



An Coimisiún um  
**Rialáil Cumarsáide**  
Commission for  
**Communications Regulation**

# Plum Report

## Review of the Satellite Earth Station Licensing Regime

Consultant Report

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**An Coimisiún um Rialáil Cumarsáide**  
**Commission for Communications Regulation**

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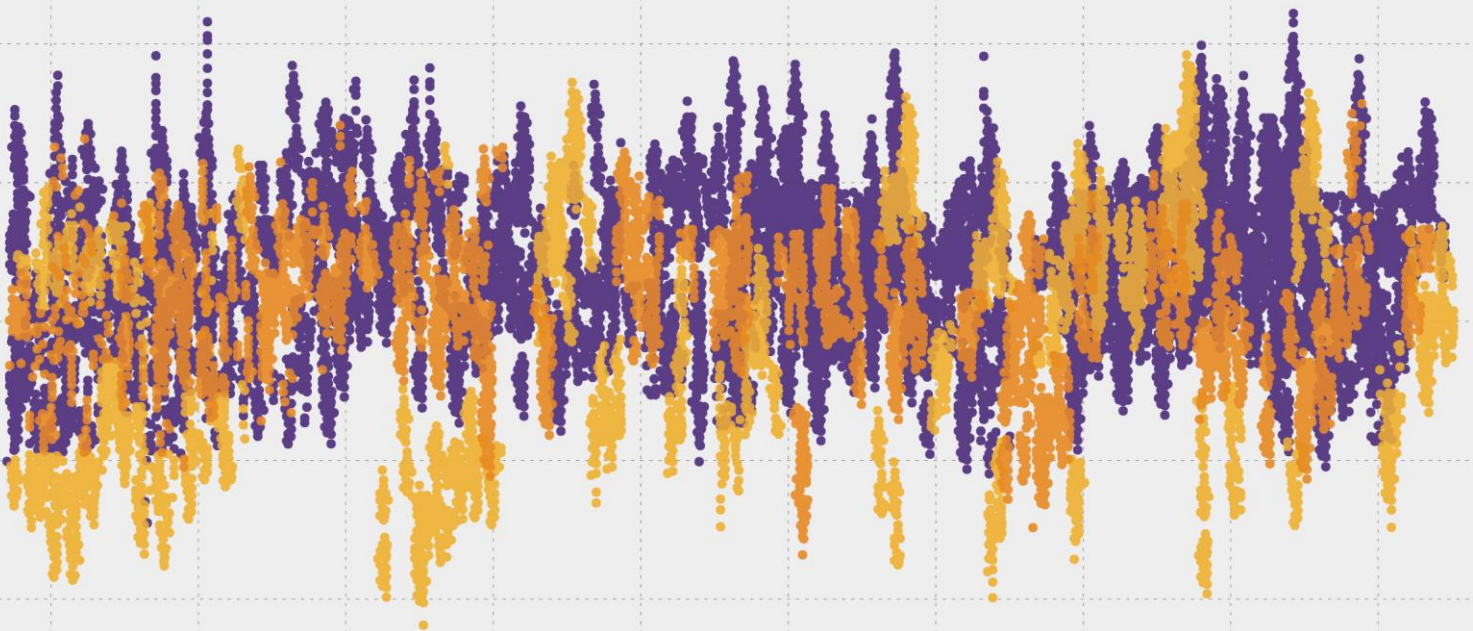


# Technical criteria for licensing satellite earth stations

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## About Plum

Plum is an independent consulting firm, focused on the telecommunications, media, technology, and adjacent sectors. We apply extensive industry knowledge, consulting experience, and rigorous analysis to address challenges and opportunities across regulatory, radio spectrum, economic, commercial, and technology domains.



## About this study

This study for Client Name identifies the necessary technical criteria for licensing of satellite Earth stations used in the Fixed Satellite Service.

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# Executive Summary

This study defines the technical requirements for licensing Satellite Earth Stations (SES), both transmit and receive, used in the Fixed Satellite Service based on the applicable frequency band. SES are typically larger installations at fixed locations and used for backhaul, broadcast feeder links and corporate type communications. ComReg document 00/64R3 details the frequency bands identified for SES licences in frequencies above 3 GHz<sup>1</sup>. In addition the bands 401 – 403 MHz, 2025 – 2110 MHz, 2200 – 2290 MHz, 47.2 – 50.2 GHz and 50.4 – 52.4 GHz are currently being considered as part of ComReg’s consultation on its satellite earth station licensing regime and 17.3 – 20.2 GHz and 37.5 – 42.5 GHz are being proposed for receiver SES licensing based on responses to the ComReg consultation document 22/56. Terminals for satellite services (TSS) are outside the scope of this study and are already addressed in ComReg document 20/47R.

In the case of SES the technical requirements are intended to enable coexistence with other co-frequency and adjacent band radio systems. These conditions can be general, i.e. covering many satellite bands, or specific, i.e. defined for a given satellite band and they are typically specified in the relevant ITU Radio Regulations. The main sources of information are:

- **Article 5** which provides a list of frequency bands allocated to satellite services together with footnotes associated with specific frequency bands describing technical and operational conditions. This includes the relevant satellite services that may utilise the band(s), associated coordination requirements and technical requirements for Earth stations (e.g. power limits, minimum antenna diameter, eirp density limits, power flux density limits produced by Earth stations at a given distance/height).
- **Article 21** which addresses terrestrial and space services sharing frequency bands above 1 GHz and describes power limits for Earth stations (in the form of eirp as a function of the angle of elevation of the horizon or off-axis angle) and minimum angle of elevation. Power flux density limits are also specified for space stations as a function of arrival above the horizontal plane on the surface of the Earth.
- **Article 22** which addresses space services and defines equivalent power flux density limits to protect GSO Earth station and satellite receivers from the aggregate emissions of NGSO systems, together with reference antenna patterns. Eirp limits (as a function of off-axis angle) are also defined for Earth stations operating in GSO (geostationary orbit) FSS (fixed satellite services) networks in Ku- and Ka-band frequencies.

In the case of **SES transmit operation (i.e. Earth to space)** the following apply:

- There is no restriction on eirp levels for Earth station elevation angles greater than 5 degrees (No. 21.9).
- For Earth stations with elevation angles less than 5 degrees and frequencies listed in No. 21.12, Table 21-3, and shared with fixed or mobile services the eirp limits for the two frequency ranges 1 to 15 GHz and above 15 GHz are provided in No. 21.8.
- The eirp limits provided in No. 21.8 may be exceeded by not more than 10 dB subject to agreement (No. 21.11).
- In the case of 13.75 – 14 GHz No. 21.13A provides the off-axis eirp for GSO FSS Earth station antennas smaller than 4.5 metre diameter.

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<sup>1</sup> It should be noted that it is proposed to delete some frequency ranges in the current document 00/64R3 as they are not identified in the Irish National Frequency Usage or Article 5 of the Radio Regulations. The frequencies are 5.25 – 5.35 GHz, 5.35 – 5.47 GHz and 5.47 – 5.57 GHz in Table 1 and 7.9 – 8.4 GHz in Table 2.

- Earth station antennas shall not be employed for transmission at elevation angles of less than 3° except when agreed to by administrations concerned and those whose services may be affected. (No. 21.14)
- Table 22-2 provides the eirp uplink limits in the geostationary-satellite orbit by emissions from all the Earth stations in a non-geostationary-satellite system in the fixed-satellite service in the listed frequency bands (No. 22.5D).
- There are eirp limits provided for off-axis of the main lobe for GSO Earth stations in the bands 12.75 – 13.25, 13.75 – 14 and 14 – 14.5 GHz in Nos. 22.26 – 22.29, 22.31 and 22.37.
- There are eirp limits provided for off-axis of the main lobe for GSO Earth stations in 29.5 – 30 GHz in Nos. 22.32, 22.35, 22.36, 22.38 and 22.39

In the case of **SES receive operation (i.e. space to Earth)** the following apply:

- In the case of receive Earth stations (s – E) No. 21.14 says, “In case of reception by an Earth station, the above value [3°] shall be used for coordination purposes if the operating angle of elevation is less than that value.”
- The power flux-density at the Earth’s surface produced by emissions from a space station, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed the limit given in Table 21-4 that apply to the FSS. This applies to bands shared with fixed or mobile service (No. 21.16).
- Tables 22-1A to 22-1E provide the eirp↓ limits at any point on the Earth’s surface radiated by non GSO satellite systems in the FSS (No. 22.5C) in the listed frequency bands.

There are also requirements for specific bands, such as 13.75 – 14 GHz provided in the footnotes of Article 5 (frequency allocations).

Maximum eirp levels for Earth stations in the vicinity of airfields apply according to ECC Report 272.

In addition to the above technical requirements, Plum recommends that applicants for a SES licence should be required to demonstrate that co-existence is possible with existing licensed Earth stations and other licensed services, predominantly fixed terrestrial links. Specifically, applicants should identify the stations falling within the coordination contours, based on principles provided in Appendix 7 employing ITU-R space network software, and inform ComReg of any potential issues associated with the detailed coordination process.

# 1 Introduction

The aim of the study is to define the technical requirements for licensing Satellite Earth Stations (SES) used in the fixed satellite service. SES are typically larger installations at fixed locations and used for backhaul, broadcast feeder links and corporate type communications. ComReg document 00/64R3 details the frequency bands identified for SES licences in frequencies above 3 GHz<sup>2</sup>. In addition the bands 401 – 403 MHz, 2025 – 2110 MHz, 2200 – 2290 MHz, 47.2 – 50.2 GHz and 50.4 – 52.4 GHz are currently being considered as part of ComReg’s consultation on its satellite earth station licensing regime. Further, based on responses to ComReg’s consultation document 22/56, ComReg is proposing to include 17.7 – 19.7 GHz<sup>3</sup> and 37.5 – 42.5 GHz for receive operation.

Terminals for satellite services (TSS) are outside the scope of this study and are addressed in ComReg document 20/47R where the technical conditions are provided for licence exempt use based on ECC Decisions which harmonise the exemption from individual licensing and free circulation of certain TSS in Europe. TSS include Aircraft Earth Stations, Earth Stations on Mobile Platforms, Earth Stations on Vessels, High E.I.R.P Satellite Terminals and Low E.I.R.P Satellite Terminals.

