSI EN 302 574-3 [i.14] is an important Harmonized Standard for Mobile Earth Stations and User Equipment operating in the 1 980 MHz to 2 010 MHz and 2 170 MHz to 2 200 MHz MSS frequency bands. It specifically addresses UE for narrowband systems and supports compliance with Article 3.2 of the Radio Equipment Directive by defining technical requirements and conformance tests related to efficient spectrum use and avoidance of harmful interference. The standard is particularly relevant for narrowband MSS applications, including messaging, telemetry, tracking, emergency communications, safety-related services and satellite IoT/M2M connectivity. These use cases may not require broadband capacity, but they depend on reliable, spectrum-efficient and well-controlled access to satellite networks.

The most important technical elements of the standard are the control of unwanted emissions, spurious emissions, network access, terminal transmission states and prevention of uncontrolled transmissions. These requirements are essential to protect MSS operations, adjacent terrestrial mobile services and other systems using nearby frequency bands.

Although the standard remains valid and useful, the satellite sector has evolved significantly since the publication of ETSI EN 302 574-3 [i.14] (V2.1.1). Modern narrowband MSS terminals are increasingly software-controlled, remotely managed, integrated into IoT ecosystems and potentially deployed at large scale. These developments justify the review of the standard by the Experts Group.

ETSI EN 302 574-3 [i.14] should be maintained as a Harmonized Standard, but updated where necessary to reflect current RED requirements, modern narrowband MSS technologies, updated ETSI drafting practices and the continued need for robust interference protection in the 2 GHz MSS bands.

Experts Group- Review ETSI EN 303 980

ETSI EN 303 980 [i.5] - Fixed and in-motion Earth Stations communicating with non-geostationary satellite systems (NEST) in the 11 GHz to 14 GHz frequency bands

1. Introduction

ETSI EN 303 980 [i.5] is a Harmonized Standard developed by ETSI Technical Committee Satellite Earth Stations and Systems (SES). It applies to fixed and in-motion Earth Stations communicating with non-geostationary satellite systems, referred to as NEST, operating in the 11 GHz to 14 GHz Fixed-Satellite Service frequency bands. The standard specifies technical characteristics and methods of measurement for NEST terminals operating with NGSO FSS satellite systems. It covers terminals designed for both stationary and in-motion operation, including use on platforms such as trains, maritime vessels, aircraft and other vehicles. The current published version identified by ETSI is ETSI EN 303 980 [i.5] (V1.3.1), published in 2022. The standard supports compliance with Article 3.2 of Directive 2014/53/EU, the Radio Equipment Directive, which requires radio equipment to effectively use and support the efficient use of radio spectrum in order to avoid harmful interference.

ETSI EN 303 980 [i.5] is particularly important because it addresses a modern and rapidly growing category of satellite earth stations: user terminals communicating with NGSO broadband constellations in Ku-band. These systems are increasingly used for fixed broadband, maritime connectivity, aeronautical connectivity, land-mobile communications, enterprise services, cellular backhaul and resilient communications.

Within the Experts Group , ETSI EN 303 980 [i.5] is highly relevant because NGSO FSS networks have evolved quickly in recent years. Modern terminals are increasingly electronically steered, software-controlled, remotely managed and capable of dynamic satellite tracking. This creates a strong need to ensure that the Harmonized Standard remains aligned with current RED requirements, CEPT conditions, ITU regulatory provisions and industry practice.

2. Purpose of ETSI EN 303 980

The purpose of ETSI EN 303 980 [i.5] is to define technical requirements and test methods for fixed and in-motion Earth Stations communicating with NGSO satellite systems in the 11 GHz to 14 GHz FSS frequency bands. The standard provides a harmonized route for manufacturers to demonstrate conformity with Article 3.2 of the RED. It does not assign spectrum, authorise satellite networks or replace ITU coordination and national licensing obligations. Instead, it defines equipment-level requirements to ensure that NEST terminals use spectrum efficiently and avoid causing harmful interference.

The main objectives of the standard include:

- Ensuring that NEST terminals transmit only under controlled conditions.
- Limiting unwanted and spurious emissions.
- Controlling off-axis emissions.
- Ensuring accurate antenna beam pointing and satellite tracking.
- Ensuring correct operation during handover between NGSO satellites.
- Preventing transmissions when the terminal is not properly authorized or aligned.

- Protecting GSO FSS networks, other NGSO systems and terrestrial services where relevant.

