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| U.S. Radiocommunications Sector  Fact Sheet | | |
| **Working Party:** ITU-R WP 5C | **Document No:** USWP5C-0A | |
| **Ref:** WRC-27 AI 1.10 | **Date:** March 8, 2025 | |
| **Document Title:** Working Document on Sharing Studies under Agenda Item 1.10 | | |
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| **Purpose/Objective:** This contribution progresses ITU WP 5C’s efforts on WRC-27 agenda item 1.10. | | |
| **Abstract:** At the last meeting of WP 5C, the group developed a new working document on sharing studies under agenda item 1.10. This contribution provides additional information on incumbent systems, including information from contributing groups. | | |

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| **Radiocommunication Study Groups** |  |
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| Source: Annex 2.4 of 5C/[152](https://www.itu.int/dms_ties/itu-r/md/23/wp5c/c/R23-WP5C-C-0152!N02.04!MSW-E.docx)  Subject: WRC-27 Agenda Item 1.10 | **Document 5C/** |
| **Date** |
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| United States of America | |
| WORKING DOCUMENT ON SHARING STUDIES UNDER AGENDA ITEM 1.10 | | |
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**Introduction**

WRC-27 agenda item 1.10 addresses:

*1.10 to consider developing power flux density and equivalent isotropically radiated power limits for inclusion in Article* ***21*** *of the Radio Regulations for the fixed-satellite, mobile-satellite and broadcasting-satellite services to protect the fixed and mobile services in the frequency bands 71-76 GHz and 81-86 GHz, in accordance with Resolution* ***775 (Rev.WRC-23)****;*

This contribution provides updates, shown in tracked changes, to the working document initiated at the last meeting of Working Party (WP) 5C in order to progress WP 5C’s studies to determine power flux-density (pfd) and equivalent isotropically radiated power (e.i.r.p.) limits to be included in Article **21** for satellite services (fixed-satellite service (FSS), mobile-satellite service (MSS) and broadcasting-satellite service (BSS)) to protect the current and planned fixed and mobile services in the frequency bands 71-76 GHz and 81-86 GHz.

Attachment: 1

ATTACHMENT

|  |
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| **Annex 2.4 to Working Party 5C Chair’s Report** |
| WORKING DOCUMENT ON SHARING STUDIES UNDER AGENDA ITEM 1.10 |
|  |

**1. Introduction**

WRC-27 agenda item 1.10 addresses:

*1.10 to consider developing power flux density and equivalent isotropically radiated power limits for inclusion in Article* ***21*** *of the Radio Regulations for the fixed-satellite, mobile-satellite and broadcasting-satellite services to protect the fixed and mobile services in the frequency bands 71-76 GHz and 81-86 GHz, in accordance with Resolution* ***775 (Rev.WRC-23)****;*

In Resolution **775 (WRC-23)**, the World Radiocommunication Conference (Dubai, 2023),

*resolves to invite the ITU Radiocommunication Sector to complete in time for the 2027 world radiocommunication conference*

*the appropriate studies to determine power flux-density (pfd) and equivalent isotropically radiated power (e.i.r.p.) limits to be included in Article* ***21*** *for satellite services (fixed-satellite service (FSS), mobile-satellite service (MSS) and broadcasting-satellite service (BSS)) to protect the current and planned fixed and mobile services in the frequency bands 71-76 GHz and 81-86 GHz, …*

This document contains the result of the studies under WRC-27 agenda item 1.10, in response to Resolution **775 (Rev.WRC-23)**.

**2. Provisions of the Radio Regulations**

The extracts from Article **5** of the Radio Regulations (RR), edition 2024, is presented in Tables 1 and 2 for the frequency ranges 71-76 GHz and 81-86 GHz, respectively.