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<sup>2</sup> Subject to proposed amendments to listed frequency bands in section 2

<sup>3</sup> It should also be noted that 17.7 – 21.2 GHz is identified in the Radio Frequency Plan for Ireland for terminals for satellite services (s-E) as in ComReg document 20/47 revised.

## 2 Relevant frequencies

As noted above, ComReg document 00/64R3 details the frequency bands identified for SES licences at frequencies above 3 GHz. It has been noted, however, that a number of these bands are not allocated for Fixed Satellite in Region 1 (Article 5 of the Radio Regulations) or within the European Common Allocation Table or for the direction of transmission identified (i.e. s-E or E-s). We would therefore recommend that ComReg :

- removes the frequency ranges 5.25 – 5.35 GHz, 5.35 – 5.47 GHz and 5.47 – 5.57 GHz from Appendix 2 Table 1 and 7.9 – 8.4 GHz in Appendix 2 Table 2.

We note that in Document 22/56, ComReg has proposed to make the 27.5 GHz – 30 GHz, 47.2 – 50.2 GHz, and 50.4 – 52.4 GHz frequency bands available for SES licensing. Therefore, we recommend the addition of 27.5 – 29.5, 47.2 – 50.2 and 50.4 – 52.4 GHz to Appendix 2 Table 1 and 48.2 – 48.54 and 49.44 – 50.2 GHz to Appendix 2 Table 2.

ComReg, based on the responses to the consultation document 22/56, is also proposing to include:

- 17.7 – 20.2 GHz for SES receiver licensing for FSS (i.e. s-E), as currently document 00/64R3 only addresses 17.3 – 18.1 GHz (E-s) and 19.7 – 20.2 GHz (s-E), and
- 37.5 – 42.5 GHz (s-E).

We have therefore also included these bands in the relevant tables below.

The other primary and secondary users listed in the tables in document 00/64R3 are specific to the use in Ireland and do not reflect all the services listed in Article 5 for Region 1 or in the European Common Allocation Table for the bands.

**Figure 2.1: Proposed amended Table 1 for Appendix 2 Document 00/64R3 for SES transmit operation**

Frequency (GHz)	Other primary and secondary users – see Radio Frequency Plan for Ireland, National Usage
5.15 – 5.25	SRDs <sup>5</sup>
5.725 – 5.85	Amateur (secondary), SRDs, FWA (5.725 – 5.875 GHz)
5.85 – 5.925	Amateur (secondary), SRDs, FWA (5.725 – 5.875 GHz)
5.925 – 6.7	SRDs, Fixed links (L6 GHz (5.925 – 6.425) GHz and U6 GHz (6.425 – 7.125 GHz) )
6.7 – 7.075	Fixed links (U6 GHz (6.425 – 7.125 GHz))
7.9 – 8.4	SRDs, Fixed links (L8 GHz (7.725 – 8.275 GHz) and U8 GHz (8.275 – 8.5 GHz))
10.7 – 11.7	Fixed links (11 GHz (10.7 – 11.7 GHz)) <i>Note use of the band 10.7-11.7 GHz by the fixed-satellite service (Earth-to-space) is limited to feeder links for the broadcasting-satellite service</i>
12.5 – 12.75	None. Exclusive satellite band.
12.75 – 13.25	Fixed links (13 GHz (12.75 – 13.25 GHz))
13.75 – 14.0	SRDs, Radiolocation

<sup>4</sup> See [Radio Frequency Plan For Ireland \(comreg.ie\)](https://www.comreg.ie/publication/radio-frequency-plan-for-ireland)

<sup>5</sup> For information on SRD use see Doc. 02/71 R14 at <https://www.comreg.ie/publication/permitted-short-range-devices-in-ireland-5>



Frequency (GHz)	Other primary and secondary users – see Radio Frequency Plan for Ireland, National Usage
14.0 – 14.25	None. Exclusive satellite band.
14.25 – 14.5	PMSE
17.3 – 18.1	Fixed links (18 GHz (17.7 – 19.7 GHz)) <i>Note limited to feeder links for BSS</i>
27.5 – 29.5	Fixed links (28 GHz (27.9405 – 28.445 / 28.9485 – 29.4525 GHz))
29.5 – 30.0	None
47.2 – 50.2	None
50.4 – 52.4	None

Figure 2.2: Proposed amended Table 2 for Appendix 2 Document 00/64R3 for SES receive operation

Frequency (GHz)	Other primary and secondary users – see Radio Frequency Plan for Ireland, National Usage
3.4 – 3.6	Fixed terrestrial for ECS, Mobile terrestrial for ECS, State services
3.6 – 4.2	Fixed terrestrial for ECS (3.6 – 3.8 GHz), Mobile terrestrial for ECS (3.6 – 3.8 GHz)
4.5 – 4.8	
6.7 – 7.075	Fixed links (U6 GHz (6.425 – 7.125 GHz))
7.25 – 7.3	SRDs, Fixed links (L7 GHz (7.125 – 7.425 GHz))
7.3 – 7.45	Fixed links (L7 GHz (7.125 – 7.425 GHz))
7.45 – 7.55	SRDs, Fixed links (U7 GHz (7.425 – 7.725 GHz))
7.55 – 7.75	SRDs, Fixed links (U7 GHz (7.425 – 7.725 GHz) and L8 GHz (7.725 – 8.275 GHz))
10.7 – 11.7	Fixed links (11 GHz (10.7 – 11.7 GHz))
11.7 – 12.5	PMSE
12.5 – 12.75	
17.3 – 17.7	
17.7 – 19.7	Fixed links (18 GHz (17.7 – 19.7GHz))
19.7 – 20.2	
37.5 – 42.5	Fixed links (38 GHz (37.5 – 39.5 GHz) and 42 GHz (40.5 – 43.5 GHz))
48.2 – 48.54	None
49.44 – 50.2	None

<sup>6</sup> See [Radio Frequency Plan For Ireland \(comreg.ie\)](https://www.comreg.ie/Radio-Frequency-Plan-For-Ireland)

### 3 Technical requirements for SES in bands above 3 GHz

In the case of SES the technical requirements are intended to enable coexistence with other co-frequency and adjacent band radio systems. These conditions can be general, i.e. covering many satellite bands, or specific, i.e. defined for a given satellite band and they are typically specified in the relevant ITU Radio Regulations. The main sources of information are:

- **Article 5** which provides a list of frequency bands allocated to satellite services together with footnotes associated with specific frequency bands describing technical and operational conditions. This includes the relevant satellite services that may utilise the band(s), associated coordination requirements and technical requirements for Earth stations (e.g. power limits, minimum antenna diameter, eirp density limits, power flux density limits produced by Earth stations at a given distance/height).
- **Article 21** which addresses terrestrial and space services sharing frequency bands above 1 GHz and describes power limits for Earth stations (in the form of eirp as a function of the angle of elevation of the horizon or off-axis angle) and minimum angle of elevation. Power flux density limits are also specified for space stations as a function of arrival above the horizontal plane on the surface of the Earth.
- **Article 22** which addresses space services and defines equivalent power flux density limits to protect GSO Earth station and satellite receivers from aggregate emissions of NGSO systems together with reference antenna patterns. Eirp limits (as a function of off-axis angle) are also defined for Earth stations operating in GSO (geostationary orbit) FSS (fixed satellite services) networks in Ku- and Ka-band frequencies.

In the following table the relevant operational and technical conditions are provided for each frequency band based on the above Articles. The following should be noted when using the table:

- In Column 3 those bands that are shared by the satellite service on an equal basis (i.e. co-primary) with the mobile and / or fixed services, based on current use provided in the ComReg interactive radio frequency plan<sup>7</sup>, are identified (i.e. shown as Yes in column 3). In addition those bands where the Fixed-Satellite allocation is co-primary with the mobile and / or fixed services allocations in Region 1, Article 5, are shown by a hatch sign (#).
- Columns 4, 5 and 6 consider Nos. 21.8, 21.9, 21.11 and 21.12.

No 21.12 says the limits given in No. 21.8 apply, where applicable, to the services and frequency bands indicated in Table 21-3 for transmission by Earth stations where the frequency bands are shared with equal rights with the fixed or mobile service. Column 6 identifies the relevant frequencies based on Table 21-3 which lists possible frequency bands, footnotes and applicable regions. Table 21-3 lists a number of different services but it is not clear which frequency bands apply to which service, so it has been assumed that all fixed satellite bands listed in the Table 21-3 should be considered (subject to footnotes and region) as needing to meet the limits given in No. 21.8. To ensure any future sharing with fixed or mobile services the technical criteria have assumed sharing is determined according to Article 5 allocations not the current sharing arrangements in Ireland.

<sup>7</sup> See Radio Frequency Plan For Ireland (comreg.ie)

No. 21.8 provides the equivalent isotropically radiated power (e.i.r.p.) limits transmitted in any direction towards the horizon by an Earth station, except as provided in No. 21.10 or 21.11, for frequency bands between 1 and 15 GHz and above 15 GHz and between angles of elevation of 0 and 5 degrees.

No. 21.9 indicates that for angles of elevation of the horizon greater than 5° there shall be no restriction as to the equivalent isotropically radiated power (e.i.r.p.) transmitted by an Earth station towards the horizon

No. 21.11 indicates the limits may be exceeded by not more than 10dB.

- Column 6 considers No. 21.14 which says, "earth station antennas shall not be employed for transmission at elevation angles of less than 3° measured from the horizontal plane to the direction of maximum radiation, except when agreed to by administrations concerned and those whose services may be affected". This requirement therefore applies to all frequency bands where the direction of transmission is earth to space (E-s).

In addition No. 21.14 says, in "case of reception by an earth station, the above value [3°] shall be used for coordination purposes if the operating angle of elevation is less than that value". The frequency bands where this requirement applies are identified by Note 1 in the relevant frequency bands.

- Column 8 identifies those frequency bands where No. 21.16 and therefore No. 21.17 apply. No. 21.16 provides the power flux-density limits at the Earth's surface, for bands shared with equal rights with the fixed or mobile service, produced by emissions from a space station in Table 21-4. The applicable frequency bands and limits are those identified for the fixed satellite service in Table 21-4. To ensure any future sharing with fixed or mobile services the technical criteria have assumed sharing is determined according to Article 5 allocations not the current sharing arrangements in Ireland.
- Column 12 provides information on the use of the bands by FSS and relevant ITU RR Article 5 footnotes.

