ETSI TR 103 896 V1.1.1 (2023-07)

TECHNICAL REPORT

Satellite Earth Stations and Systems (SES); Considerations on off-axis EIRP density mask applicability for Ka band GSO ESOMPs in relation to potential revision to ETSI EN 303 978 (V2.1.2)

Reference
DTR/SES-00463

Keywords
radio parameters, satellite

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

Important notice

The present document can be downloaded from:
https://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

If you find a security vulnerability in the present document, please report it through our Coordinated Vulnerability Disclosure Program:
https://www.etsi.org/standards/coordinated-vulnerability-disclosure

Notice of disclaimer & limitation of liability

The information provided in the present deliverable is directed solely to professionals who have the appropriate degree of experience to understand and interpret its content in accordance with generally accepted engineering or other professional standard and applicable regulations.
No recommendation as to products and services or vendors is made or should be implied.
No representation or warranty is made that this deliverable is technically accurate or sufficient or conforms to any law and/or governmental rule and/or regulation and further, no representation or warranty is made of merchantability or fitness for any particular purpose or against infringement of intellectual property rights.
In no event shall ETSI be held liable for loss of profits or any other incidental or consequential damages.

Any software contained in this deliverable is provided "AS IS" with no warranties, express or implied, including but not limited to, the warranties of merchantability, fitness for a particular purpose and non-infringement of intellectual property rights and ETSI shall not be held liable in any event for any damages whatsoever (including, without limitation, damages for loss of profits, business interruption, loss of information, or any other pecuniary loss) arising out of or related to the use of or inability to use the software.

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.
The content of the PDF version shall not be modified without the written authorization of ETSI.
The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2023.
All rights reserved.

Contents

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM**® and the GSM logo are trademarks registered and owned by the GSM Association.

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).

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

Executive summary

The off-axis EIRP density mask included in clause 4.2.3 of ETSI EN 303 978 [i.4], which refers to COPOL and crosspol components (and the consequential test clause 6.4 of ETSI EN 303 978 [i.4]) has not been reconsidered since its creation in 2013. It now appears that consideration of total transmitted off axis EIRP density rather than its polarized components would bring ETSI EN 303 978 [i.4] more in line with the masks used in ITU-R Resolution 156 [i.6] on Earth Stations In Motion (ESIM) and Recommendation ITU-R S.524-9 [i.1]. These masks are used globally, including in Europe for inter-satellite coordination and for the protection of the GSO arc.

Introduction

It is proposed to revise the off axis EIRP density mask which has been inserted in ETSI EN 303 978 [i.4] in 2013 and in the subsequent versions up to V2.1.2. The present document is intended to show that considering the total transmitted off axis EIRP rather than its polarized components is consistent with other International masks and equally suitable for the protection of satellites on the GSO arc.

ETSI EN 303 978 [i.4] was published ten years ago in 2013. Experience acquired since then on ESOMPs has shown that protection of the GSO arc from their off-axis transmissions using a mask for the total transmitted off axis EIRP density is more consistent with current practices than use of the present masks which consider the polarized components of the off-axis transmission.

1 Scope

The present document aims at studying the implications of reviewing the applicability of the mask for off-axis EIRP density in ETSI EN 303 978 (V2.1.2) [i.9].

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

[i.1] Recommendation ITU-R S.524 (May 2000): "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.2] ETSI EN 301 459 (October 2000): "Satellite Earth Stations and Systems (SES); Harmonized EN for Satellite Interactive Terminals (SIT) and Satellite User Terminals (SUT) transmitting towards satellites in geostationary orbit in the 29,5 to 30,0 GHz frequency bands covering essential requirements under article 3.2 of the R&TTE Directive".

[i.3] Recommendation ITU-R S.1594 (September 2022): "Maximum emission levels and associated requirements of high density fixed-satellite service earth stations transmitting towards geostationary fixed-satellite service space stations in the 30 GHz range".

[i.4] ETSI EN 303 978 (V1.1.2) (2013): "Satellite Earth Stations and Systems (SES); Harmonised Standard for Earth Stations on Mobile Platforms (ESOMP) transmitting towards satellites in geostationary orbit, operating in the 27,5 GHz to 30,0 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.5] Report ITU-R S.2357 (2015-06): "Technical and operational guidelines for earth stations on mobile platforms communicating with geostationary space stations in the fixed-satellite service in the frequency bands 19.7 20.2 GHz and 29.5-30.0 GHz".

[i.6] ITU-R Final Acts (WRC-15) (2015) Resolution 156: "Use of the frequency bands 19.7-20.2 GHz and 29.5-30.0 GHz by earth stations in motion communicating with geostationary space stations in the fixed-satellite service".

[i.7] FCC 47 CFR 25.138 (2014): "Licensing requirements for GSO FSS Earth Stations in the 18.3-18.8 GHz (space-to-Earth), 19.7-20.2 GHz (space-to-Earth), 28.35-28.6 GHz (Earth-to-space), and 29.25-30.0 GHz (Earth-to-space) bands".

[i.8] ITU-R Final Acts (WRC-19) Resolution 169: "Use of the frequency bands 17.7-19.7 GHz and 27.5-29.5 GHz by earth stations in motion communicating with geostationary space stations in the fixed-satellite service".

[i.9] ETSI EN 303 978 (V2.1.2) (2016): "Satellite Earth Stations and Systems (SES); Harmonised Standard for Earth Stations on Mobile Platforms (ESOMP) transmitting towards satellites in geostationary orbit, operating in the 27,5 GHz to 30,0 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

3 Definition of terms, symbols, and abbreviations

3.1 Terms

Void.