Table 1

**Extract from Article 5 of Radio Regulations for 71-76 GHz band**

|  |  |  |
| --- | --- | --- |
| **Allocation to services** | | |
| **Region 1** | **Region 2** | **Region 3** |
| **71-74** FIXED  FIXED-SATELLITE (space-to-Earth)  MOBILE  MOBILE-SATELLITE (space-to-Earth) | | |
| **74-76** FIXED  FIXED-SATELLITE (space-to-Earth)  MOBILE  BROADCASTING  BROADCASTING-SATELLITE  Space research (space-to-Earth)  5.561 | | |

Table 2

**Extract from Article 5 of Radio Regulations for 81-86 GHz band**

|  |  |  |
| --- | --- | --- |
| **Allocation to services** | | |
| **Region 1** | **Region 2** | **Region 3** |
| **81-84** FIXED 5.338A  FIXED-SATELLITE (Earth-to-space)  MOBILE  MOBILE-SATELLITE (Earth-to-space)  RADIO ASTRONOMY  Space research (space-to-Earth)  5.149 5.561A | | |
| **84-86** FIXED 5.338A  FIXED-SATELLITE (Earth-to-space) 5.561B  MOBILE  RADIO ASTRONOMY  5.149 | | |

Based on the information provided above, the appropriate studies could be carried out taking into account the nature of frequency bands and the service allocation in these frequency bands, to determine related PFD and E.I.R.P limits, as shown below:

– PFD limit for fixed-satellite service (space-to-Earth) to protect mobile service and fixed service in 71-76 GHz;

– PFD limit for mobile-satellite service (space-to-Earth) to protect mobile service and Fixed Service in 71-74 GHz;

– PFD limit for broadcasting-satellite service to protect mobile service and fixed service in 74-76 GHz;

– E.I.R.P limit for fixed-satellite service (Earth-to-space) to protect mobile service and fixed service in 81-86 GHz;

– E.I.R.P limit for mobile-satellite service (Earth-to-space) to protect mobile service and fixed service in 81-84 GHz.

**3. Propagation conditions**

Document [5C/74](https://www.itu.int/md/R23-WP5C-C-0074/en) from WPs 3J and 3M contains references to the following recommendations:

**Recommendation** [**ITU-R P.452**](https://www.itu.int/rec/R-REC-P.452/en) **is applicable for sharing studies between stations on the surface of the Earth.** **While the models have been tested up to 50 GHz, it is considered that it can be used for frequencies up to 100 GHz with the following caveats:**

1 The free space loss component is applicable for all frequencies without limit.

2 The gaseous attenuation component, based on Recommendation [ITU-R P.676](https://www.itu.int/rec/R-REC-P.676/en), is applicable to 1 000 GHz.

3 The prediction method for diffraction loss is applicable for frequencies to at least 100 GHz although the input data required, such as terrain profiles, may not be detailed enough at the higher frequencies. However, the loss due to diffraction at these frequencies is quite large, so once a path is fully transhorizon, the only significant propagation mechanism is troposcatter.

4 While the troposcatter and anomalous propagation methods are based on measurements up to 50 GHz and have not been tested at higher frequencies, there is nothing intrinsic in the methods that would prevent their use between 50 and 86 GHz.

**Recommendation** [**ITU-R P.619**](http://www.itu.int/rec/R-REC-P.619/en) **is applicable for sharing studies between stations in space and stations on the Earth’s surface.**

**Recommendation** [**ITU-R P.2108**](https://www.itu.int/rec/R-REC-P.2108/en) **– *Prediction of clutter loss*.**

Notwithstanding the elements received from WPs 3J and 3M, in Section V of RR Article **21** (e.g.No. **21.16**), the limit of power flux-density from space-stations relates to the power flux-density which would be obtained under assumed free-space propagation conditions.

**4. Characteristics and protection criteria of FS stations**

*Editor’s note: Further discussion is necessary to determine what range of values should be used for FS characteristics, if single or ranges of typical values should be considered, and if the characteristics represent representative or worst-case values. The tables below provide a compilation of the characteristics proposed by input contributions to the Nov 2024 meeting of WP 5C.*

The following ITU-R Recommendation contain relevant technical and operational characteristics as well as protection criteria for on FS systems:

– ITU-R [F.758-7](https://www.itu.int/rec/R-REC-F.758/recommendation.asp?lang=en&parent=R-REC-F.758-7-201911-I) contains the principles for the development of sharing criteria of digital systems in the FS. It also contains information on representative technical characteristics of digital fixed wireless systems (FWS) in the FS for use in sharing studies above about 30 MHz. For agenda item (AI) 1.10, the following table abstracted from Table 11 contains the system parameters for PP FS systems in allocated bands from 71-76 GHz and 81-86 GHz.