The details of the main, relevant Article numbers are provided in Appendix A.

Figure 3.1: Summary table of operational and technical requirements by frequency band

Frequency band (GHz)	s-E / E-s	Shared with MS or FS (based on current band usage data in Ireland)	No. 21.8 and No. 21.11	No. 21.9	No. 21.12 Table 21-3	No. 21.14	No. 21.16 (Note 3) and No. 21.17	No. 22.5C	No. 22.5D Table 22-2	No. 22.26, 22.27, 22.28, 22.29 and 22.37	Other
3.4 – 3.6	s – E	Yes #	X	X	X	Note 2	√ Table 21-4	X	X	X	
3.6 – 4.2	s – E	Yes, 3.6 – 3.8 GHz #	X	X	X	Note 2	√ Table 21-4	√ Table 22-1E (3.7 – 4.2 GHz)	X	X	
4.5 – 4.8	s – E	No #	X	X	X	Note 2	√ Table 21-4	X	X	X	No. 5.441: The use of the band by FSS is in acc. with App 30B.
5.15 – 5.25	E – s	No #	X	√	X	√	X	X	X	X	No. 5.447A: FSS use limited to MSS GSO feeder links,
5.725 – 5.85	E – s	Yes, 5.725 – 5.875 GHz*	X	√	X	√	X	X	X	X	
5.85 – 5.925	E – s	Yes, 5.725 – 5.875 GHz #	√	√	√ (5.85 – 7.075 GHz)	√	X	X	X	X	
5.925 – 6.7	E – s	Yes #	√	√	√ (5.85 – 7.075 GHz)	√	X	X	√ (5.925 – 6.725 GHz)	X	No. 5.457A: ES on-board vessels can operate under FSS.
6.7 – 7.075	E – s, s – E	Yes #	√	√	√ (5.85 – 7.075 GHz)	√	√ Table 21-4	X	√ (5.925 – 6.725 GHz)	X	No. 5.441: The use of the band by FSS is in acc. with App 30B. Other relevant ITU RR Art. 5 No's: 5.458, 5.458A and 5.458B
7.25 – 7.75	s – E	Yes #	X	X	X	Note 2	X	X	X	X	No. 5.461: 7250-7375 MHz is also allocated to MSS on a primary basis subject to No. 9.21.

Frequency band (GHz)	s-E / E-s	Shared with MS or FS (based on current band usage data in Ireland)	No. 21.8 and No. 21.11	No. 21.9	No. 21.12 Table 21-3	No. 21.14	No. 21.16 (Note 3) and No. 21.17	No. 22.5C	No. 22.5D Table 22-2	No. 22.26, 22.27, 22.28, 22.29 and 22.37	Other
7.9 – 8.4	E – s	Yes #	√	√	√	√	X	X	X	X	No. 5.461: 7900-8025 MHz is also allocated to MSS on a primary basis subject to No. 9.21.
10.7 – 11.7	E – s, s - E	Yes #	√	√	√	√	√ Table 21-4	√ Table 22-1A	X	X	No: 5.484: E – s limited to F/L for BSS No. 5.441: The use of the bands 10.7-10.95 GHz and 11.2-11.45 GHz (s-E) by GSO FSS is in acc. with App 30B. Other relevant ITU RR Art. 5 Nos: 5.484A and 5.484B
11.7 – 12.5	s – E	No #	X	X	X	Note 2	√ Table 21-4	√ Table 22-1D B/casting Sat Service	X	X	Broadcasting Satellite Service allocation. No. 5.487A: FSS use is allowed but limited to NGSO systems. No. 5.492: BSS assignments confirming App 30 plan/list may be used in FSS.
12.5 – 12.75	E – s, s - E	No	X	√	X	√	X	√ Table 22-1A	√	X	Exclusive FSS band Relevant ITU RR Art. 5 Nos: 5.484A and 5.484B,
12.75 – 13.25	E – s	Yes #	√	√	√	√	X	X	√	√	No. 5.441: The use of the band by GSO FSS is in acc. with App 30B.

Frequency band (GHz)	s-E / E-s	Shared with MS or FS (based on current band usage data in Ireland)	No. 21.8 and No. 21.11	No. 21.9	No. 21.12 Table 21-3	No. 21.14	No. 21.16 (Note 3) and No. 21.17	No. 22.5C	No. 22.5D Table 22-2	No. 22.26, 22.27, 22.28, 22.29 and 22.37	Other
13.75 – 14.0	E – s	No	X	√	X	√	X	X	√	√	No. 21.13A Relevant ITU RR Art 5 Nos: 5.484A, 5.502 and 5.503.
14.0 – 14.25	E – s	No	X	√	X	√	X	X	√	√	Exclusive satellite band No. 5.457A: ES on-board vessels can operate under FSS. Other relevant ITU RR Art 5 Nos: 5.484A, 5.484B and 5.506.
14.25 – 14.5	E – s	No # 14.3 – 14.8 GHz	√	√	√ 14.3-14.8 GHz in Table 21-3.	√	X	X	√	√	No. 5.457A: ES on-board vessels can operate under FSS. Other relevant ITU RR Art 5 Nos: 5.484A, and 5.484B.
17.3 – 18.1	E – s, s – E (17.3 – 17.7 GHz)	Yes, 17.7 – 18.1 GHz #17.7 – 18.1 GHz	√	√	√ 17.7 -18.1 GHz in Table 21-3	√	√ Table 21-4 (17.7 – 19.3 GHz)	X	√	X	No. 5.516: GSO FSS E-s limited to feeder links for BSS. Other relevant ITU RR Art 5 Nos: 5.484A, 5.516A, 5.516B and 5.517A.
18.1 – 19.7 Note 1	s -	Yes, 18.1 – 19.7 GHz #18.1 – 19.7 GHz	X	X	X	Note 2	√ Table 21-4 (17.7 – 19.3 GHz)	√ Table 22-1B (17.8 - 18.6 GHz)	X	X	Relevant ITU RR Art 5 Nos: 5.484A, 5.516B, 5.517A, 5.522B, 5.523A, 5.522A.
19.7 – 20.2	s – E	No	X	X	X	Note 2	X	√ Table 22-1C	X	X	Relevant ITU RR Art 5 Nos: 5.484A, 5.484B, 5.516B, 5.527A, 5.525 and 5.526.

Frequency band (GHz)	s-E / E-s	Shared with MS or FS (based on current band usage data in Ireland)	No. 21.8 and No. 21.11	No. 21.9	No. 21.12 Table 21-3	No. 21.14	No. 21.16 (Note 3) and No. 21.17	No. 22.5C	No. 22.5D Table 22-2	No. 22.26, 22.27, 22.28, 22.29 and 22.37	Other
27.5 – 29.5	E – s	Yes #	√	√	√	√	X	X	√ (27.5 – 28.6 GHz)	X	Relevant ITU RR Art 5 Nos: 5.484A, 5.516B, 5.517A, 5.523A, 5.523C, 5.523E, 5.535A, 5.538, 5.539, 5.540 and 5.541A,
29.5 - 30	E – s	No	X	√	X	√	X	X	√	X	No. 22.32, No. 22.35, No. 22.36, No. 22.38 and No. 22.39 Relevant ITU RR Art 5 Nos: 5.484A, 5.484B, 5.516B, 5.525, 5.526, 5.527A, 5.538, 5.539 and 5.540.
37.5 – 42.5	s - E	Yes, 37.5 – 39 GHz and 40.5 – 43.5 GHz # 37.5 – 39 GHz and 40.5 – 43.5 GHz	X	X	X	Note 2	√ Table 21-4 (37.5 – 42.5 GHz)	X	X	X	Relevant ITU RR Art 5 Nos: 5.547, 5.550C, 5.516B, 5.550E
47.2 – 50.2	E-s (47.2-47.5 GHz, 47.9-48.2 GHz, 48.54-49.44 GHz) E-s & s-E (47.5 – 47.9 GHz, 48.2-48.54 GHz, 49.44 – 50.2 GHz)	No #	X	√	X	√	√ Table 21-4 (47.5 – 47.9, 48.2 – 48.54, 49.44 – 50.2 GHz)	X	X	X	Currently in Ireland no services identified No. 5.554A: The use of the bands 47.5-47.9 GHz, 48.2-48.54 GHz and 49.44-50.2 GHz by FSS (s-E) is limited to GSO satellites. Other relevant ITU RR Art 5 Nos: 5.149, 5.516B, 5.338A, 5.340, 5.550C, 5.552 and 5.555B.

Frequency band (GHz)	s-E / E-s	Shared with MS or FS (based on current band usage data in Ireland)	No. 21.8 and No. 21.11	No. 21.9	No. 21.12 Table 21-3	No. 21.14	No. 21.16 (Note 3) and No. 21.17	No. 22.5C	No. 22.5D Table 22-2	No. 22.26, 22.27, 22.28, 22.29 and 22.37	Other
50.4 – 52.4	E-s	No #	√	√	√ 51.4 – 52.4 GHz in Table 21-3	√	X	X	X	X	Currently in Ireland no services identified No. 5.555C: The use of the frequency band 51.4-52.4 GHz by FSS (E-s) is limited to GSO networks. Other relevant ITU RR Art 5 Nos: 5.338A, 5.547 and 5.550C.

\* In Ireland 5.725 – 5.875 GHz used for FWA/MAN – ISM band.

Note 1: In the band 18.1 – 19.7 GHz only allow for receive Earth stations (s-E) although Article 5 includes 18.1 – 18.4 GHz and 19.3 – 19.7 GHz (E-s).

Note 2: In the case of receive Earth stations (s – E) No. 21.14 says, “In case of reception by an earth station, the above value [3°] shall be used for coordination purposes if the operating angle of elevation is less than that value.”

Note 3: No. 21.16, Table 21-14 applies to bands shared with the fixed or mobile service. To ensure any future sharing potential the relevant technical criteria have been assumed even if the band is not currently shared in Ireland – for example in the 4.5 – 4.8 GHz band.



## 4 Technical requirements for 401 – 403 MHz, 2025 – 2110 MHz and 2200 – 2290 MHz

The following technical requirements apply to the 401- 403 MHz, 2025 – 2110 MHz and 2200 – 2290 MHz bands.