3.2 Symbols

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

$U_{TOT}(\theta,\phi)$ radiation intensity of an antenna defined as the power per unit solid angle (distance independent)

NOTE: The subscript denotes the polarization basis (TOT = total polarization, L = left handed circular, etc.).

(θ,ϕ) spherical coordinate system
P_{Acc} power accepted by the antenna
η_0 free space impedance; namely 377 ohms for standard atmosphere
E_L radiated electric far field

NOTE: The subscript denotes the polarization basis (TOT = total polarization, L = left handed circular, θ is the spherical theta-aligned polarization, x is the x-aligned or horizontal linear polarization, etc.).

G_{TOT} gain of the antenna

NOTE: The subscript denotes the polarization basis.

r radial distance away from an antenna

3.3 Abbreviations

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

AZ Azimuth
COPOL CO-POLarization gain pattern
CP Circular Polarization
EIRP Effective Isotropically Radiated Power
EIRP-SD Effective Isotropically Radiated Power Spectral Density
EL Elevation
ES Earth Station
ESIM Earth Stations In Motion
ESOMP Earth Station Onboard Mobile Platform
FCC US Federal Communications Commission
GSO Geostationnary Orbit
LHCP Left Hand Circular Polarization
RHCP Right Hand Circular Polarization
RX Receive
TOT Total polarization
TOTPOL Total Polarization gain pattern
TX Transmit
WRC World Radiocommunications Conference
XPOL Cross-Polarization gain pattern

4 Applicability of off-axis EIRP density within the band in ETSI EN 303 978

4.0 General

The specifications for off-axis EIRP density within the band for different standardization texts referenced in clause 2.2 above are compared in Table 1 below.

Table 1: Comparison of Ka band ES off-axis EIRP density in published standardization texts

Source	Date	Applicability	Co-polarization	Cross polarization	No reference to polarization
Recommendation ITU-R S.524 [i.1]	May 2000	within ±3° of the GSO			19 - 25 log Φ dBW/40 kHz for 2,0° ≤ Φ ≤ 7,0°; -2 dBW/40 kHz for 7,0° < Φ ≤ 9,2°; 22 - 25 log Φ dBW/40 kHz for 9,2° < Φ ≤ 48°; -10 dBW/40 kHz for 48° < Φ ≤ 180°
ETSI EN 301 459 [i.2]	End 2000	within ±3° of the GSO	19 - 25 log Φ dBW/40 kHz for 1,8° ≤ Φ ≤ 7,0°; -2 dBW/40 kHz for 7,0° < Φ ≤ 9,2°; 22 - 25 log Φ dBW/40 kHz for 9,2° < Φ ≤ 48°; -10 dBW/40 kHz for 48° < Φ ≤ 180°	9 - 25 log Φ dBW/40 kHz for 1,8° ≤ Φ ≤ 7,0° -12 dBW/40 kHz for 7,0° < Φ ≤ 9,2°	
Recommendation ITU-R S.1594 [i.3]	September 2002	within ±3° of the GSO	19 - 25 log Φ dBW/40 kHz for 2,0° ≤ Φ ≤ 7,0°; -2 dBW/40 kHz for 7,0° < Φ ≤ 9,2°; 22 - 25 log Φ dBW/40 kHz for 9,2° < Φ ≤ 48°; -10 dBW/40 kHz for 48° < Φ ≤ 180°	9 - 25 log Φ dBW/40 kHz for 2,0° ≤ Φ ≤ 7,0° -12 dBW/40 kHz for 7,0° < Φ ≤ 9,2°	
ETSI EN 303 978 [i.4]	2013	within ±3° of the GSO	19 - 25 log Φ dBW/40 kHz for 2,0° ≤ Φ ≤ 7,0° -2 dBW/40 kHz for 7,0° < Φ ≤ 9,2° 22 - 25 log Φ dBW/40 kHz for 9,2° < Φ ≤ 48° -10 dBW/40 kHz for 48° < Φ ≤ 180°	9 - 25 log Φ dBW/40 kHz for 2,0° ≤ Φ ≤ 7,0° -12 dBW/40 kHz for 7,0° < Φ ≤ 9,2°	
FCC 47 CFR 25.138 [i.7]	2014	within ±3° of the GSO	18,5 - 25 logΦ dBW/40 kHz for 2,0° ≤Φ ≤7° -2,63 dBW/40 kHz for 7° ≤Φ ≤9,23° 21,5 - 25 logΦ dBW/40 kHz for 9,23° ≤Φ ≤48° -10,5 dBW/40 kHz for 48°<Φ ≤180°	8,5 - 25 logΦ dBW/40 kHz for 2,0° <Φ ≤7,0° -12,63 dBW/40 kHz for 7.0°<Φ ≤9,23°	
Report ITU-R S.2357 [i.5] & ITU-R Resolution 156 (WRC-15) [i.6]	2015	within ±3° of the GSO			19 - 25 log Φ dBW/40 kHz for 2,0° ≤ Φ ≤ 7,0°; -2 dBW/40 kHz for 7,0° < Φ ≤ 9,2°; 22 - 25 log Φ dBW/40 kHz for 9,2° < Φ ≤ 48°; -10 dBW/40 kHz for 48° < Φ ≤ 180°;

The latest regulatory texts (Report ITU-R S.2357 [i.5], ITU-R Resolution 156 (WRC-15) [i.6] and ITU-R Resolution 169 (WRC-19)) [i.8] do not mention explicitly a reference to polarization for the mask.