Table 3

**Typical values for FS point-point system parameters in the frequency band 71-76 and 81-86 GHz**

|  |  |  |
| --- | --- | --- |
| **Frequency range (GHz)** | **71-76/81-86** | |
| Reference ITU-R Recommendation | F.2006 | |
| Modulation | QPSK | 64-QAM |
| Channel spacing and receiver noise bandwidth (MHz) | 250, 500, 750, 1 000, **1 250**, 1 500, 1 750, 2 000, 2 250 | 500, 700, 1 000 |
| Tx output power range (dBW) | –10 | –20 |
| Tx output power density range (dBW/MHz)(1) | –41 | –47…-50 |
| Feeder/multiplexer loss range (dB) | 0 | 0 |
| Antenna gain range (dBi) | 54 | 44…50 |
| e.i.r.p. range (dBW) | 44 | 24…30 |
| e.i.r.p. density range (dBW/MHz)(1) | 13 | –6…3 |
| Receiver noise figure typical (dB) | 10 | 8 |
| Receiver noise power density typical (=*NRX*) (dBW/MHz) | –134 | –136 |
| Normalized Rx input level for 1 × 10–6 BER (dBW/MHz) | –120.5 | –94…-91 |
| Nominal long-term interference power density (dBW/MHz)(2) | –134 + *I*/*N* | –136 + *I*/*N* |

– ITU-R [F.699-8](https://www.itu.int/rec/R-REC-F.699/en) provides reference radiation patterns for, and information on, point-to-point FWS antennas in the frequency range from 100 MHz to 86 GHz. This information may be used in single-entry analyses and interference assessments when information concerning the FWS antenna is not available.

– ITU-R [F.1245-3](https://www.itu.int/rec/R-REC-F.1245/en)provides average sidelobes and related reference radiation patterns for point-to-point FWS antennas in the frequency range from 1 GHz to 86 GHz. This information may be used for aggregate coordination and interference assessment studies when information concerning the FWS antenna is not available.

Typical FS station parameters are provided in the following table, to facilitate the sharing study.

*Editor’s note: Table 1 is the result from offline discussion on typical parameters.*

Table 4

**Typical values for FS point-point system parameters in the frequency band 71-76 and 81-86 GHz**

|  |  |
| --- | --- |
| **System parameters** | **Typical Value** |
| Channel spacing and receiver noise bandwidth (MHz) | 500 |
| Modulation | 128 QAM |
| Feeder/multiplexer loss (dB) | 0 |
| Antenna gain (dBi) | 51 |
| Antenna size (m) | 0.6 |
| Receiver noise figure (dB) | 7 |
| Antenna height(m) | 30 |
| Antenna RPE | F.699-8 and F.1245-3 |
| Link length (km) | 3 |
| Elevation angle (degree) | -5-5 |

The following protection criteria used in study of AI 1.10 are:

‒ for the long-term, the *I/N* at the input of the FS receiver should not exceed –10 dB for more than 20% of the time;

‒ for the short-term, the *I/N* at the input of the FS receiver should not exceed +9 dB for more than 1.3 x 10-5 of the time. The derivation methodology is in Attachment 1.

**5. Characteristics and protection criteria of AMS stations**

(5C/[149](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R23-WP5C-C-0149))

Receivers operating in these bands for end points in motion have typical characteristics of other receivers in the band, with the difference being that they may be pointed above the horizon and therefore must be protected from emissions from earth-to-space links. Receivers use a target *C/N* of 15 dB, with a 7 dB noise figure. Channelization plans for 71-76 GHz and 81-86 GHz would be based on Recommendation [ITU-R F.2006](https://www.itu.int/rec/R-REC-F.2006/en), which provides different channel sizes from 250 MHz up to 5 GHz and includes a plan for 1.25 GHz segmentation. Typical operating bandwidths for the AMS are 500 to 1 000 MHz. The target thermal noise is ‒164 dBm/Hz and the target RX power is ‒92 dBW.