Frequency band	Relevant Documents	Criterion and comments
401 – 403 MHz	Article 5	Allocated to: MetAids, Space Ops (s-E) (401-402 MHz), EESS (E-s), MetSat (E-s)
	Radio Frequency Plan	Ireland used for MetAids (radiosondes) Europe allocated to MetAids, EESS (E-s), MetSat (E-s) ComReg propose potential use for EESS (E-s), MetSat(E-s), Space Ops (s-E) should be considered
	Article 5 5.264A	Defines max eirp: In the frequency band 401-403 MHz, the maximum e.i.r.p. of any emission of each Earth station in the meteorological-satellite service and the Earth exploration-satellite service shall not exceed 22 dBW in any 4 kHz band for geostationary-satellite systems and non-geostationary-satellite systems with an orbit of apogee equal or greater than 35 786 km. The maximum e.i.r.p. of any emission of each Earth station in the meteorological-satellite service and the Earth exploration-satellite service shall not exceed 7 dBW in any 4 kHz band for non-geostationary-satellite systems with an orbit of apogee lower than 35 786 km. The maximum e.i.r.p. of each Earth station in the meteorological-satellite service and the Earth exploration satellite service shall not exceed 22 dBW for geostationary-satellite systems and non-geostationary-satellite systems with an orbit of apogee equal or greater than 35 786 km in the whole 401-403 MHz frequency band. The maximum e.i.r.p. of each Earth station in the meteorological-satellite service and the Earth exploration-satellite service shall not exceed 7 dBW for non-geostationary-satellite systems with an orbit of apogee lower than 35 786 km in the whole 401-403 MHz frequency band. Until 22 November 2029, these limits shall not apply to satellite systems for which complete notification information has been received by the Radiocommunication Bureau by 22 November 2019 and that have been brought into use by that date. After 22 November 2029, these limits shall apply to all systems within the meteorological-satellite service and the Earth exploration-satellite service operating in this frequency band. (WRC-19)
	Article 5 5.264B	Non-geostationary-satellite systems in the meteorological-satellite service and the Earth exploration satellite service for which complete notification information has been received by the Radiocommunication Bureau before 28 April 2007 are exempt from provisions of No. 5.264A and may continue to operate in the frequency band 401.898- 402.522 MHz on a primary basis without exceeding a maximum e.i.r.p. level of 12 dBW. (WRC-19)
	Rec. ITU-R SA1258-1	Co-channel sharing Recommends: 1 that co-channel sharing is feasible between GSO MetSat and MetAids services in the band 401-403 MHz only in locations where the spatial density of data collection platforms is low and where they meet the following conditions: uplink e.i.r.p. density limitations of 22 dB(W/100 Hz) and transmission durations of up to 1 min per message; 2 that co-channel sharing is not feasible between the MetAids service on the one hand, and non-GSO EES, or non-GSO MetSat services on the other in the band 401-403 MHz; 3 that systems which do not meet the restrictions of recommends 1 require coordination between MetAids operators, MetSat and EES operators prior to implementation.

Frequency band	Relevant Documents	Criterion and comments
	Rec. ITU-R SA2044-0	Provides information on the performance and interference criteria for non-GSO Data Collection Systems (DCS) in the 401-403 MHz Recommends 1 that the analysis to determine the effect on non-GSO DCS systems in the 401-403 MHz should be based on the following protection criteria: –197.9 dB(W/(m <sup>2</sup> · Hz)) maximum aggregate acceptable spectral power flux-density (spfd) at the antenna of a non-GSO DCS instrument for broadband noise interference (see Annex 1); –165.4 dB(W/m <sup>2</sup> ) maximum power flux-density (pfd) within a resolution bandwidth of 19 Hz at the antenna of a non-GSO DCS instrument for each narrow-band spectral line interference (see Annex 2); 2 that protection criteria defined in recommends 1 should not be exceeded for more than a percentage of 1% of time in the field of view of the satellite.
	Rec. ITU-R SA2045-0	Partitioning of the band 401-403 MHz for future long-term coordinated use of DCS (Data Collection Systems) systems on geostationary and non-geostationary MetSat and EESS – see Annex on how band sub-divided
2025 – 2110 MHz	Article 5	Allocated to SpaceOps (E-s)(s-s), EESS (E-s)(s-s), Fixed, Mobile, Space Research (E-s)(s-s)
	Radio Frequency Plan	Ireland use for fixed pt-pt and SAP/SAB Europe allocations as per Article 5 ComReg propose should consider possible use of SpaceOps, EESS and Space Research
	No. 21.8	1) The equivalent isotropically radiated power (e.i.r.p.) transmitted in any direction towards the horizon by an Earth station shall not exceed the following limits except as provided in No. 21.10 or 21.11: a) in frequency bands between 1 GHz and 15 GHz +40 dBW in any 4 kHz band for $\theta \leq 0^\circ + 40 + 3\theta$ dBW in any 4 kHz band for $0^\circ < \theta \leq 5^\circ$ ; where $\theta$ is the angle of elevation of the horizon viewed from the centre of radiation of the antenna of the Earth station and measured in degrees as positive above the horizontal plane and negative below it.
	No. 21.10	The equivalent isotropically radiated power (e.i.r.p.) towards the horizon for an Earth station in the space research service (deep space) shall not exceed +55 dBW in any 4 kHz band in frequency bands between 1 GHz and 15 GHz
	No. 21.5	ES for space research (near Earth) minimum angle of elevation not less than 5 degrees and for deep space not less than 10 degrees
	No. 21.16 Table 21-4	PFD at Earth's surface from a space station. Limit in dBW/m <sup>2</sup> for angles of arrival ( $\vartheta$ ) above the horizontal plane in 4 kHz bandwidth. 0 – 5 degrees -154 5 – 25 degrees $-154 + 0.5(\vartheta - 5)$ 25 – 90 degrees -144

Frequency band	Relevant Documents	Criterion and comments
	Rec. ITU-R SA1273	<p>Power flux density levels from the space research, space operation and Earth exploration satellite services at the surface of the Earth required to protect the fixed service in the bands 2025 - 2110 MHz and 2200 – 2290 MHz recommends</p> <p>3 that in the band 2 025-2 110 MHz the maximum pfd produced at the surface of the Earth by emissions from a DRS in GSO, for all conditions and methods of modulation, should not exceed:</p> <p>–130 dB(W/m<sup>2</sup>) in any 1 MHz for angles of arrival less than 5° above the horizontal plane; – 130 + 0.5 (δ – 5) dB(W/m<sup>2</sup>) in any 1 MHz for angles of arrival δ (degrees) between 5° and 25° above the horizontal plane;</p> <p>–120 dB(W/m<sup>2</sup>) in any 1 MHz for angles of arrival between 25° and 90° above the horizontal plane;</p> <p>3.1 that the value of –130 dB(W/m<sup>2</sup>) in any 1 MHz may need to be exceeded in rare occasions by up to 6 dB but for not more than 5% of the time to compensate for background interference;</p> <p>4 that the above limits relate to the pfd and angles of arrival which would be obtained under free-space propagation conditions;</p> <p>5 that Annex 1 should be referred to for additional guidance relating to this Recommendation.</p>
2200 – 2290 MHz	Article 5	Allocations to: SpaceOps (s-E)(s-s), EESS (s-E)(s-s), Fixed, Mobile, Space Research(s-E)(s-s)
	Radio Frequency Plan	<p>Ireland used for fixed pt-pt and SAP/SAB</p> <p>Europe allocation as per Article 5</p> <p>ComReg propose should consider possible use of SpaceOps, EESS and Space Research</p>
	No. 21.16 Table 21-4	<p>PFD at Earth's surface from a space station. Limit in dBW/m<sup>2</sup> for angles of arrival (θ) above the horizontal plane in 4 kHz bandwidth.</p> <p>0 – 5 degrees -154</p> <p>5 – 25 degrees -154 + 0.5(θ - 5)</p> <p>25 – 90 degrees -144</p>
	Rec. ITU-R SA1273	<p>Power flux density levels from the space research, space operation and Earth exploration satellite services at the surface of the Earth required to protect the fixed service in the bands 2025 - 2110 MHz and 2200 – 2290 MHz recommends</p> <p>3 that in the band 2 025-2 110 MHz the maximum pfd produced at the surface of the Earth by emissions from a DRS in GSO, for all conditions and methods of modulation, should not exceed:</p> <p>–130 dB(W/m<sup>2</sup>) in any 1 MHz for angles of arrival less than 5° above the horizontal plane; – 130 + 0.5 (δ – 5) dB(W/m<sup>2</sup>) in any 1 MHz for angles of arrival δ (degrees) between 5° and 25° above the horizontal plane;</p> <p>–120 dB(W/m<sup>2</sup>) in any 1 MHz for angles of arrival between 25° and 90° above the horizontal plane;</p> <p>3.1 that the value of –130 dB(W/m<sup>2</sup>) in any 1 MHz may need to be exceeded in rare occasions by up to 6 dB but for not more than 5% of the time to compensate for background interference;</p> <p>4 that the above limits relate to the pfd and angles of arrival which would be obtained under free-space propagation conditions;</p> <p>5 that Annex 1 should be referred to for additional guidance relating to this Recommendation.</p>

## 5 Co-ordination with aircraft

ECC Report 272 provides the maximum eirp levels from Earth Stations in the vicinity of aircraft in the 4-6, 12-18 and 18 – 40 GHz bands to ensure compliance with aircraft HIRF (High Intensity Radiated Field) protection criteria. No restrictions on operations in the proximity of or within airfields (airports and helipads) are required for Earth stations complying with the e.i.r.p. levels specified in Table 12 in ECC Report 272, part of which is replicated below:

Earth station deployment type	Maximum eirp levels (dBW)		
	4 - 6 GHz	12 – 18 GHz	18 – 40 GHz
Earth stations in a fixed location within airport premises	67	68.4	66.4
Fixed Earth stations or mobile Earth stations on land within a wedge shaped area originating at the departure and arrival end of the runway and extending for 3 nautical miles over which aircraft would normally track**	73	74.5	72.4
Fixed Earth stations or land mobile Earth stations operating with NGSO satellites located outside the wedge shaped area extending for 3 nautical miles from the runway of an airfield over which aircraft would normally track**	79	80.5	78.4
Fixed Earth stations or land mobile Earth stations operating with GSO satellites located outside the wedge shaped area extending for 3 nautical miles from the runway of an airfield over which aircraft would normally track**	80.7 – 93*	82.2 – 94.5*	80.2 – 92.4*