In order to protect other satellites on the geostationary orbit, it makes more sense to take into account the total off-axis transmitted power rather than taking into account a co-pol and a cross- pol components which may become meaningless a few degrees away from the main axis of the transmit antenna. In fact, the majority of ITU inter-satellite coordination agreements do not consider co-pol and cross-pol components separately and set limits on emissions towards each other's networks based on power density without regard to polarization. The rationale for use of a total EIRP density limit toward other GSO satellite networks is reasonable because GSO satellites typically operate on both polarizations. That is, the target GSO satellite can operate with either RHCP, LHCP, or both polarizations in a given geographic area. Operators of nearby GSO satellites can expect full power emissions from either polarization from the satellite and from earth stations accessing the target satellite, reduced only by the off-axis gain reduction in the direction of the given nearby satellite.

On-axis cross-polar emission limits are needed mainly for the purposes of frequency reuse on the target satellite - not for adjacent or nearby satellites which as noted above could see co-polar emissions on both polarizations from earth stations of the target GSO Network.

It is thus proposed to:

1) suppress the reference to polarization in clause 4.2.3 of ETSI EN 303 978 [i.9], replacing the EIRP density limitation on polarized components by total transmitted power density;

2) maintain the present mask which applied for the co-polarized component and becomes a mask for total transmitted off-axis EIRP density (which would be in line with ITU-R Resolution 156 (WRC-15) [i.6].

Consequently, changes in clause 4.2.3 of ETSI EN 303 978 [i.9] would read as follows:

"4.2.3.2 ~~Co-polarized~~ Specification

The following specifications apply to the ESOMP transmitting at EIRP values up to $EIRP_{max}$.

The ~~maximum~~ <u>total</u> EIRP in any 40 kHz band within the nominated bandwidth ~~of the co-polarized component~~ in any direction ϕ degrees from the antenna main beam axis shall not exceed the following limits for more than 0,01 % of the time:

19 - 25 log ϕ -K	*dBW*	*for*	*2,0°*	≤	ϕ	≤	*7,0°;*
-2 - K	*dBW*	*for*	*7,0°*	<	ϕ	≤	*9,2°;*
22 - 25 log ϕ -K	*dBW*	*for*	*9,2°*	<	ϕ	≤	*48°;*
-10 -K	*dBW*	*for*	*48*	<	ϕ	≤	*180°;*

where:

- *ϕ is the angle, in degrees, between the main beam axis and the direction considered; and*
- *K is as defined in clause 4.2.2.2.1."*

4.2.3.4 Cross-polarization Specification

The following mask is included in ETSI EN 303 978 (V2.1.2) [i.9]:

9 - 25 log Φ dBW/40 kHz	for 2,0° ≤ Φ ≤ 7,0°
-12 dBW/40 kHz	for 7,0° < Φ ≤ 9,2°)

It would become Void in any revision of ETSI EN 303 978 for the reasons developed in the present document.

Suggested changes to clause 6.4:

6.4 Off-axis EIRP emission density within the band

Currently, the fourth paragraph of this clause reads:

"The EIRP density is determined from the measurements of the antenna copolar and crosspolar gain patterns, and of the power density at the antenna flange."

Suggested new text developing the total off-axis EIRP density method is as follows:

"The total off-axis EIRP density is determined from the measurements of the antenna copolar and crosspolar gain patterns, and of the power density at the antenna flange. For each off-axis angle considered, the copolar and crosspolar gains are combined together to develop a total gain in that direction."

New clause 6.4.1.4 should be added which describes how the copolar and crosspolar gains are numerically combined for the azimuth and elevation gain pattern cuts to develop a total off-axis gain pattern for azimuth and elevation.

Basically, for each angle X between ±180°, compute:

10 × $\log_{10}$(10^(copolar gain (dBi) at angle X/10) + 10^(crosspolar gain(dBi) at angle X/10))

and record this new value as the total off-axis gain (dB) to be combined with the antenna input power density to determine the total off-axis EIRP density.

4.1 Rationale for revision of off-axis EIRP density applicability

The rationale is to better protect neighbouring satellites on the geostationary orbit from off-axis transmission from an ESOMP with a mask consistent with modern regulatory framework for ESOMPs and with current inter-satellite coordination practices.

4.2 Total Gain Definition

The total EIRP density which has been referenced earlier is the product of the transmitted power density by the "total gain" of the ESOMP. This "total gain" is defined in this clause.

Radiation intensity or "U" can be expressed conventionally by either total or individual polarization (e.g. "L" or LHCP):

$$U_{TOT}(\theta,\phi) = \frac{1}{2}\frac{\left|\vec{E}\right|^2}{\eta_0}r^2$$

$$Or\ Single\ POL, e.g.: U_L(\theta,\phi) = \frac{1}{2}\frac{\left|\vec{E}_L\right|^2}{\eta_0}r^2$$

This is directly proportional to the gain by:

$$G_{TOT}(\theta,\phi) = \frac{4\pi}{P_{Acc}}U_{TOT}(\theta,\phi)$$

$$Or\ Single\ POL, e.g.: G_L(\theta,\phi) = \frac{4\pi}{P_{Acc}}U_L(\theta,\phi)$$