Antenna characteristics:

A variety of different types of antennas are used by systems in the 71-76 GHz and 81-86 GHz frequency bands. Antennas in these bands are generally of a variety of sizes (0.3 to 0.6 m) and vary between the airborne component of the link and the ground-based component of the link. The airborne antennas gain is typically in the 44-51 dBi range and will be in operation at elevations between 10 000 and 50 000 feet. The ground-based antenna gain is typically near 51 dBi. Horizontal, vertical and circular polarizations are used with circular as the preferred polarisation. Ground stations operate with a minimum elevation angle of 5 degrees and a maximum elevation angle of 45 degrees.

If antenna characteristics provided in Table 1 are sufficient, these characteristics should be used in sharing analyses. If additional characteristics are required, the first source of the data should be measured antenna characteristics. Recommendation [ITU-R F.699](https://www.itu.int/rec/R-REC-F.699/en) patterns are used for the mobile antennas given that these platforms can operate within the context of a coordinated fixed service.

Protection criteria for the aeronautical mobile service

When operating near the maximum radio line-of-sight distance separation between the transmitter and receiver, the performance of the communication link is often noise limited. An increase in receiver effective noise of 1 dB would constitute significant degradation communication range, equivalent to a reduction in communication range of approximately 10% in a free‑space propagation environment.

Such an increased effective receiver noise corresponds to an (*I* + *N*)/*N* ratio of 1.26, or an *I*/*N* ratio of about −6 dB. This represents the required protection criterion for these systems from all sources of interference.

TABLE 5

**Representative receiver technical characteristics of the aeronautical mobile service systems**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | | **Units** | **Airborne Receiver** | **Ground Receiver** | **Air-to-air (ATA) System Airborne** |
| Tuning range | | GHz | 81-86 | 71-76 | 71-76 & 81-86 |
| RF selectivity | 3 dB | MHz | 100 | 100 | 100 |
| 20 dB | MHz | 500/750/1 000 | 500/750/1 000 | 500/750/1 000 |
| 60 dB | MHz | 5 000 | 5 000 | 5 000 |
| IF selectivity | 3 dB | MHz | 100 | 100 | 100 |
| 20 dB | MHz | 500/750/1 000 | 500/750/1 000 | 500/750/1 000 |
| 60 dB | MHz | 5 000 | 5 000 | 5 000 |
| NF | | dB | 7 | 7 | 7 |
| Sensitivity | | dBm | −75 to −80 | −80 to −90 | −75 to −80 |
| Image rejection | | dB | 20 | 20 | 20 |
| Spurious rejection | | dB | 20 | 20 | 20 |
| Antenna gain | | dBi | 51 | 51 | 51 |
| 1st sidelobe | | dBi | 5 @ 0.7° for horizontal  5 @ 1.1° for vertical | 5 @ 0.7° for horizontal  5 @ 1.1° for vertical | 5 @ 0.7° for horizontal  5 @ 1.1° for vertical |
| Polarization | |  | RHCP1 & LHCP2 | RHCP1 & LHCP2 | RHCP1 & LHCP2 |
| Antenna pattern/type | |  | Parabolic or phased array | Horn | Parabolic or phased array |
| Horizontal BW | | degrees | 0.5 | 0.5 | 0.5 |
| Vertical BW | | degrees | 0.9 | 0.5 | 0.9 |
| Antenna model | |  | Recommendation ITU-R F.699 | Recommendation ITU-R F.699 | Recommendation ITU-R F.699 |

**6. Characteristics of FSS & BSS stations**

Tables in Attachment 3 summarize system characteristics, sent by WP 4A in Document 5C/142, that could be used in sharing studies within the context of WRC-27 AI 1.10. Satellite systems and networks in BR IFIC (Space services) with frequency assignments in the 71-76 GHz and 81‑86 GHz bands could also be used for sharing studies.

With respect to the question on how to model multiple systems to perform aggregate interference calculations, WP 4A recommends conducting simulations with the systems listed in the Attachment 3 noting that (1) additional satellite systems and networks in BR IFIC (Space services) could be included in aggregate interference calculations and (2) multiple co-frequency GSOs can operate over the same area from different longitudes on the GSO arc.