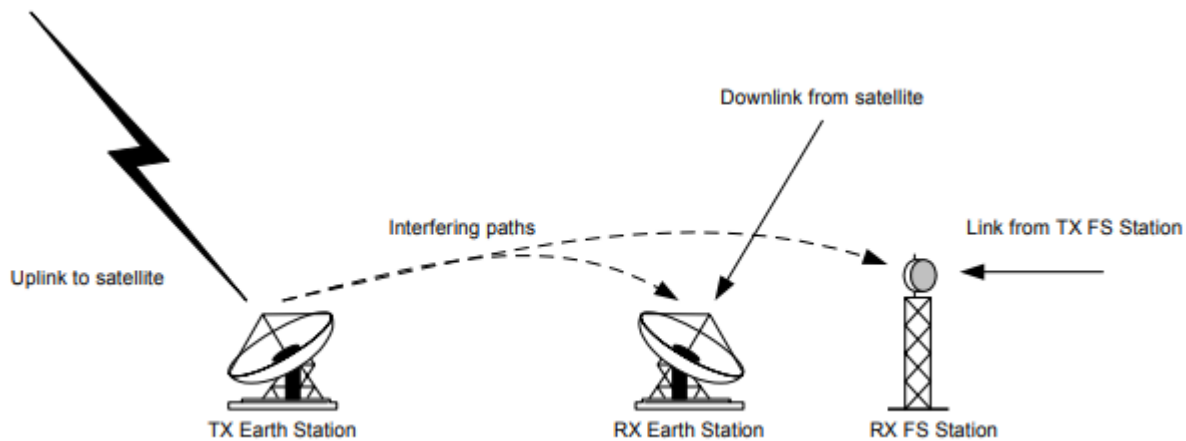
\* eirp values are dependent on Earth station latitude

\*\* the width of the wedge shaped area originating at the departure and arrival end of the runway and extending for 3 nm from the runway over which aircraft would normally track depends on the airfield and is determined by the airport authority.

## 6 Coordination with fixed point to point links and other satellite Earth stations

The licensing of any new transmit Earth station has the potential to interfere with any existing fixed link and SES receiver stations as they often operate in the same shared frequency bands as shown in Figure 6.1:

Figure 6.1: Transmit Earth Station interference into existing fixed link and SES receiver stations



The coordination process for a new satellite Earth station involves the following steps:

- Coordination data collection by using ITU-R space networks software called SpaceCap<sup>8</sup>. The data is based on ITU RR Appendix 4 Annex 2 format.
- Coordination contour derivation by using ITU-R space networks software called GIBC which includes AP7 option for coordination contours. ITU RR Appendix 7 describes in detail methods for determining the coordination area around an earth station operating in bands between 100 MHz and 105 GHz.
- Determination of affected administrations (with which coordination is required) by using GIBC/AP7 reporting facility. Affected administrations are determined based on the principles described in ITU RR Appendix 5.
- Provision of coordination information (including SpaceCap Appendix 4 data, GIBC/AP7 coordination contours and any other relevant data) by the requesting administration to the affected administrations in line with ITU RR Article 9 where coordination procedures are described in detail.
- Response from each affected administration either
  - agreeing to the request for coordination, informing the requesting administration and providing the full characteristics of affected stations; or
  - disagreeing to the request for coordination, providing information regarding assignments the disagreement is based on and suggestions for the satisfactory resolution.

<sup>8</sup> <https://www.itu.int/en/ITU-R/software/Pages/spacecap.aspx>

- Successful coordination agreement (assuming disagreement between the requesting and affected administrations is resolved and coordination is successfully concluded).
- Notification of the coordinated assignments to ITU BR in line with Article 11 provisions.

As mentioned above, Appendix 7 to the Radio Regulations, "Method for the determination of the coordination area around an Earth station in frequency bands between 100 MHz and 105 GHz" describes how to calculate the coordination contour. The coordination area could apply nationally or over a number of countries. The detailed analysis can take into account the specific technical details of the stations being coordinated and any interference mitigation measures such as local shielding of the Earth station. As an indication only, the possible coordination distances may be around 210 kms for frequencies below 12 GHz and 160 kms above 12 GHz.

ComReg should require licence applicants for new SES to undertake the steps outlined above. Our recommended licence application procedure is shown in Appendix A.

## 7 Concluding remarks

The appropriate technical requirements for SES licensing have been considered for:

- the frequency bands included in ComReg document 00/64R3 which details the frequency bands identified for SES licences in frequencies above 3 GHz<sup>9</sup>,
- bands 401 – 403 MHz, 2025 – 2110 MHz, 2200 – 2290 MHz, 47.2 – 50.2 GHz and 50.4 – 52.4 GHz which are currently being considered as part of ComReg’s consultation on its satellite earth station licensing regime (document 22/56), and
- 17.3 – 20.2 GHz and 37.5 – 42.5 GHz which are proposed for SES licensing based on responses to the ComReg consultation document 22/56.

It should be noted that terminals for satellite services (TSS) are outside the scope of this study and are already addressed in ComReg document 20/47R.

In the case of SES, the technical requirements are intended to enable coexistence with other co-frequency and adjacent band radio systems. These conditions can be general, i.e. covering many satellite bands, or specific, i.e. defined for a given satellite band and they are typically specified in the relevant ITU Radio Regulations. These Regulations “ensure interference-free operations of radiocommunication systems and provide all countries with equitable access to the radio spectrum — a scarce natural resource that does not distinguish national borders and needs to be harmonised globally”<sup>10</sup>. The main sources of information are:

- **Article 5** which provides a list of frequency bands allocated to satellite services together with footnotes associated with specific frequency bands describing technical and operational conditions. This includes the relevant satellite services that may utilise the band(s), associated coordination requirements and technical requirements for Earth stations (e.g. power limits, minimum antenna diameter, eirp density limits, power flux density limits produced by Earth stations at a given distance/height).
- **Article 21** which addresses terrestrial and space services sharing frequency bands above 1 GHz and describes power limits for Earth stations (in the form of eirp as a function of the angle of elevation of the horizon or off-axis angle) and minimum angle of elevation. Power flux density limits are also specified for space stations as a function of arrival above the horizontal plane on the surface of the Earth.
- **Article 22** which addresses space services and defines equivalent power flux density limits to protect GSO Earth station and satellite receivers from the aggregate emissions of NGSO systems, together with reference antenna patterns. Eirp limits (as a function of off-axis angle) are also defined for Earth stations operating in GSO (geostationary orbit) FSS (fixed satellite services) networks in Ku- and Ka-band frequencies.

In the case of **SES transmit operation (i.e. Earth to space)** the following apply:

- There is no restriction on eirp levels for Earth station elevation angles greater than 5 degrees (No. 21.9).

<sup>9</sup> It should be noted that it is proposed to delete some frequency ranges in the current document 00/64R3 as they are not identified in the Irish National Frequency Usage or Article 5 of the Radio Regulations. The frequencies are 5.25 – 5.35 GHz, 5.35 – 5.47 GHz and 5.47 – 5.57 GHz in Table 1 and 7.9 – 8.4 GHz in Table 2.

<sup>10</sup> Quote from Houlin Zao, ITU Secretary General

- For Earth stations with elevation angles less than 5 degrees and frequencies listed in No. 21.12, Table 21-3, and shared with fixed or mobile services the eirp limits for the two frequency ranges 1 to 15 GHz and above 15 GHz are provided in No. 21.8.
- The eirp limits provided in No. 21.8 may be exceeded by not more than 10 dB subject to agreement (No. 21.11).
- In the case of 13.75 – 14 GHz No. 21.13A provides the off-axis eirp for GSO FSS Earth station antennas smaller than 4.5 metre diameter.
- Earth station antennas shall not be employed for transmission at elevation angles of less than 3° except when agreed to by administrations concerned and those whose services may be affected. (No. 21.14)
- Table 22-2 provides the eirp uplink limits in the geostationary-satellite orbit by emissions from all the Earth stations in a non-geostationary-satellite system in the fixed-satellite service in the listed frequency bands (No. 22.5D).
- There are eirp limits provided for off-axis of the main lobe for GSO Earth stations in the bands 12.75 – 13.25, 13.75 – 14 and 14 – 14.5 GHz in Nos. 22.26 – 22.29, 22.31 and 22.37.
- There are eirp limits provided for off-axis of the main lobe for GSO Earth stations in 29.5 – 30 GHz in Nos. 22.32, 22.35, 22.36, 22.38 and 22.39

In the case of **SES receive operation (i.e. space to Earth)** the following apply:

- In the case of receive Earth stations (s – E) No. 21.14 says, “In case of reception by an Earth station, the above value [3°] shall be used for coordination purposes if the operating angle of elevation is less than that value.”
- The power flux-density at the Earth’s surface produced by emissions from a space station, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed the limit given in Table 21-4 that apply to the FSS. This applies to bands shared with fixed or mobile service (No. 21.16).
- Tables 22-1A to 22-1E provide the eirp↓ limits at any point on the Earth’s surface radiated by non GSO satellite systems in the FSS (No. 22.5C) in the listed frequency bands.

There are also requirements for specific bands, such as 13.75 – 14 GHz provided in the footnotes of Article 5 (frequency allocations).

Maximum eirp levels for Earth stations in the vicinity of airfields apply according to ECC Report 272.

On the basis of the technical conditions outlined above Plum recommends that the relevant limits for a band should apply to minimise the potential for interference, maximise spectrum use and ensure compatibility with other countries.