Where the total electric field can be expressed as:

$$\vec{E} = E_L\hat{L} + E_R\hat{R} = E_x\hat{x} + E_y\hat{y} = E_\theta\hat{\theta} + E_\phi\hat{\phi}$$

$$where\ E_{POL} = \vec{E}\cdot P\hat{O}L^*$$

And the squared, complex L2-norm of E can be expressed by:

$$\left|\vec{E}\right|^2 = |E_L|^2 + |E_R|^2 = |E_x|^2 + \left|E_y\right|^2 = |E_\theta|^2 + \left|E_\phi\right|^2$$

Thus the total radiation intensity can be expressed as (for example):

$$U(\theta,\phi)=\frac{1}{2}\frac{|E_L|^2+|E_R|^2}{\eta_0}r^2=U_L(\theta,\phi)+U_R(\theta,\phi)$$

And finally total gain can be expressed as (for example):

$$\boxed{G_{TOT}(\theta,\phi)=G_L(\theta,\phi)+G_R(\theta,\phi)}$$

Or in dB form:

$$\boxed{10\log_{10}\big(G_{TOT}(\theta,\phi)\big)=10\log_{10}\big(G_L(\theta,\phi)+G_R(\theta,\phi)\big)}$$

5 Total Off-Axis Gain Case Studies

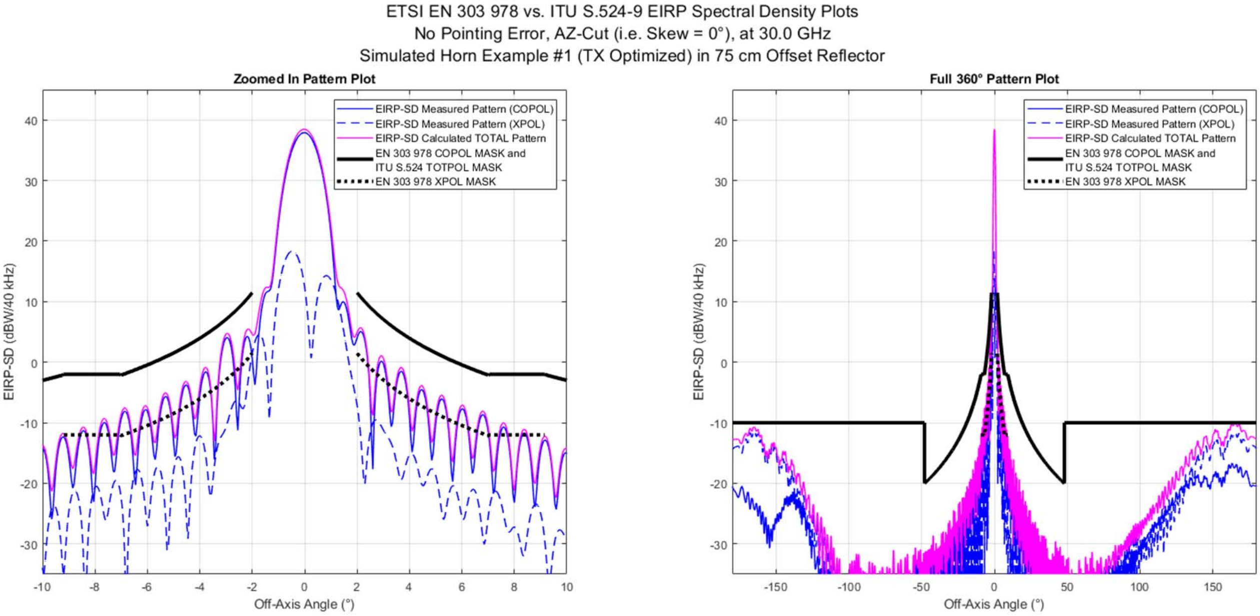
This clause illustrates the concepts outlined in the previous clause by applying the concept of total polarization against Recommendation ITU-R S.524 [i.1] (or equivalently Report ITU-R S.2357 [i.5] & ITU-R Resolution 156 [i.6]) EIRP-SD mask vs. the separated-by-polarization EIRP-SD mask recommendation in ETSI EN 303 978 [i.4]. Two antenna configurations are considered:

1) a 29,5 to 30,0 GHz optimized horn (TX) in an offset 75 cm reflector; and

2) a 18,7 to 19,2 GHz optimized horn (RX) in an offset 75 cm reflector.