A key purpose of the standard is therefore to manage the specific interference risks associated with NGSO earth stations. Unlike conventional GSO VSAT terminals, NEST terminals may track moving satellites across the sky, switch between satellites and operate from moving platforms. This makes beam pointing, terminal control and dynamic operational behaviour particularly important.

3. Technical Scope

ETSI EN 303 980 [i.5] applies to fixed and in-motion Earth Stations communicating with NGSO FSS satellite systems in Ku-band. The standard covers terminals operating in the following frequency ranges:

Direction	Frequency band	Use
Space-to-Earth	10,70 GHz - 12,75 GHz	Reception from NGSO FSS satellites
Earth-to-space	14,00 GHz - 14,50 GHz	Transmission from NEST to NGSO FSS satellites

The standard specifies that NEST terminals transmit in the 14,0 GHz to 14,5 GHz band and receive in the 10,7 GHz to 12,75 GHz band. It also identifies that terminals may be designed for stationary and in-motion operation.

The main technical areas covered include:

- Antenna beam pointing.
- Off-axis e.i.r.p. density.
- Unwanted emissions.
- Spurious emissions.
- Carrier-on and carrier-off states.
- Emissions disabled state.
- Terminal control and monitoring.
- Operation during satellite acquisition and tracking.
- Operation during handover between NGSO satellites.
- Conformance measurement methods.

The most distinctive technical feature of ETSI EN 303 980 [i.5] is that it addresses terminals communicating with NGSO satellite systems. Since NGSO satellites move relative to the earth station, the terminal should maintain accurate tracking and should avoid transmitting when the antenna beam is mis pointed or when the terminal is not under proper network control. This is particularly relevant for electronically steered antennas and phased-array terminals, where the antenna patterns, beam steering behaviour and sidelobe performance may differ significantly from traditional parabolic antennas.

4. Technological Relevance

ETSI EN 303 980 [i.5] is one of the most technologically relevant ETSI satellite Harmonised Standards because it addresses the deployment of modern NGSO FSS broadband systems. The satellite sector has changed substantially with the emergence of large NGSO constellations providing low-latency broadband connectivity. These systems differ from traditional GEO networks because satellites move rapidly relative to the user terminal, requiring continuous tracking, frequent handovers and dynamic resource management.

NEST terminals are therefore technologically more complex than traditional fixed VSATs. They may include electronically steered antennas, phased arrays, software-defined modems, automatic satellite acquisition, network-controlled transmit authorisation, adaptive coding and modulation, dynamic power control and remote software management. The standard is relevant for both fixed and in-motion connectivity. In fixed use cases, NEST terminals may provide broadband connectivity to homes, enterprises, remote sites, public services or backhaul locations. In in-motion use cases, they may support connectivity on aircraft, ships, trains, emergency vehicles, buses or other mobile platforms.

The technological relevance of ETSI EN 303 980 [i.5] is also linked to the need to protect existing GSO FSS networks. NGSO terminals operating in Ku-band may transmit towards satellites that move across the sky, creating a risk of interference into GSO satellites if antenna pointing, off-axis emissions and operational controls are not properly managed.

For this reason, ETSI EN 303 980 [i.5] is not only a terminal conformity standard. It is also an important element of the broader regulatory and technical framework that enables NGSO FSS systems to coexist with GSO FSS systems, other NGSO systems and terrestrial services.

5. Use by Industry

ETSI EN 303 980 [i.5] is used by equipment manufacturers, NGSO satellite operators, service providers, test laboratories, notified bodies, regulators and market surveillance authorities.

- For manufacturers, the standard provides a route to demonstrate conformity with Article 3.2 of the RED [i.37] for NEST terminals placed on the European market.
- For NGSO satellite operators, the standard supports the deployment of user terminals by ensuring that equipment meets defined technical requirements related to emissions, pointing accuracy, tracking and network control.
- For service providers, the standard is relevant because NEST terminals are increasingly used in a wide range of commercial and public-sector connectivity services, including:
    - Consumer and enterprise broadband.
    - Maritime connectivity.
    - Aeronautical connectivity.
    - Land-mobile broadband.
    - Rail and transport connectivity.
    - Emergency and disaster recovery communications.
    - Cellular backhaul.
    - Remote industrial connectivity.
    - Government and public safety communications.
- For regulators and market surveillance authorities, ETSI EN 303 980 [i.5] provides an equipment-level reference to assess whether NEST terminals are suitable for operation under the RED framework.