Moreover, WP 4A notes that non‑GSO systems may implement mitigation measures among themselves. Normally, these measures, if applied, are confidential, but one possible technique to model these measures is to use avoidance angle between co-frequency beams. That is, for instance, on a given frequency, System A’s beam will need to have at least 1.5° angular separation with System B’s beam if they are serving the same area on Earth. It is not feasible to serve the same spot on the same frequency from satellites that are in close proximity of each other.

When considering aggregate interference from GSO satellites, a minimum longitude difference between satellites of 1° could be used.

Table 2 and 3 of Attachment 3, as well as BR IFIC (Space Service) contains characteristics of earth stations to be considered by WP 5C to determine appropriate e.i.r.p. limits.

Additional information provided by the BR has been provided in 5C/[148](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R23-WP5C-C-0148). Two attached Microsoft Excel documents contain information on:

– The characteristics of FSS and MSS networks and systems in the bands 71-74 GHz and 81-84 GHz as currently contained BR IFIC 3034 dated 12 November 2024;

– To cover FSS only use of the frequency bands 74-76 GHz and 84-86 GHz the characteristics of FSS and MSS networks and systems are provided for the whole frequency bands 71-76 GHz and 81-86 GHz.

These characteristics include frequency assignments using space operation classes of stations which can be considered as operating under either FSS or MSS allocations depending on the case.

**7. Characteristics of MSS stations**

*Editor’s note: Consultation with BR is necessary to provide the necessary information from the data filings that can be used for the sharing studies, as 4C did not provide any MSS characteristics. Upon received proper and workable information from BR, that may be conveyed to 4C.*

Upon request of WP 4C (see Document 5C/143), BR reviewed the satellite filings to gather characteristics of MSS networks or systems in the frequency bands 71-74 GHz and 81-84 GHz and sent them directly to WP 5C. The data can be found [here](https://eur01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fextranet.itu.int%2Frsg-meetings%2Fsg5%2Fwp5c%2FShare%2FForms%2FColumn%2520view.aspx%3FRootFolder%3D%252Frsg-meetings%252Fsg5%252Fwp5c%252FShare%252FWG%25205C-2%2520Sharing%252C%2520compatibility%2520aspects%2520and%2520WRCs%2520issues%26FolderCTID%3D0x0120003D12FDCA4AB21246A058EC9F73544730%26View%3D%257BD767BD77-F6D3-429A-BA07-6B1F103BD607%257D&data=05%7C02%7CNasarat.Ali%40ofcom.org.uk%7C5acfc255dc794d30b57008dd08bc1371%7C0af648de310c40688ae4f9418bae24cc%7C0%7C0%7C638676326146941601%7CUnknown%7CTWFpbGZsb3d8eyJFbXB0eU1hcGkiOnRydWUsIlYiOiIwLjAuMDAwMCIsIlAiOiJXaW4zMiIsIkFOIjoiTWFpbCIsIldUIjoyfQ%3D%3D%7C0%7C%7C%7C&sdata=iqYDdAt934iliKA%2Ba7L9h9c4iRGk4FAUyxXK9wa2qTs%3D&reserved=0). It includes orbital parameters of satellite systems published by administration in BR IFIC (Space Services). BR has also provided information on characteristics of FSS and MSS networks and systems in Document 5C/148.

Attachment 4 in this working document presents 4 systems extracted from that dataset, to be used as possible examples of MSS systems for studies under this agenda item.

**8. Methodology for sharing study with the Fixed Service**

**8.1 Methodology for the determination of power flux-density (pfd) limits**

Determination of pfd limits for possible inclusion in RR Article **21** may result in the addition of one or several entries in Table **21-4** which defines pfd limits in dB(W/m2) for angles of arrival (δ) above the horizontal plane.

To calculate this angle of arrival, and hence, the pfd limits, positions of the interfering satellite and of the victim station are necessary.