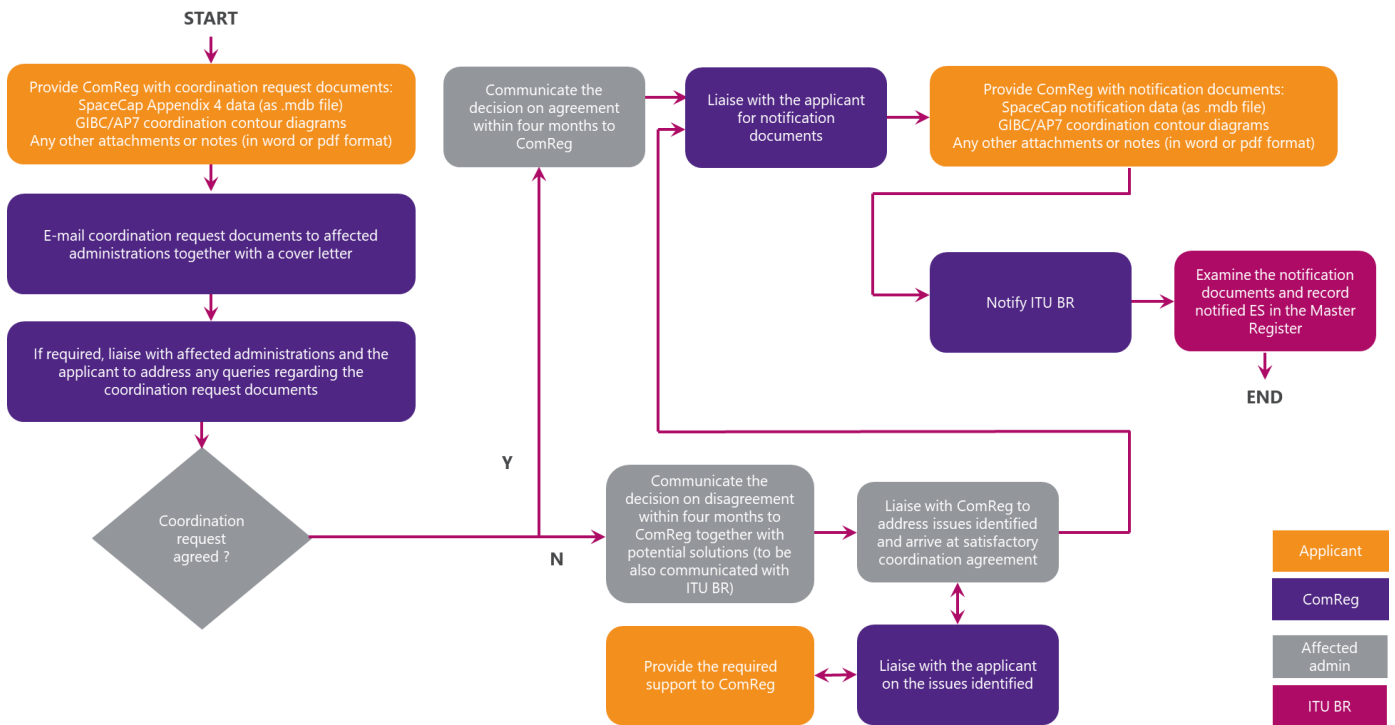
In addition to the above technical requirements, Plum recommends that applicants for a SES licence should be required to demonstrate that co-existence is possible with existing licensed Earth stations and other licensed services, predominantly fixed terrestrial links. We propose there should be a clear and easy to use approach as described in this report. - Applicants should identify the stations falling within the coordination contours, based on principles provided in Appendix 7, by using the ITU-R space network software and inform ComReg of any potential issues associated with the detailed coordination process.



# Appendix A Recommended licensing approach

ComReg needs to ensure that ITU RR satellite earth station coordination and notification procedures are followed. Given the complex provisions defined in ITU RR Article 9 and 11, it is recommended that the satellite earth station licence applicant should implement these procedures and provide the required documentation to ComReg for communication with affected administrations and the ITU BR.

The recommended approach is shown in the following diagram.



## Appendix B Details of relevant articles

In the following sections the main relevant articles are provided for convenience.

**Article 5.** The following details some of the main applicable footnotes noted in Figure 3.1. For others please refer to Article 5 in Radio Regulations, Volume 1:

- 5.441. The use of the bands 4 500-4 800 MHz (space-to-Earth), 6 725-7 025 MHz (Earth-to-space) by the fixed satellite service shall be in accordance with the provisions of Appendix 30B. The use of the bands 10.7-10.95 GHz (space-to-Earth), 11.2-11.45 GHz (space-to-Earth) and 12.75-13.25 GHz (Earth-to-space) by geostationary-satellite systems in the fixed-satellite service shall be in accordance with the provisions of Appendix 30B. The use of the bands 10.7-10.95 GHz (space-to-Earth), 11.2-11.45 GHz (space-to-Earth) and 12.75-13.25 GHz (Earth-to-space) by a non-geostationary-satellite system in the fixed-satellite service is subject to application of the provisions of No. 9.12 for coordination with other non-geostationary-satellite systems in the fixed-satellite service. Non-geostationary-satellite systems in the fixed-satellite service shall not claim protection from geostationary-satellite networks in the fixed-satellite service operating in accordance with the Radio Regulations, irrespective of the dates of receipt by the Bureau of the complete coordination or notification information, as appropriate, for the non-geostationary-satellite systems in the fixed satellite service and of the complete coordination or notification information, as appropriate, for the geostationary-satellite networks, and No. 5.43A does not apply. Non-geostationary-satellite systems in the fixed-satellite service in the above bands shall be operated in such a way that any unacceptable interference that may occur during their operation shall be rapidly eliminated.
- 5.447A. The allocation to the fixed-satellite service (Earth-to-space) in the band 5 150-5 250 MHz is limited to feeder links of non-geostationary-satellite systems in the mobile-satellite service and is subject to coordination under No. 9.11A.
- 5.457A. In the frequency bands 5 925-6 425 MHz and 14-14.5 GHz, earth stations located on board vessels may communicate with space stations of the fixed-satellite service. Such use shall be in accordance with Resolution 902 (WRC-03). In the frequency band 5 925-6 425 MHz, earth stations located on board vessels and communicating with space stations of the fixed-satellite service may employ transmit antennas with minimum diameter of 1.2 m and operate without prior agreement of any administration if located at least 330 km away from the low-water mark as officially recognized by the coastal State. All other provisions of Resolution 902 (WRC-03) shall apply. (WRC-15)
- 5.458. In the band 6 425-7 075 MHz, passive microwave sensor measurements are carried out over the oceans. In the band 7 075-7 250 MHz, passive microwave sensor measurements are carried out. Administrations should bear in mind the needs of the Earth exploration-satellite (passive) and space research (passive) services in their future planning of the bands 6 425-7 075 MHz and 7 075-7 250 MHz.
- 5.458B. The space-to-Earth allocation to the fixed-satellite service in the band 6 700-7 075 MHz is limited to feeder links for non-geostationary satellite systems of the mobile-satellite service and is subject to coordination under No. 9.11A. The use of the band 6 700-7 075 MHz (space-to-Earth) by feeder links for non-geostationary satellite systems in the mobile-satellite service is not subject to No. 22.2.
- 5.461. Additional allocation: the bands 7 250-7 375 MHz (space-to-Earth) and 7 900-8 025 MHz (Earth-to-space) are also allocated to the mobile-satellite service on a primary basis, subject to agreement obtained under No. 9.21.

- 5. 484. In Region 1, the use of the band 10.7-11.7 GHz by the fixed-satellite service (Earth-to-space) is limited to feeder links for the broadcasting-satellite service
- 5.484A. The use of the bands 10.95-11.2 GHz (space-to-Earth), 11.45-11.7 GHz (space-to-Earth), 11.7-12.2 GHz (space-to-Earth) in Region 2, 12.2-12.75 GHz (space-to-Earth) in Region 3, 12.5-12.75 GHz (space-to-Earth) in Region 1, 13.75-14.5 GHz (Earth-to-space), 17.8-18.6 GHz (space-to-Earth), 19.7-20.2 GHz (space-to-Earth), 27.5-28.6 GHz (Earth-to-space), 29.5-30 GHz (Earth-to-space) by a non-geostationary-satellite system in the fixed-satellite service is subject to application of the provisions of No. 9.12 for coordination with other non-geostationary-satellite systems in the fixed-satellite service. Non-geostationary-satellite systems in the fixed-satellite service shall not claim protection from geostationary-satellite networks in the fixed-satellite service operating in accordance with the Radio Regulations, irrespective of the dates of receipt by the Bureau of the complete coordination or notification information, as appropriate, for the non-geostationary-satellite systems in the fixed-satellite service and of the complete coordination or notification information, as appropriate, for the geostationary-satellite networks, and No. 5.43A does not apply. Non-geostationary satellite systems in the fixed-satellite service in the above bands shall be operated in such a way that any unacceptable interference that may occur during their operation shall be rapidly eliminated.
- 5.487A. Additional allocation: in Region 1, the band 11.7-12.5 GHz, in Region 2, the band 12.2-12.7 GHz and, in Region 3, the band 11.7-12.2 GHz, are also allocated to the fixed-satellite service (space-to-Earth) on a primary basis, limited to non-geostationary systems and subject to application of the provisions of No. 9.12 for coordination with other non-geostationary-satellite systems in the fixed-satellite service. Non-geostationary-satellite systems in the fixed-satellite service shall not claim protection from geostationary-satellite networks in the broadcasting-satellite service operating in accordance with the Radio Regulations, irrespective of the dates of receipt by the Bureau of the complete coordination or notification information, as appropriate, for the non-geostationary-satellite systems in the fixed-satellite service and of the complete coordination or notification information, as appropriate, for the geostationary-satellite networks, and No. 5.43A does not apply. Non-geostationary-satellite systems in the fixed-satellite service in the above bands shall be operated in such a way that any unacceptable interference that may occur during their operation shall be rapidly eliminated. (WRC-03)
- 5.492. Assignments to stations of the broadcasting-satellite service which are in conformity with the appropriate regional Plan or included in the Regions 1 and 3 List in Appendix 30 may also be used for transmissions in the fixed satellite service (space-to-Earth), provided that such transmissions do not cause more interference, or require more protection from interference, than the broadcasting-satellite service transmissions operating in conformity with the Plan or the List, as appropriate. (WRC-2000)
- 5.502. In the band 13.75-14 GHz, an earth station of a geostationary fixed-satellite service network shall have a minimum antenna diameter of 1.2 m and an earth station of a non-geostationary fixed-satellite service system shall have a minimum antenna diameter of 4.5 m. In addition, the e.i.r.p., averaged over one second, radiated by a station in the radiolocation or radionavigation services shall not exceed 59 dBW for elevation angles above 2° and 65 dBW at lower angles. Before an administration brings into use an earth station in a geostationary-satellite network in the fixed-satellite service in this band with an antenna diameter smaller than 4.5 m, it shall ensure that the power flux-density produced by this earth station does not exceed:
  - –115 dB(W/(m<sup>2</sup> · 10 MHz)) for more than 1% of the time produced at 36 m above sea level at the low water mark, as officially recognized by the coastal State;