The industrial importance of ETSI EN 303 980 [i.5] is expected to increase as NGSO FSS systems continue to expand and as electronically steered user terminals become more common. This makes the review particularly important.

6. Relationship with CEPT and ITU

ETSI EN 303 980 [i.5] operates within a broader regulatory ecosystem.

- At CEPT level, the most relevant instrument is ECC/DEC/(17)04 [i.16], which addresses the harmonized use of the frequency bands 10,7 GHz to 12,75 GHz in the space-to-Earth direction and 14,0 GHz to 14,5 GHz in the Earth-to-space direction for fixed earth stations operating with NGSO FSS satellite systems. ECC/DEC/(17)04 [i.16] also allows exemption from individual licensing for fixed earth stations operating with NGSO FSS systems under defined conditions and requires protection of radio astronomy stations listed in its annexes. CEPT also identifies ETSI EN 303 980 [i.5] as the applicable Harmonized Standard for ESIM and NGSO FSS applications in the 10,7 GHz to 12,75 GHz and 14,0 GHz to 14,5 GHz frequency ranges.

In addition, ECC Report 279 [i.47] is relevant because it addresses technical, operational and regulatory requirements for the authorisation of Earth Stations In-Motion operating with NGSO FSS systems. This is particularly important for the in-motion part of ETSI EN 303 980 [i.5], where terminals may operate on aircraft, ships, trains or other vehicles.

- At ITU level, the 10,7 GHz to 12,75 GHz and 14,0 GHz to 14,5 GHz bands are part of the international Fixed-Satellite Service allocation framework under Article 5 of the Radio Regulations. NGSO FSS systems operating in these bands are subject to ITU coordination and notification procedures, particularly under Article 9 and Article 11.

The relationship with ITU is especially important because NGSO FSS systems need to coexist with GSO FSS networks and other NGSO systems. The ITU framework includes regulatory and technical mechanisms intended to ensure that NGSO systems do not cause unacceptable interference to GSO networks. This is directly relevant to the technical requirements in ETSI EN 303 980 [i.5] concerning off-axis emissions, antenna pointing, tracking accuracy and transmission control.

Relevant ITU-R material includes recommendations and studies on FSS earth station antenna patterns, off-axis e.i.r.p. density, NGSO/GSO sharing and equivalent power flux-density control. These technical concepts are reflected in the requirements of ETSI EN 303 980 [i.5], particularly where terminal emissions and antenna pointing behaviour affect interference into other satellite systems.

The relationship can therefore be summarised as follows:

Layer	Role
ITU Radio Regulations	International FSS allocation, coordination, notification and NGSO/GSO coexistence framework
ITU-R Recommendations and studies	Technical basis for sharing, antenna performance, off-axis emissions and interference management
CEPT/ECC Decisions and Reports	European harmonisation, licensing exemption and authorisation framework for NGSO FSS earth stations
ETSI EN 303 980 [i.5]	Equipment-level technical requirements and test methods for fixed and in-motion NEST terminals
RED 2014/53/EU [i.37]	Legal conformity framework for radio equipment placed on the EU market

ETSI EN 303 980 [i.5] does not replace ITU filing, coordination, notification or national authorisation obligations. It is concerned with the conformity of radio equipment. Network operators should still ensure that their satellite systems comply with ITU, CEPT, EU and national regulatory obligations.

In this context, the Harmonized Standard provides a practical implementation of international and regional regulatory requirements at equipment level, ensuring that NEST terminals operate within controlled and predictable conditions.

7. Areas for potential update

Several areas may justify review or update of ETSI EN 303 980 [i.5].

1) The standard should be reviewed against the latest RED Harmonized Standard drafting requirements, including structure, terminology, normative references and Annex ZA.

2) The requirements for antenna beam pointing and tracking should be carefully reviewed. NEST terminals communicate with moving NGSO satellites, and therefore pointing accuracy, tracking performance and behaviour during satellite acquisition and handover are central to interference prevention.

3) The treatment of electronically steered antennas and phased arrays should be assessed. Many modern NGSO user terminals use flat-panel antennas rather than traditional parabolic antennas. These antennas may have different sidelobe characteristics, scan-angle behaviour and failure modes.