Recommendation [ITU-R F.1108-4](https://www.itu.int/rec/R-REC-F.1108/en) – *Determination of the criteria to protect fixed service receivers from the emissions of space stations operating in non-geostationary orbits in shared frequency bands* contains various methodologies to determine the criteria to protect fixed service receivers from emissions of space stations operating in non-geostationary orbits in shared frequency bands. Annex 1 of this Recommendation contains the necessary formulas to evaluate the satellite elevation and angular distance from the victim antenna main beam.

The following sections provides different study scenario to assess sharing between FS and FSS.

**8.1.1 Sharing with GSO satellites**

As the interference from GSO satellites is steady, the long-term protection criterion of Recommendation ITU-R F.758 is used.

**Scenario 1**

Station(s) of the fixed service are defined with the parameters of the following table.

Table 6

**Parameters of the station of the fixed service**

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Source** |
| Latitude (°) | 0, 25, 50, 75 |  |
| Longitude (°) | 0 |  |
| Altitude (m) | 30 |  |
| Antenna elevation (0) | 0, 2.5, 5 | Rec. ITU-R F.2086 |
| Azimut (°) | 0 to 180 |  |
| Antenna diameter (cm) | 20, 30 or 60 |  |
| Antenna diagram |  | Rec. ITU-R F.1245 |
| Max antenna gain |  | Rec. ITU-R F.699 |
| *I/N* (dB) long-term | ‒10 | Rec. ITU-R F.758 |
| Nominal long-term interference power density (dBW/MHz) | ‒146 | Rec. ITU-R F.758 |

GSO satellites are separated from 10, 4, or 1°.

Exceedance over the nominal long-term interference power density is assessed with several tentative pfd masks.

*{Editor’s note: The following figure provides an example of such assessment*

A graph of a graph

AI-generated content may be incorrect.}

**8.1.2 Sharing with non-GSO satellites**

Recommendation ITU-R F.1108-4 – *Determination of the criteria to protect fixed service receivers from the emissions of space stations operating in non-geostationary orbits in shared frequency bands* contains equations to simulate the operation of a non-GSO satellite and thereby the statistics necessary to determine how often a satellite will be visible in any direction for a particular terrestrial station or position.

**Scenario 1**

Station(s) of the fixed service are defined with the parameters of the following table.

Table 6

**Parameters of the station of the fixed service**

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Source** |
| Latitude (°) | 0, 25, 50, 75 |  |
| Longitude (°) | 0 |  |
| Altitude (m) | 30 |  |
| Antenna elevation (0) | 0, 2.5, 5 | Rec. ITU-R F.2086 |
| Azimut (°) | 0, 60, 120, 180 |  |
| Antenna diameter (cm) | 20, 30 or 60 |  |
| Antenna diagram |  | Rec. ITU-R F.1245 |
| Max antenna gain |  | Rec. ITU-R F.699 |
| *I/N* (dB) long-term | ‒10 | Rec. ITU-R F.758 |
| Nominal long-term interference power density (dBW/MHz) | ‒146 | Rec. ITU-R F.758 |
| *I/N* (dB) short-term | +9 | Annex 1 |
| Nominal short-term interference power density (dBW/MHz) | [TBD] |  |

Compliance with the short-term and long-term protection criteria is assessed for several tentative pfd masks.

A sensitivity analysis is provided to assess the influence of:

‒ the number of satellites in the non-GSO system (1, 10, 100, 1 000, 10 000, 100 000), or other numbers of satellites in line with the elements provided by WP 4A, and

‒ altitude of the non-GSO satellites.

**8.2 Methodology for the determination of equivalent isotropically radiated power (e.i.r.p.) limits**

TBD

**8.3 Studies for FSS & BSS stations**

TBD

**8.4 Studies for MSS stations**

TBD

**8.5 Summary of the results of studies**

TBD

**9. Methodology for sharing study with the Mobile Service**











Attachment 1

**Derivation of short-term protection criteria for agenda item 1.10**

The allowable degradation in performance of FS systems due to interference from other services sharing the same frequency bands on a primary basis are expressed as a permissible fraction (10%) of the total Error Performance Objectives (EPO) and are defined in Recommendation ITU-R F.1565 and ITU-R F.1495 for the real FS systems which may form part of the national portion of a 27 500 km HRP, assumed to be representative of the 71-76 GHz and 81-86 GHz FS links.