- $-115 \text{ dB(W/(m}^2 \cdot 10 \text{ MHz))}$  for more than 1% of the time produced 3 m above ground at the border of the territory of an administration deploying or planning to deploy land mobile radars in this band, unless prior agreement has been obtained.
- For earth stations within the fixed-satellite service having an antenna diameter greater than or equal to 4.5 m, the e.i.r.p. of any emission should be at least 68 dBW and should not exceed 85 dBW. (WRC-03)
- 5.503. In the band 13.75-14 GHz, geostationary space stations in the space research service for which information for advance publication has been received by the Bureau prior to 31 January 1992 shall operate on an equal basis with stations in the fixed-satellite service; after that date, new geostationary space stations in the space research service will operate on a secondary basis. Until those geostationary space stations in the space research service for which information for advance publication has been received by the Bureau prior to 31 January 1992 cease to operate in this band:
  - in the band 13.77-13.78 GHz, the e.i.r.p. density of emissions from any earth station in the fixed satellite service operating with a space station in geostationary-satellite orbit shall not exceed:
    - i)  $4.7D + 28 \text{ dB(W/40 kHz)}$ , where D is the fixed-satellite service earth station antenna diameter (m) for antenna diameters equal to or greater than 1.2 m and less than 4.5 m;
    - ii)  $49.2 + 20 \log(D/4.5) \text{ dB(W/40 kHz)}$ , where D is the fixed-satellite service earth station antenna diameter (m) for antenna diameters equal to or greater than 4.5 m and less than 31.9 m;
    - iii)  $66.2 \text{ dB(W/40 kHz)}$  for any fixed-satellite service earth station for antenna diameters (m) equal to or greater than 31.9 m;
    - iv)  $56.2 \text{ dB(W/4 kHz)}$  for narrow-band (less than 40 kHz of necessary bandwidth) fixed-satellite service earth station emissions from any fixed-satellite service earth station having an antenna diameter of 4.5 m or greater; –
  - The e.i.r.p. density of emissions from any earth station in the fixed-satellite service operating with a space station in non-geostationary-satellite orbit shall not exceed 51 dBW in the 6 MHz band from 13.772 to 13.778 GHz.

Automatic power control may be used to increase the e.i.r.p. density in these frequency ranges to compensate for rain attenuation, to the extent that the power flux-density at the fixed-satellite service space station does not exceed the value resulting from use by an earth station of an e.i.r.p. meeting the above limits in clear-sky conditions. (WRC-03)

- 5.516. Use of the band 17.3-18.1 GHz by geostationary-satellite systems in the fixed-satellite service (Earth to-space) is limited to feeder links for the broadcasting-satellite service. The use of the bands 17.3-18.1 GHz (Earth-to-space) in Regions 1 and 3 by non-geostationary-satellite systems in the fixed-satellite service is subject to application of the provisions of No. 9.12 for coordination with other non-geostationary-satellite systems in the fixed-satellite service. Non-geostationary-satellite systems in the fixed-satellite service shall not claim protection from geostationary-satellite networks in the fixed-satellite service operating in accordance with the Radio Regulations, irrespective of the dates of receipt by the Bureau of the complete coordination or notification information, as appropriate, for the non-geostationary-satellite systems in the fixed satellite service and of the complete coordination or notification information, as appropriate, for the geostationary-satellite networks, and No. 5.43A does not apply. Non-geostationary-satellite systems in the fixed-satellite

service in the above bands shall be operated in such a way that any unacceptable interference that may occur during their operation shall be rapidly eliminated. (WRC-2000)

- 5.516A. In the band 17.3-17.7 GHz, earth stations of the fixed-satellite service (space-to-Earth) in Region 1 shall not claim protection from the broadcasting-satellite service feeder-link earth stations operating under Appendix 30A, nor put any limitations or restrictions on the locations of the broadcasting-satellite service feeder-link earth stations anywhere within the service area of the feeder link. (WRC-03)
- 5.516B. The following bands are identified for use by high-density applications in the fixed-satellite service:
  - 17.3-17.7 GHz (space-to-Earth) in Region 1,
  - 19.7-20.2 GHz (space-to-Earth) in all Regions,
  - 39.5-40 GHz (space-to-Earth) in Region 1,
  - 40-40.5 GHz (space-to-Earth) in all Regions,
  - 47.5-47.9 GHz (space-to-Earth) in Region 1,
  - 48.2-48.54 GHz (space-to-Earth) in Region 1,
  - 49.44-50.2 GHz (space-to-Earth) in Region 1, and
  - 27.5-27.82 GHz (Earth-to-space) in Region 1,
  - 28.45-28.94 GHz (Earth-to-space) in all Regions,
  - 29.46-30 GHz (Earth-to-space) in all Regions.

This identification does not preclude the use of these frequency bands by other fixed-satellite service applications or by other services to which these frequency bands are allocated on a co-primary basis and does not establish priority in these Radio Regulations among users of the frequency bands. Administrations should take this into account when considering regulatory provisions in relation to these frequency bands. See Resolution 143 (Rev.WRC-19). (WRC-19)

- 5.522B . The use of the band 18.6-18.8 GHz by the fixed-satellite service is limited to geostationary systems and systems with an orbit of apogee greater than 20 000 km.
- 5.526. In the bands 19.7-20.2 GHz and 29.5-30 GHz in Region 2, and in the bands 20.1-20.2 GHz and 29.9- 30 GHz in Regions 1 and 3, networks which are both in the fixed-satellite service and in the mobile-satellite service may include links between earth stations at specified or unspecified points or while in motion, through one or more satellites for point-to-point and point-to-multipoint communications.
- 5.535A. The use of the band 29.1-29.5 GHz (Earth-to-space) by the fixed-satellite service is limited to geostationary satellite systems and feeder links to non-geostationary-satellite systems in the mobile-satellite service. Such use is subject to the application of the provisions of No. 9.11A, but not subject to the provisions of No. 22.2, except as indicated in Nos. 5.523C and 5.523E where such use is not subject to the provisions of No. 9.11A and shall continue to be subject to Articles 9 (except No. 9.11A) and 11 procedures, and to the provisions of No. 22.2. (WRC-97)

- 5.538. Additional allocation: the bands 27.500-27.501 GHz and 29.999-30.000 GHz are also allocated to the fixed-satellite service (space-to-Earth) on a primary basis for the beacon transmissions intended for up-link power control. Such space-to-Earth transmissions shall not exceed an equivalent isotropically radiated power (e.i.r.p.) of 10 dBW in the direction of adjacent satellites on the geostationary-satellite orbit. (WRC-07)
- 5.539. The band 27.5-30 GHz may be used by the fixed-satellite service (Earth-to-space) for the provision of feeder links for the broadcasting-satellite service.
- 5.540. Additional allocation: the band 27.501-29.999 GHz is also allocated to the fixed-satellite service (space-to-Earth) on a secondary basis for beacon transmissions intended for up-link power control.
- 5.541A. Feeder links of non-geostationary networks in the mobile-satellite service and geostationary networks in the fixed-satellite service operating in the band 29.1-29.5 GHz (Earth-to-space) shall employ uplink adaptive power control or other methods of fade compensation, such that the earth station transmissions shall be conducted at the power level required to meet the desired link performance while reducing the level of mutual interference between both networks. These methods shall apply to networks for which Appendix 4 coordination information is considered as having been received by the Bureau after 17 May 1996 and until they are changed by a future competent world radiocommunication conference. Administrations submitting Appendix 4 information for coordination before this date are encouraged to utilize these techniques to the extent practicable. (WRC-2000)
- 5.547. The bands 31.8-33.4 GHz, 37-40 GHz, 40.5-43.5 GHz, 51.4-52.6 GHz, 55.78-59 GHz and 64-66 GHz are available for high-density applications in the fixed service (see Resolution 75 (WRC-2000)\*). Administrations should take this into account when considering regulatory provisions in relation to these bands. Because of the potential deployment of high-density applications in the fixed-satellite service in the bands 39.5-40 GHz and 40.5-42 GHz (see No. 5.516B), administrations should further take into account potential constraints to high-density applications in the fixed service, as appropriate. (WRC-07)
- 5.550C. The use of the frequency bands 37.5-39.5 GHz (space-to-Earth), 39.5-42.5 GHz (space-to-Earth), 47.2- 50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space) by a non-geostationary-satellite system in the fixed satellite service is subject to the application of the provisions of No. 9.12 for coordination with other non-geostationary satellite systems in the fixed-satellite service but not with non-geostationary-satellite systems in other services. Resolution 770 (WRC-19) shall also apply, and No. 22.2 shall continue to apply. (WRC-19)
- 5.550E. The use of the frequency bands 39.5-40 GHz and 40-40.5 GHz by non-geostationary-satellite systems in the mobile-satellite service (space-to-Earth) and by non-geostationary-satellite systems in the fixed-satellite service (space-to-Earth) is subject to the application of the provisions of No. 9.12 for coordination with other non-geostationary satellite systems in the fixed-satellite and mobile-satellite services but not with non-geostationary-satellite systems in other services. No. 22.2 shall continue to apply for non-geostationary-satellite-systems.
- 5.552. The allocation of the spectrum for the fixed-satellite service in the bands 42.5-43.5 GHz and 47.2-50.2 GHz for Earth-to-space transmission is greater than that in the band 37.5-39.5 GHz for space-to-Earth transmission in order to accommodate feeder links to broadcasting satellites. Administrations are urged to take all practicable steps to reserve the band 47.2-49.2 GHz for feeder links for the broadcasting-satellite service operating in the band 40.5-42.5 GHz.