4) The requirements for in-motion operation should be reviewed. Terminals installed on aircraft, ships, trains or vehicles may experience vibration, acceleration, blockage, rapid attitude changes and dynamic pointing constraints. The standard should ensure that the terminal does not transmit in unsafe or non-compliant conditions.

5) Network control and software-defined operation should be addressed clearly. Modern terminals may be remotely configured, updated and controlled by the satellite network. The standard should ensure that software-controlled parameters, power control, beam selection and transmit authorisation remain testable and predictable.

6) The standard should be reviewed for consistency with CEPT authorisation frameworks, especially ECC/DEC/(17)04 [i.16] and ECC Report 279 [i.47]. This is important because equipment conformity, licensing exemption and operational authorisation are linked but not identical regulatory concepts.

7) Coexistence with GSO FSS systems and other NGSO systems should remain a central focus. The Ku-band environment is increasingly dense, and robust control of emissions, pointing and terminal states is essential.

8) The standard should be reviewed for consistency with other ETSI SES Harmonised Standards covering ESIM, VSAT and NGSO terminals, and provides an opportunity to harmonise terminology and test method presentation across the standards family.

8. Conclusions

ETSI EN 303 980 [i.5] is a highly important Harmonized Standard for fixed and in-motion Earth Stations communicating with non-geostationary satellite systems in the 11 GHz to 14 GHz frequency bands. It supports compliance with Article 3.2 of the Radio Equipment Directive by defining technical requirements and conformance tests related to efficient spectrum use and avoidance of harmful interference. The standard is particularly relevant because NGSO FSS systems are now a central part of the satellite communications market. NEST terminals are used for fixed broadband, maritime connectivity, aeronautical connectivity, land-mobile services, enterprise networks, emergency communications and cellular backhaul.

The most important technical elements of the standard are antenna beam pointing, satellite tracking, off-axis e.i.r.p. density, unwanted emissions, spurious emissions, transmission control and terminal behaviour during acquisition, tracking and handover. These requirements are essential to protect GSO FSS networks, other NGSO systems, radio astronomy stations and, where relevant, terrestrial services.

Although ETSI EN 303 980 [i.5] remains valid and highly relevant, the satellite sector has evolved rapidly since its first publication. Modern NEST terminals are increasingly based on electronically steered antennas, software-defined control, remote management and dynamic operation across complex NGSO constellations. These developments justify the review of the standard.

ETSI EN 303 980 [i.5] should be maintained as a Harmonized Standard, but updated where necessary to reflect current RED requirements, modern NGSO terminal technologies, updated ETSI drafting practices and the continued need for robust interference protection in Ku-band NGSO FSS operations.

B.6 Analysis Expert "JS"

Experts Group - Review of ETSI EN 301 721

LEO MSS Applications below 1 GHz and ETSI EN 301 721 [i.11] in the European Framework (ECC Report 322 [i.56])

1. Introduction

This analysis provides an overview of the European regulatory and standardization framework applicable to Low Earth Orbit (LEO) Mobile Satellite Service (MSS) systems operating below 1 GHz, with a specific focus on:

- ETSI EN 301 721 [i.11].
- Relevant CEPT / ECC documentation.
- Practical use in commercial applications.
- National regulatory authorities that actively rely on the corresponding CEPT technical studies.

The scope intentionally covers low bit rate data communications (LBRDC) and excludes broadband or IMT NTN systems.

2. ETSI EN 301 721 - Purpose and Scope

2.1 Definition

ETSI EN 301 721 [i.11] is a Harmonised European Standard under the Radio Equipment Directive (2014/53/EU [i.37] - RED).

It applies to:

- Mobile Earth Stations (MES).
- Providing Low Bit Rate Data Communications (LBRDC).
- Through LEO satellite systems.
- Operating below 1 GHz.
- In the Mobile Satellite Service (MSS).

The standard covers Article 3.2 of the RED, i.e. effective and efficient use of radio spectrum.

2.2 Frequency Bands Covered

ETSI EN 301 721 [i.11] applies to MES operating in MSS allocations below 1 GHz, including:

- 137 MHz - 138 MHz.
- 148 MHz - 150,05 MHz.
- 399,9 MHz - 400,05 MHz.
- 400,15 MHz - 401 MHz.

These are commonly referred to as the "Little LEO" MSS bands.