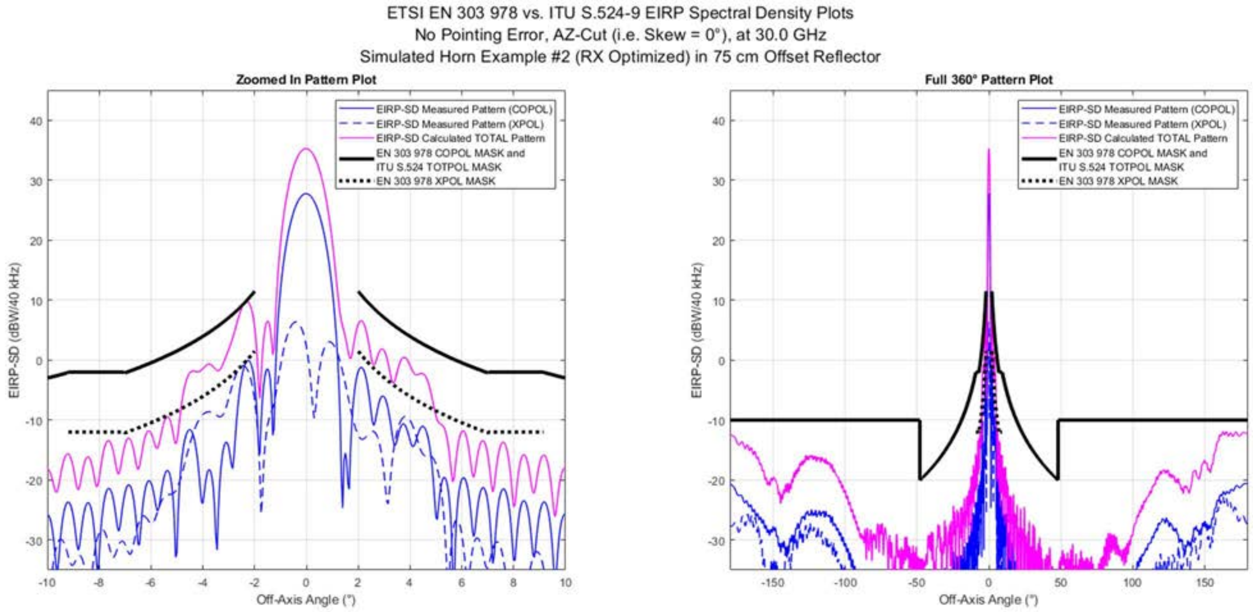
Horn #1 (TX) has lower sidelobes and thus has a higher reported ETSI EN 303 978 [i.4] EIRP-SD vs Horn #2 (RX). However, the discrepancy narrows when the total polarization mask is considered leading to Recommendation ITU-R S.524 [i.1] EIRP-SD being more closely related. Horn #1 (TX) has a lower ITU EIRP-SD compared to ETSI EIRP-SD while the reverse is true of Horn #2 (RX).

Case #1: AZ-Cut (i.e. Skew = 0°) at 30,0 GHz with no pointing error (Figure 1 is Horn #1; Figure 2 is Horn #2)



NOTE: Horn #1 (TX) has almost equivalent on-axis ETSI-CP and ITU-TOT EIRP-SD values, yet they are limited in two different ways. For the ITU-TOT, it is spillover-limited whereas the ETSI-CP is XPOL limited. It brings an important implication that, as is, the ETSI-CP mask would not catch spillover as it is a XPOL phenomenon for single reflector antennas, yet the ITU-TOT does catch it. In other words, the current ETSI cross-polarization mask only covers the angular range of ±(2 to 9,2)° off-axis, so the cross-polar component of off-axis EIRP density in the spillover region from ~±(100 to 180)° off-axis would not be accounted for or limited by the current ETSI cross-polarization specification.
The proposed total EIRP spectral density mask that follows the ITU Resolution/Recommendations would limit the total EIRP spectral density in the spillover region from ~±(100 to 180)° off-axis regardless of the polarity of the components.

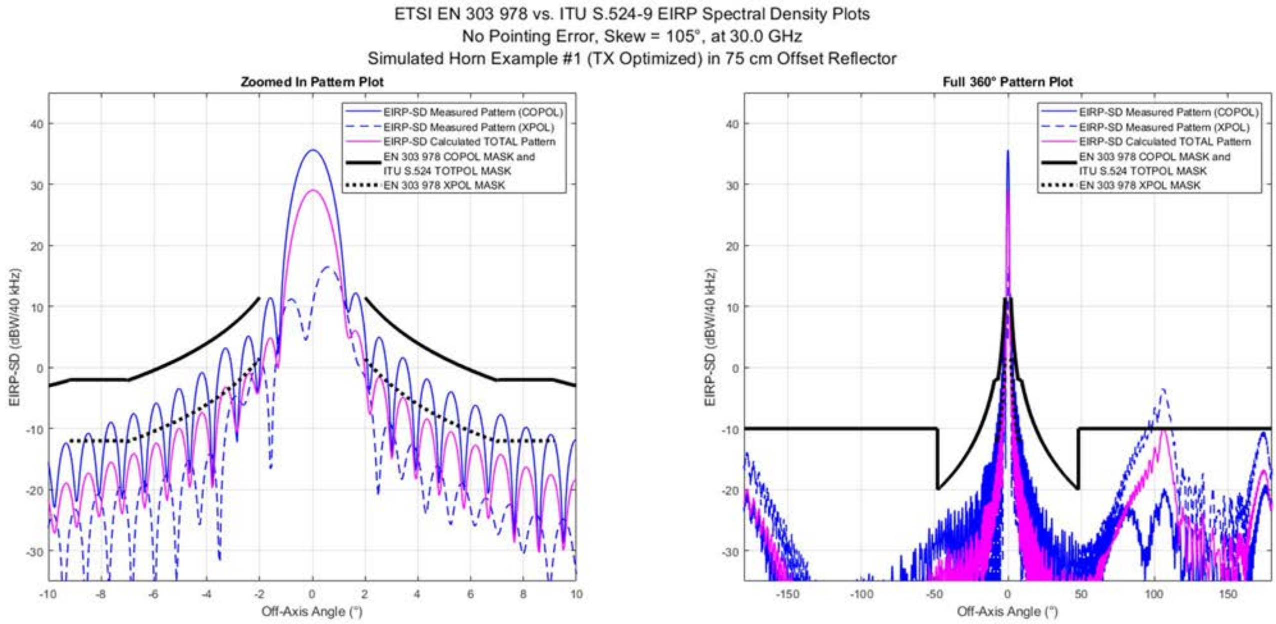
Figure 1



NOTE: Horn #2 (RX) has differed on-axis ITU-TOT and ETSI-CP EIRP-SD values and the ITU-TOT gives a value closer to that given for Horn #1 in Figure 1 while that ETSI-CP heavily penalizes the XPOL patterns. Note however, that both the ITU-TOT value and ETSI-CP value are actually limited at the same off-axis angle (~2,5°) both by the XPOL sidelobes. This suggests that the ITU-TOT formulation is still applicable to catch any unwanted XPOL sidelobe performance (as is illustrated here).