- 5.554A. The use of the bands 47.5-47.9 GHz, 48.2-48.54 GHz and 49.44-50.2 GHz by the fixed-satellite service (space-to-Earth) is limited to geostationary satellites. (WRC-03)
- 5.555B. The power flux-density in the band 48.94-49.04 GHz produced by any geostationary space station in the fixed-satellite service (space-to-Earth) operating in the bands 48.2-48.54 GHz and 49.44-50.2 GHz shall not exceed  $-151.8$  dB(W/m<sup>2</sup>) in any 500 kHz band at the site of any radio astronomy station. (WRC-03)
- 5.555C. The use of the frequency band 51.4-52.4 GHz by the fixed-satellite service (Earth-to-space) is limited to geostationary-satellite networks. The earth stations shall be limited to gateway earth stations with a minimum antenna diameter of 2.4 metres. (WRC-19)

**Article 21.** The following provide the relevant excerpts from Article 21:

- No. 21.8 § 4 1) The equivalent isotropically radiated power (e.i.r.p.) transmitted in any direction towards the horizon by an earth station shall not exceed the following limits except as provided in No. 21.10 or 21.11:
  - a) in frequency bands between 1 GHz and 15 GHz  $+40$  dBW in any 4 kHz band for  $\theta \leq 0^\circ$   $+40 + 3 \theta$  dBW in any 4 kHz band for  $0^\circ < \theta \leq 5^\circ$ ; and
  - b) in frequency bands above 15 GHz  $+64$  dBW in any 1 MHz band for  $\theta \leq 0^\circ$   $+64 + 3 \theta$  dBW in any 1 MHz band for  $0^\circ < \theta \leq 5^\circ$ , where  $\theta$  is the angle of elevation of the horizon viewed from the centre of radiation of the antenna of the earth station and measured in degrees as positive above the horizontal plane and negative below it.
- **No. 21.9** 2) For angles of elevation of the horizon greater than  $5^\circ$  there shall be no restriction as to the equivalent isotropically radiated power (e.i.r.p.) transmitted by an earth station towards the horizon.
- **No. 21.11** 4) The limits given in Nos. 21.8 and 21.10, as applicable, may be exceeded by not more than 10 dB. However, when the resulting coordination area extends into the territory of another country, such increase shall be subject to agreement by the administration of that country.
- **No. 21.12** 5) The limits given in No. 21.8 apply, where applicable, to the services and frequency bands indicated in Table 21-3 for transmission by earth stations where the frequency bands are shared with equal rights with the fixed or mobile service.
- **No. 21.13A** 7) In the band 13.75-14 GHz, the level of off-axis e.i.r.p. emitted by an earth station of a geostationary fixed-satellite service network with an antenna diameter smaller than 4.5 m shall not exceed the following values:

Angle off-axis (degrees)	Maximum e.i.r.p. in any 1 MHz band (dBW)
$2 \leq \varphi \leq 7$	$43 - 25 \log \varphi$
$7 < \varphi \leq 9.2$	22
$9.2 < \varphi \leq 48$	$46 - 25 \log \varphi$
$\varphi > 48$	4

- **No. 21.14** § 5 1) Earth station antennas shall not be employed for transmission at elevation angles of less than  $3^\circ$  measured from the horizontal plane to the direction of maximum radiation, except

when agreed to by administrations concerned and those whose services may be affected. In case of reception by an earth station, the above value shall be used for coordination purposes if the operating angle of elevation is less than that value.

- **No. 21.16** § 6 1) The power flux-density at the Earth's surface produced by emissions from a space station, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed the limit given in Table 21-4. The limit relates to the power flux-density which would be obtained under assumed free-space propagation conditions and applies to emissions by a space station of the service indicated where the frequency bands are shared with equal rights with the fixed or mobile service, unless otherwise stated.

- **Article 22.** The following provide the relevant excerpts from Article 22:

Section II – Control of interference to geostationary-satellite systems. Includes articles that define epfd (down) limits to protect GSO ES receivers from NGSO satellite interference, so they define protection levels for ES receivers.

- **No. 22.25C** § 6 1) The equivalent power flux-density<sup>11</sup>,  $epfd_{\downarrow}$ , at any point on the Earth's surface visible from the geostationary-satellite orbit, produced by emissions from all the space stations of a non-geostationary-satellite system in the fixed-satellite service in the frequency bands listed in Tables 22-1A to 22-1E, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed the limits given in Tables 22-1A to 22-1E for the given percentages of time. These limits relate to the equivalent power flux-density which would be obtained under free-space propagation conditions, into a reference antenna and in the reference bandwidth specified in Tables 22-1A to 22-1E, for all pointing directions towards the geostationary-satellite orbit. (WRC-03)
- **No. 22.25D** 3) The equivalent power flux-density<sup>12</sup>,  $epfd_{\uparrow}$ , produced at any point in the geostationary-satellite orbit by emissions from all the earth stations in a non-geostationary-satellite system in the fixed-satellite service in the frequency bands listed in Table 22-2, for all conditions and for all methods of modulation, shall not exceed the limits given in Table 22-2 for the specified percentages of time. These limits relate to the equivalent power flux-density which would be obtained under free-space propagation conditions, into a reference antenna and in the reference bandwidth specified in Table 22-2, for all pointing directions towards the Earth's surface visible from any given location in the geostationary-satellite orbit. (WRC-2000)

Section VI – Off-axis power limits on earth stations of a geostationary-satellite network in the fixed-satellite service.

- **No. 22.26** § 9 The level of equivalent isotropically radiated power (e.i.r.p.) emitted by an earth station of a geostationary-satellite network shall not exceed the following values for any off-axis angle  $M$  which is  $3^{\circ}$  or more off the main-lobe axis of an earth station antenna:

Off-axis angle	Maximum eirp
$3^{\circ} \leq \Phi \leq 7^{\circ}$	$42 - 25 \log \Phi$ dB (W/40 kHz)
$7^{\circ} < \Phi \leq 9.2^{\circ}$	21 dB (W/40 kHz)
$9.2^{\circ} < \Phi \leq 48^{\circ}$	$45 - 25 \log \Phi$ dB (W/40 kHz)

<sup>11</sup> 22.5C.1 The equivalent power flux-density is defined as the sum of the power flux-densities produced at a geostationary-satellite system receive station on the Earth's surface or in the geostationary orbit, as appropriate, by all the transmit stations within a non-geostationary-satellite system, taking into account the off-axis discrimination of a reference receiving antenna assumed to be pointing in its nominal direction

<sup>12</sup> 22.5D.1 See No. 22.5C.1. (WRC-2000)



Off-axis angle	Maximum eirp
$48^\circ < \Phi \leq 180^\circ$	3 dB (W/40 kHz)

- **No. 22.27** For frequency-modulated television emissions with energy dispersal, the limits in No. 22.26 above may be exceeded by up to 3 dB, provided that the off-axis total e.i.r.p. of the transmitted frequency-modulated television carrier does not exceed the following values:

Off-axis angle	Maximum eirp
$3^\circ \leq \Phi \leq 7^\circ$	$56 - 25 \log \Phi$ dBW
$7^\circ < \Phi \leq 9.2^\circ$	35 dBW
$9.2^\circ < \Phi \leq 48^\circ$	$59 - 25 \log \Phi$ dBW
$48^\circ < \Phi \leq 180^\circ$	17 dBW

- **No. 22.28** Frequency-modulated television carriers which operate without energy dispersal should be modulated at all times with programme material or appropriate test patterns. In this case, the off-axis total e.i.r.p. of the emitted frequency-modulated television carrier shall not exceed the following values:

Off-axis angle	Maximum eirp
$3^\circ \leq \Phi \leq 7^\circ$	$56 - 25 \log \Phi$ dBW
$7^\circ < \Phi \leq 9.2^\circ$	35 dBW
$9.2^\circ < \Phi \leq 48^\circ$	$59 - 25 \log \Phi$ dBW
$48^\circ < \Phi \leq 180^\circ$	17 dBW

- **No. 22.29** The e.i.r.p. limits given in Nos. 22.26, 22.27 and 22.28 are applicable in the following frequency bands allocated to the fixed-satellite service (Earth-to-space):

12.75-13.25 GHz

13.75-14 GHz

14-14.5 GHz. (WRC-97)

- **No. 22.32 § 10** The level of equivalent isotropically radiated power (e.i.r.p.) density emitted by an earth station in a geostationary-satellite network in the 29.5-30 GHz frequency band shall not exceed the following values for any off-axis angle  $\Phi$  which is  $3^\circ$  or more off the main-lobe axis of an earth station antenna:

Off-axis angle	Maximum eirp
$3^\circ \leq \Phi \leq 7^\circ$	$28 - 25 \log \Phi$ dB (W/40 kHz)
$7^\circ < \Phi \leq 9.2^\circ$	7 dB (W/40 kHz)
$9.2^\circ < \Phi \leq 48^\circ$	$31 - 25 \log \Phi$ dB (W/40 kHz)
$48^\circ < \Phi \leq 180^\circ$	-1 dB (W/40 kHz)

- **No. 22.35** For geostationary-satellite systems in which the earth stations are expected to transmit simultaneously in the same 40 kHz band, e.g. for geostationary-satellite systems employing code-division multiple access, the maximum e.i.r.p. values given in No. 22.32 should be decreased by  $10 \log(N)$  dB, where N is the number of earth stations which are in the receive satellite beam of the satellite with which these earth stations are communicating and which are expected to transmit simultaneously on the same frequency. (WRC-2000)
- **No. 22.36** Earth stations operating in the frequency band 29.5-30 GHz should be designed in such a manner that 90% of their peak off-axis e.i.r.p. density levels do not exceed the values given in No. 22.32. Further study is needed to determine the off-axis angular range over which these exceedances would be permitted, taking into account the interference level into adjacent satellites. The statistical processing of the off-axis e.i.r.p. density peaks should be carried out using the method given in the most recent version of Recommendation ITU-R S.732. (WRC-07)
- **No. 22.37** The limits given in Nos. 22.26 to 22.28 and 22.32 apply under clear-sky conditions. During rain-fade conditions, the limits may be exceeded by earth stations when using uplink power control. (WRC-2000)
- **No. 22.38** Earth stations in the fixed-satellite service operating in the 29.5-30 GHz band, which have lower elevation angles to the geostationary-satellite orbit, will require higher e.i.r.p. levels relative to the same terminals at higher elevation angles to achieve the same power flux-densities at the geostationary-satellite orbit, due to the combined effect of increased distance and atmospheric absorption. Earth stations with low elevation angles may exceed the levels given in No. 22.32 by the following amounts:

Elevation angle to geostationary-satellite orbit, $\epsilon$	Increase in e.i.r.p. density (dB)
$\epsilon \leq 5^\circ$	2.5
$5^\circ < \epsilon \leq 30$	$0.1(25 - \epsilon) + 0.5$

- **No. 22.39** The values in No. 22.32 applicable to the off-axis angle range from  $48^\circ$  to  $180^\circ$  are intended to account for spillover effects. (WRC-2000)

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