2.3 Nature of the Standard

Key characteristics:

- ETSI EN 301 721 [i.11] is a terminal equipment standard, not an operator or network standard.
- Compliance is normally demonstrated by manufacturers as part of CE marking.
- Operators are not expected to publicly reference ETSI EN 301 721 [i.11], even when their terminals comply with it.

This explains why direct references to ETSI EN 301 721 [i.11] are rare in operator-facing documentation.

3. Commercial Applications Covered by ETSI EN 301 721

Although the standard does not list operators or services, its technical scope clearly aligns with well established commercial uses, including:

- Satellite IoT (low data rate).
- Asset tracking and logistics.
- Environmental and agricultural monitoring.
- Industrial telemetry and SCADA-style monitoring.
- Maritime and remote-area messaging.
- Safety, emergency, and professional communications.

All these applications share:

- Very low throughput.
- Short message length.
- High robustness.

- Wide-area / global coverage.

4. Operators Whose Systems Fall Within the Scope

While operators do not explicitly state compliance with ETSI EN 301 721 [i.11], several commercial LEO MSS operators operate systems that technically fall within its scope in Europe, including:

- Argos / Kinéis.
- ORBCOMM.
- Iridium (for low-rate data services).
- New-generation IoT-focused LEO MSS operators (e.g. Swarm, Myriota, Hiber).

For equipment placed on the EU market, ETSI EN 301 721 [i.11] is the relevant harmonized standard typically used for RED Article 3.2 compliance.

5. CEPT / ECC Framework for LEO MSS below 1 GHz

5.1 Role of CEPT vs ETSI

The regulatory architecture is deliberate:

- CEPT / ECC:
    - Defines spectrum access conditions.
    - Performs compatibility and sharing studies.
    - Supports ECC Decisions and national authorisations.
- ETSI:
    - Defines technical equipment requirements.
    - Provides harmonized standards under EU law.

As a result, ECC Decisions and Reports do not usually cite ETSI standards by number.

6. Key ECC Report Applicable to These Systems

ECC Report 322 [i.56] (2022)

Title: Compatibility analysis (inter service and intra service) for S PCS below 1 GHz

Relevance:

- Explicitly addresses LEO Mobile Satellite Systems below 1 GHz.
- Covers non voice, low bit rate data services.
- Analyses inter service and intra service coexistence.
- Studies concrete systems such as:
    - ARGOS / Kinéis.
    - Swarm.
    - Myriota.
    - Hiber.
    - Other S PCS / MSS LEO systems.

Frequency range:

- 137 MHz - 138 MHz.
- 148 MHz - 150 MHz.
- 399,9 MHz - 401 MHz.

ECC Report 322 [i.56] is therefore the main CEPT technical reference for "Little LEO" MSS systems and is fully aligned with the scope of ETSI EN 301 721 [i.11].

6.1 Relationship Between ECC Report 322 and ETSI EN 301 721

- ECC Report 322 [i.56]:
  - Justifies if and how spectrum can be used.
  - Defines coexistence assumptions.
- ETSI EN 301 721 [i.11]:
  - Defines how the terminal equipment should behave.
  - Enables market access under the RED.

They are complementary, not overlapping.

7. National Administrations Actively Using ECC Report 322

7.1 France - ANFR

France is the most prominent national administration using ECC Report 322 [i.56] in practice:

- Hosts and regulates Argos / Kinéis.
- Actively participates in ECC Working Groups (WG SE, SE40).
- Uses ECC Report 322 [i.56] as a technical basis for MSS LEO below 1 GHz authorisations.
- Relies on it for compatibility assessment and spectrum coordination.

ANFR is therefore the clearest national example.

7.2 Germany - Bundesnetzagentur (BNetzA)

Germany also makes clear technical use of ECC Report 322 [i.56]:

- Applies it particularly in the 400,15 MHz - 401 MHz band.
- Treats MSS LEO spectrum as a shared resource.
- Uses ECC Report 322 [i.56] assumptions in coexistence and spectrum occupation analysis.
- Actively contributed to working documents linked to the report.

7.3 Other CEPT Administrations

- Other CEPT countries generally:
  - Follow ECC Decisions.
  - Use ECC Reports indirectly.
- ECC Report 322 [i.56] is increasingly referenced as best technical practice, even where not cited explicitly in licenses

8. Conclusions

- ETSI EN 301 721 [i.11] is the harmonized standard for LEO MSS terminal equipment operating below 1 GHz in Europe.
- ECC Report 322 [i.56] is the central CEPT technical study for these systems.
- The two documents are structurally complementary:
  - ECC justifies spectrum use
  - ETSI enables equipment compliance
- France (ANFR) and Germany (BNetzA) are the administrations that most clearly rely on ECC Report 322 in national practice.
- The framework is commercially active and mature, not experimental.