Figure 2

Case #2: Worst-case Over All Skews (i.e. min over 0° - 180°), and All Frequencies (i.e. min over 29,5 GHz to 30,0 GHz) with no pointing error (Figure 3 is Horn #1; Figure 4 is Horn #2)



NOTE: Considering a near-equatorial skew plane (approximately EL) giving the worst-case value for EIRP-SD shows better a comparison of the masks since now the patterns are asymmetric and subject to higher levels of spillover. Here the ITU-TOT mask gives a much stricter limit on the EIRP-SD and is limited by spillover since it shows up in the TOTPOL patterns, while the ETSI-CP mask only considers it out to 9,2°, thus allowing for a large 5+ dB spillover to occur and only limiting itself by the near-in XPOL sidelobes levels around 2°. This example is especially important as it shows the TOTPOL approach can give a more conservative estimate.

Figure 3

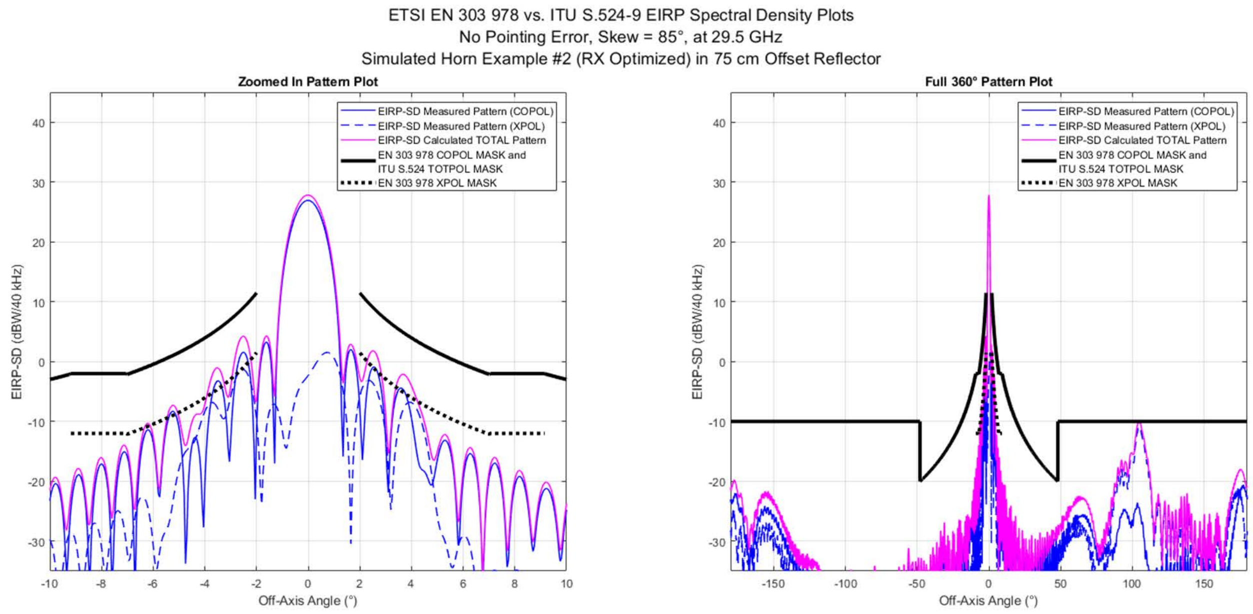
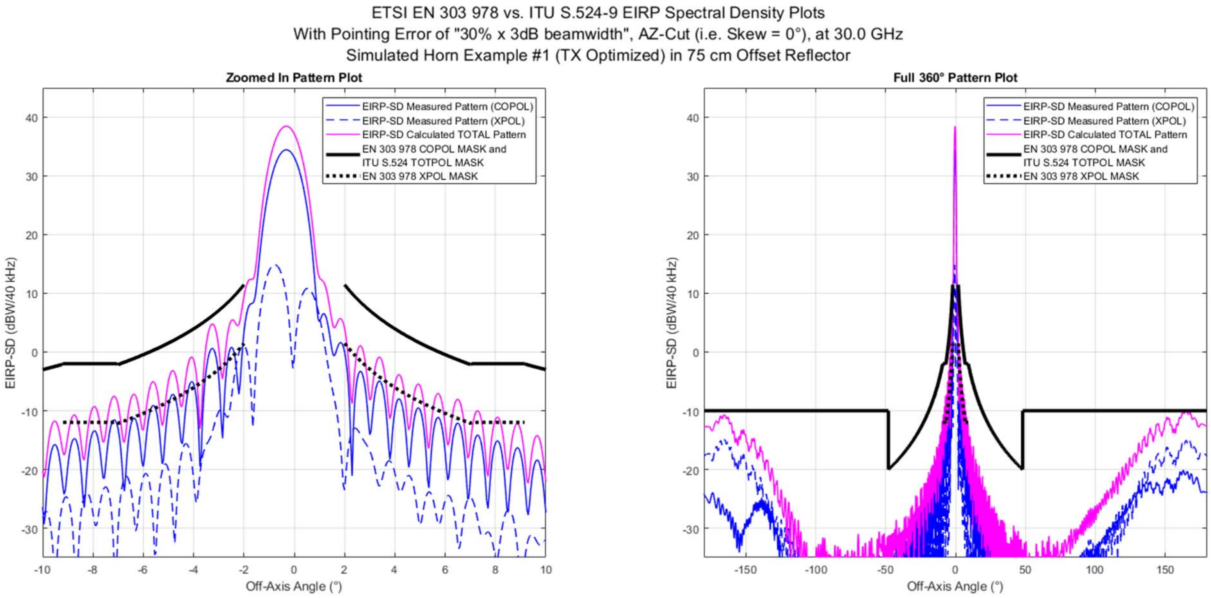