The total corresponding EPO value is calculated to be 1.6  10–5 for severely errored second ratio, and correspond to the following assumptions:

– Access network section (Tables 10 of Recommendation ITU-R F.1565-1 below);

– Only SESR applies here as there is no ESR value in this table for 160 to 3 500 Mbit/s;

– Rate from 160 to 3 500 Mbit/s in Tables 10 of Recommendation ITU-R F.1565-1;

– *C*  8%.

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Description automatically generated

Table 10 from Recommendation ITU-R F.1565-1.

It is well-known that rain is the dominating factor in fading at 71-76 GHz and 81-86 GHz. Therefore, even if long-term interference has an effect on the performance of the link, the main way to have an outage of the FS link is to have an interference level higher than the fade margin of the link, whatever the propagation conditions may be.

On this basis, the following apportionment of the effect of interference on the degradation of the link (and on the EPOs) has been assumed:

– 20% of FS link degradation due to long-term interference;

– 80% of FS link degradation due to short-term interference.

Then the corresponding EPO value for short-term is calculated to be 1.3  10–5, with the rounding value to the nearest decimal number, according to the total EPO value calculated in above paragraphs.

Considering that in the 71-76 GHz and 81-86 GHz band FS links, rain is dominating factor in fading, then adaptive modulation is often used, and band carrier aggregation technologies are also often used to facilitate effective transmission by using 71-76 GHz and 81-86 GHz and lower band such as 18 GHz, 23 GHz etc. together, an FS fade margin of 8 dB is thought to be the typical value at this band.

As this fade margin is given for a BER of 1 × 10–6 and as the EPO are referenced to SES in Recommendation ITU-T G.826 definition, it is necessary to extrapolate the fade margin corresponding to SES levels. On the basis of the agreed assumptions that the fad margins for SES is 1 dB higher than the FM referenced to the BER 1 ×10–6 level.

Then the short-term protection criteria proposed for agenda item 1.10 is ***I/N* not exceed +9 dB for more than 1.3  10–5 of the time**.]

ATTACHMENT 2

**Proposed examples of FSS satellite systems to be considered  
for studies under WRC-27 agenda item 1.10**

Table 10

**Orbit configuration**

| **Parameter** | **System A[[1]](#footnote-2)** | **System B** | **System C** | **System D** | **System E** | **System F** | **System G** | **System H** | **System I** | **System J** | **System K** | **System L** | **System M[[2]](#footnote-3)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Height (km) | 525, 530, 535 | 590, 610, 630 | 35786 | 1050 | 1414 | 450 to 900 | 340 to 614 | 600, 1200 | 8 062 | 1 175 | 355, 347 | 500, 500, 600, 600, 700, 700, 800, 800, 900, 900, 1000, 1000, 1100, 1100, 1200, 1200, 1300, 1300, 1400, 1400, 8100, 8100, 8100, 8100, 8100, 8100, 8100, 8100, 12000, 12000, 12000, 12000, 12000, 12000, 12000, 12000, 16000, 16000, 16000, 16000, 16000, 16000, 16000, 16000, 20000, 20000, 20000, 20000, 20000, 20000, 20000, 20000, 23222, 23222, | 340, 345, 350, 360, 525, 530, 535, 604, 614 |
| Number of planes | 28, 28, (24,4) | 28, 36, 34 | 1 | 12 | 8 | 81 | 794 | 132 | 1, 4, 6 | 18 | 24, 24 | 36, 36, 36, 36, 34, 34, 30, 30, 28, 28, 24, 24, 24, 24, 22, 24, 20, 20, 18, 18, 1, 12, 12, 12, 12, 12, 12, 12, 1, 12, 12, 12, 12, 12, 12, 12, 1, 12, 12, 12, 12, 12, 12, 12, 1, 12, 12, 12, 12, 12, 12, 12, 1, 12 | 12, 18, 48, 48, 48, 30, 28, 28, 28 |
| Satellites per plane | 120, 120, (28,27) | 28, 36, 34 | 1 | 28 | 6 | 1 to 8 | 12 to 120 | 36 to 72 | 32, 16, 12 | 48 | 124 | 36, 36, 32, 32, 32, 32, 32, 32, 30, 30, 24, 24, 24, 24, 24, 24, 24, 24, 20, 20, 96, 10, 10, 10, 10, 10, 10, 10, 96, 10, 10, 10, 10, 10, 10, 10, 96, 10, 10, 10, 10, 10, 10, 10, 96, 10, 10, 10, 10, 10, 10, 10, 96, 9 | 110, 110, 110, 120, 120, 120, 120, 12, 18 |
| Inclination angle (deg) | 53, 43, 33 | 33, 42, 51.9 | 0 | 89 | 52 | 0 to 98.9 | 33 to 148 | 40 to 87.9 | 0, 90, 45 | 86.5 | 50, 50.2 | 50, 85, 50, 85, 50, 85, 50, 85, 50, 85, 50, 85, 50, 85, 50, 89, 50, 85, 50, 85, 0, 15, 45, 60, 65, 70, 75, 80, 0, 15, 45, 60, 65, 70, 75, 80, 0, 15, 45, 60, 65, 70, 75, 80, 0, 15, 45, 60, 65, 70, 75, 80, 0, 56 | 53, 46, 38, 97, 53, 43, 33, 148, 116 |
| RAAN | Equally spaced | Equally spaced |  | Equally spaced | Equally spaced | Equally spaced | Equally spaced | Equally spaced | Equally spaced | Equally spaced | Equally spaced | Equally spaced | Equally spaced |