Possible take aways for the Experts Group

Proposed update directions for ETSI EN 301 721 [i.11] to reflect ECC Report 322 [i.56] (S PCS below 1 GHz) multi system coexistence findings.

1. Background

ETSI EN 301 721 [i.11] is a Harmonized Standard addressing RED Article 3.2 for Mobile Earth Stations providing Low Bit Rate Data Communications via LEO systems below 1 GHz.

Since publication, CEPT ECC has approved ECC Report 322 [i.56], which provides detailed inter-service and intra-service compatibility studies for S PCS below 1 GHz, including multi system coexistence aspects (e.g. aggregate interference, co frequency sharing, time-domain studies) and system-specific operational constraints.

2. Problem statement / Rationale

While ETSI EN 301 721 [i.11] includes comprehensive transmitter emission and CMF requirements (e.g. unwanted emissions, EIRP density, carrier-off state, CMF authorization and frequency control, and RAS protection), it does not explicitly address:

- Intra MSS multi operator coexistence requirements and related verification methods (time-domain occupancy, aggregation assumptions).
- Explicit CMF-driven enforcement of certain operational constraints discussed in ECC Report 322 [i.56] (e.g. cessation of emissions, retransmission limiting, interference avoidance mechanisms).
- Guidance on aggregate scenarios relevant to RAS (multi constellation), as discussed in ECC Report 322 [i.56].

This may lead to uncertainty for market access, laboratory testing, and alignment with national authorization expectations derived from CEPT studies.

3. Proposed update directions (high-level)

It is proposed that TC SES considers initiating a revision of ETSI EN 301 721 [i.11] along the following lines:

(A) Add an explicit clause on intra service (MSS/MSS) coexistence

Introduce a new clause under "4.2 Conformance requirements", e.g. "4.2.9 Intra-service coexistence requirements (S PCS <1 GHz)", addressing:

- Measurable time-domain occupancy / duty-cycle parameters.
- Coexistence mechanisms (e.g. polite spectrum access).
- Criteria supporting co channel sharing and aggregation considerations.

(B) Extend CMF requirements to support operational constraints

- Update "4.2.5 MES Control and Monitoring Functions (CMF)" to include:
  - Enforceable "cessation of emissions" capability (under loss of authorisation or network command).
  - Retransmission limiting behaviour (where applicable).
  - Optional geo/time constraints enforcement (where applicable).

(C) Enhance RAS-related sections with aggregate guidance

Maintain existing "4.2.7 Protection of RAS …" and add an informative annex describing how aggregate multi constellation considerations may be assessed, aligned with ECC Report 322 [i.56] Annex 3.

(D) Update test methodologies

Update Clause 5 to include:

- Measurement/reporting of duty cycle and time-domain behaviour.
- Verification of CMF-related enforcement (time to cease, reauthorisation).
- Optional guidance for coexistence-related testing.

4. Suggested mapping between ECC Report 322 and ETSI EN 301 721 (for drafting)

ECC Report 322 [i.56] includes:

- In the chapter 2 "Services to consider…" with associated standards/recommendations, which aligns with ETSI EN 301 721 [i.11] emission and RAS protection clauses (4.2.1-4.2.4, 4.2.7).
- In the Annex 2 "Intra-services studies" including aggregate interference and time-domain studies, which currently has no explicit counterpart in ETSI EN 301 721 [i.11] and motivates the proposed new clause 4.2.9 and updated test methods.

5. Expected benefits

- Improved alignment between Harmonized Standard compliance and CEPT compatibility assumptions for S PCS below 1 GHz.
- Clearer verification of behaviours relevant to multi operator coexistence.
- Reduced ambiguity for test labs and manufacturers under RED Article 3.2 [i.37].

6. Requested action from TC SES (under support of the Experts Group)

TC SES would need:

1) Consider launching a formal revision work item for ETSI EN 301 721 [i.11] addressing the update directions above; significant work will be required to update ETSI EN 301 721 [i.11] to the latest version of the ECC Report 322 [i.56].
2) Nominate rapporteur(s) and agree an initial drafting plan (including whether coexistence elements are normative or informative where appropriate).
3) Probably, the revision of ETSI EN 301 721 [i.11] falls under lower priority among the Experts Group selected ENs.