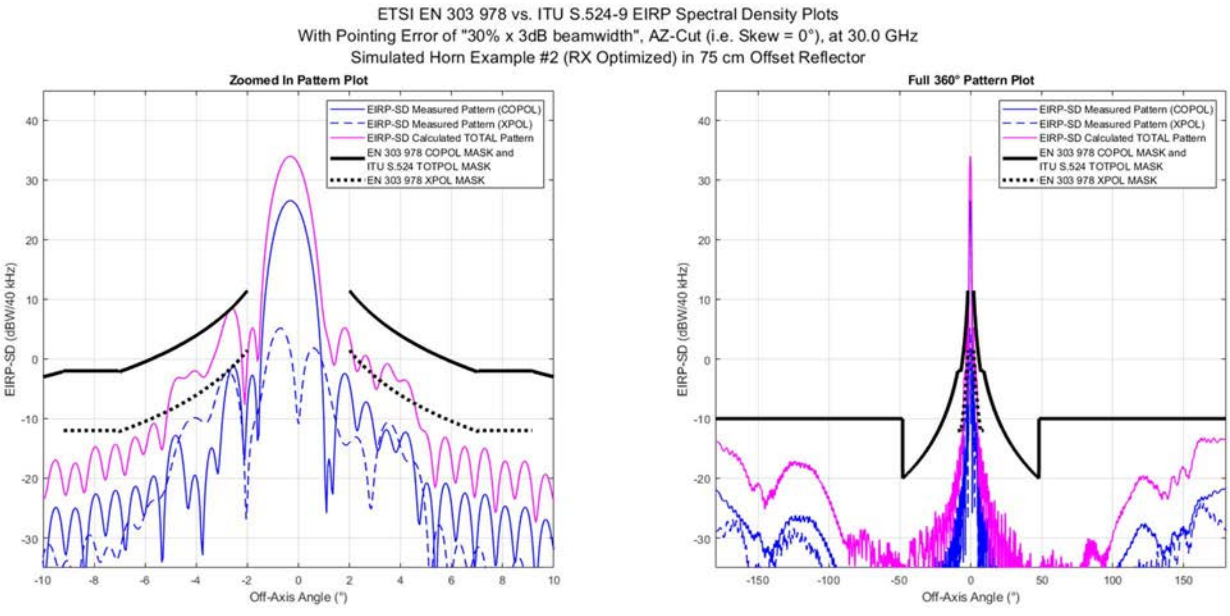
Figure 4

Case #3: AZ-Cut (i.e. Skew = 0°) at 30,0 GHz with Pointing Error of "30 % × 3 dB beamwidth" per clause 4.2.6.2b2 of ETSI EN 303 978 [i.4] (Figure 5 is Horn #1; Figure 6 is Horn #2)



NOTE: Notice that by adding in pointing error commensurate with the ETSI requirement in ETSI EN 303 978 [i.4] of "30 % x 3 dB beamwidth" (or for these examples ~ 0,3°) for Horn #1 the results differ from those in Case #1. There the ETSI-CP and ITU-TOT results were almost equivalent. While the ITU-TOT results do not change since they are spillover limited, the ETSI-CP results drop significantly due to the sensitive nature of the XPOL sidelobes.

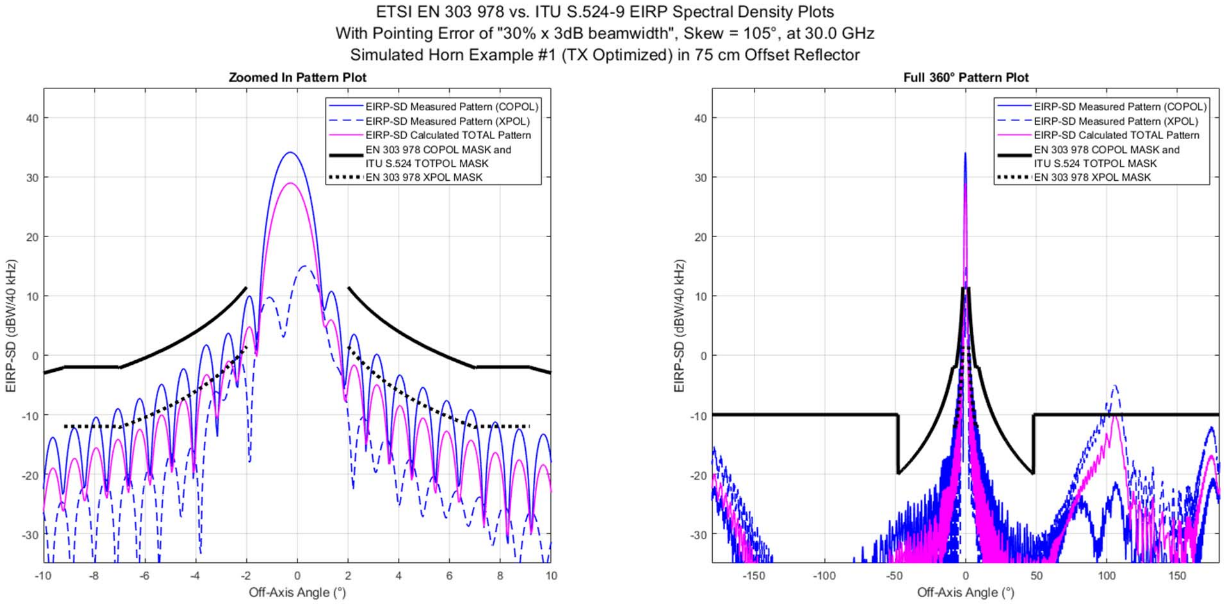
Figure 5



NOTE: Unlike Figure 5, since both ITU-TOT and ETSI-CP are limited by the XPOL sidelobe levels (in that it causes a large sidelobe at 2,3° for ITU-TOT due to the gain addition) the trend is similar to that of Case #1 but dropped by the decreased margin from adding the pattern shift.

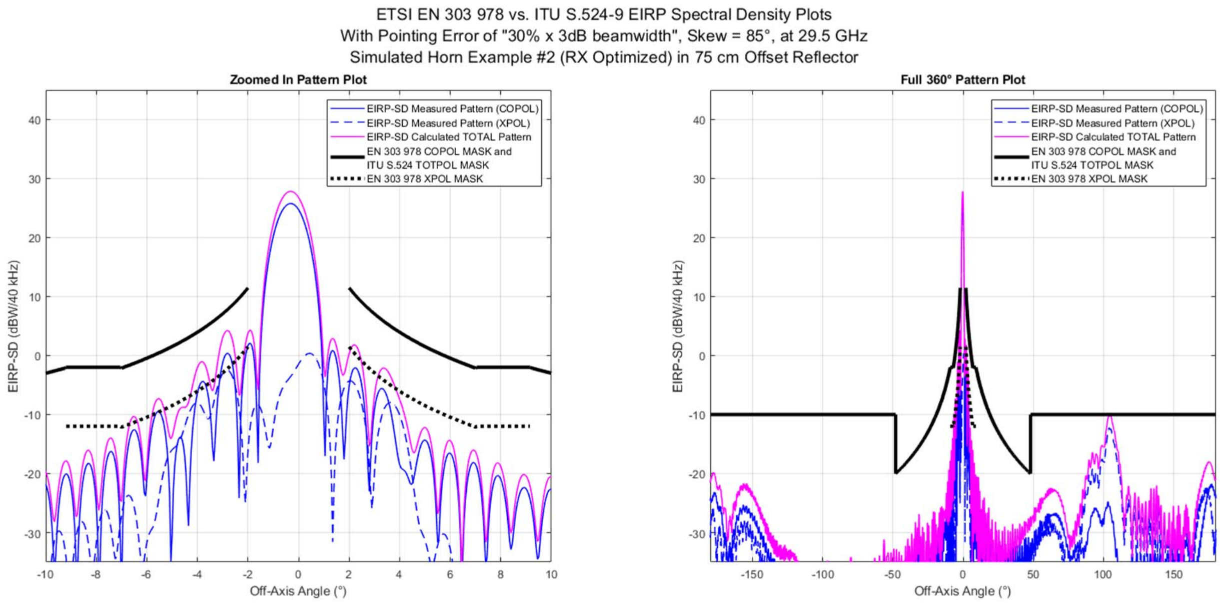
Figure 6

Case #4: Worst-case Over All Skews, and All Frequencies with Pointing Error of "30 % × 3 dB beamwidth" per clause 4.2.6.2b2 of ETSI EN 303 978 [i.4] (Figure 7 is Horn #1; Figure 8 is Horn #2)



NOTE: The commentary here is essentially the same as for Case #2 but with lower values brought on by the applied mispointing pattern shift.

Figure 7



NOTE: The commentary here is essentially the same as for Case #2 but with lower values brought on by the applied mispointing pattern shift.

Figure 8

6 Conclusion

The case study has shown by example how the ITU-TOT and ETSI-CP approaches to governing EIRP-SD may differ based on antenna configurations and sidelobe levels. It is seen that the ITU-TOT being an additive gain approach, will always give a lower value at least than the equivalent COPOL-only ETSI-CP but may give a more conservative value altogether in the higher skew regions due to spillover being more conservatively handled by the ITU-TOT approach.

This approach of a total off-axis EIRP density would thus both better protect the geostationary arc than the mask appearing in ETSI EN 303 978 (V2.1.2) [i.9], while also being more consistent with current ESOMP regulatory and inter-satellite coordination practices.

Consequently any revision of ETSI EN 303 978 (V2.1.2) [i.9] should consider the conclusion of the present document.

Annex A:
Bibliography

ETSI TR 103 233 (V1.1.1) (2016-04): "Satellite Earth Stations and Systems (SES); Technical Report on antenna performance characterization for GSO mobile applications".

Annex B: Change History

Date	Version	Information about changes
March 2023	0.0.1	Creation
April 2023	0.0.2	Revised clause 4.0 and corrections of edits

History

Document history		
V1.1.1	July 2023	Publication