Experts Group - Review ETSI EN 303 980

ETSI EN 303 980 [i.5] - NGSO Ku band Satellite Earth Stations

1. Introduction

Non geostationary satellite orbit (NGSO) systems operating in the Ku band are now widely deployed in Europe, supporting fixed and in motion connectivity through very large populations of earth stations. In this context, ETSI EN 303 980 [i.5] is the European harmonized standard enabling compliance with Article 3.2 of the Radio Equipment Directive (RED) for NGSO Ku band satellite earth stations, thereby supporting CE marking and market access.

Since the standard was adopted, NGSO deployments have become denser, more dynamic and increasingly reliant on electronically steered antennas, while regulatory focus at CEPT and ITU level has shifted towards aggregate interference and multi system coexistence. This review, carried out under the Experts Group, assesses whether ETSI EN 303 980 [i.5] remains aligned with current technological and regulatory assumptions and identifies whether targeted technical updates may be appropriate.

2. Purpose of ETSI EN 303 980

The purpose of ETSI EN 303 980 [i.5] is strictly technical and market enabling. It defines radio frequency requirements and measurement methods that allow manufacturers to demonstrate efficient spectrum use and avoidance of harmful interference in accordance with RED Article 3.2.

The standard does not regulate operators, assign spectrum, or establish system level coordination rules. Its role is limited to implementing higher level regulatory assumptions at equipment level, in line with the established European regulatory framework.

3. Technical Scope

The standard applies to fixed earth stations and Earth Stations in Motion (ESIM) associated with NGSO Fixed Satellite Service systems operating in the Ku band, typically:

- 10,7 GHz - 12,75 GHz (space to Earth).
- 14,0 GHz - 14,5 GHz (Earth to space).

It focuses on individual equipment performance, addressing EIRP and spectral density limits, out of band and spurious emissions, basic control and disabling functions, and classical RF conformity assessment methods. Aggregate or system level behaviour is outside its normative scope.

4. Technological Relevance

ETSI EN 303 980 [i.5] remains valid for controlling the RF footprint of individual terminals and for supporting reproducible conformity assessment. However, it does not explicitly address features that now dominate NGSO deployments, such as aggregate interference from large terminal populations, widespread use of electronically steered antennas, and highly dynamic domain operation.

The standard is therefore not obsolete but reflects assumptions originating from earlier NGSO deployment models.

5. Use by Industry

Manufacturers of NGSO Ku band terminals and ESIM solutions widely rely on ETSI EN 303 980 [i.5] for RF design, testing and preparation of CE marking documentation. Its role is essential for market access but largely invisible in public materials.

Satellite operators do not explicitly reference the standard, but depend directly on it, as compliant terminals are a prerequisite for operation in Europe. This applies to operators such as OneWeb, Starlink and Amazon Kuiper.

6. Relationship with CEPT and ITU

CEPT/ECC defines spectrum access conditions and coexistence assumptions, while the ITU Radio Regulations provide the global framework for NGSO operation. ETSI EN 303 980 [i.5] translates these higher level rules into verifiable equipment level requirements.

Recent regulatory work has increasingly focused on aggregate and dynamic effects, elements that are only partially reflected in ETSI EN 303 980 [i.5].

7. Areas for potential update

ETSI EN 303 980 [i.5] adequately covers power limits, spectral emissions, classical RF testing and basic control functions. Potential candidates for targeted technical update include:

- Multi operator NGSO coexistence.
- Aggregate interference assessment using statistical approaches.
- Explicit consideration of Electronically Steered Antenna (ESA) behaviour.
- Dynamic and time domain measurement methodologies.

Any update should remain equipment focused and avoid duplication of CEPT or ITU regulatory provisions.

8. Conclusions

ETSI EN 303 980 [i.5] remains an essential and valid harmonized standard enabling EU market access for Ku band NGSO satellite earth stations. At the same time, the evolution towards dense and dynamic NGSO deployments has created a growing gap between current regulatory assumptions and the equipment centric verification framework of the standard.

Final conclusion: ETSI EN 303 980 [i.5] is not obsolete, but technologically strained, and represents a clear candidate for a focused and proportionate technical review.

History

Version	Date	Status
V1.1.1	July 2026	Publication