Table 11

**Other characteristics for systems A to C**

| **Parameter** | **System A** | **System A** | **System B** | **System B** | **System C** | **System C** |
| --- | --- | --- | --- | --- | --- | --- |
| Frequency (GHz) | 71-76 | 81-86 | 71-76 | 81-86 | 71-76 | 81-86 |
| Peak antenna gain (dBi) | 52 | 60.9 (D: 1.85 m) | 41.9 or 48 | 53.6 (D: 1 m, 59.6 (D: 2 m, ), 64.5 (D: 3.5 m) | 50 | 50 (D:0.6 m) |
| Antenna Pattern | Rec S.1528  Recommend 1.2 for main beam  Recommend 1.4 for side lobes  (beyond 15°) | Recommendation ITU‑R S.580-6 | Rec. S.1528 Recommend 1.2 for main beam  Recommend 1.4 for side lobes (beyond 15°) | Recommendation ITU‑R S.580-6 | For satellite: Appendix 7 Annex 3 Section 3  G1= ‒13 dB  Beamwidth = 0.42 deg | For earth station: S.580 |
| Input power density (dBW/Hz) | ‒103 to ‒83.57  Max power only used while compensating for low elevation angles or rain fade attenuation | ‒93 to ‒80.8  Max power only used while compensating for low elevation angles or rain fade attenuation | ‒106.2 to ‒86.2  Max power only used while compensating for low elevation angles or rain fade attenuation | ‒97 to ‒77  Max power only used while compensating for low elevation angles or rain fade attenuation | ‒77.8[[3]](#footnote-4) | ‒77.8 |
| Minimum Elevation Angle (degrees) | 15 | 15 | 20 | 20 | 3 | 3 |
| Bandwidth (MHz) | 1 250 | 1 250 | 100 | 100 | 180 | 180 |
| Out of band emission mask | SM.1541-6 | SM.1541-6 | SM.1541-6 | SM.1541-6 | SM.1541-6 | SM.1541-6 |
| Number of co-frequency beams (N\_co) | 32 | 32 | 32 | 32 | 1 | 1 |
| Max Power Flux Density on the ground  dBW/m2/MHz | ‒106 | N/A | ‒104 | N/A | ‒129.85 | N/A |
| Worst[[4]](#footnote-5) Earth station density per 2 000 000 km2 | N/A | 76 | N/A | 5 | N/A | 25 |

Table 12

**Other characteristics for systems D to H**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **System** | **System D** | | **System E** | | **System F** | | **System G** | | **System H** | |
| Frequency (GHz) | 71-76 | 81-86 | 71-76 | 81-86 | 71-76 | 81-86 | 71-76 | 81-86 | 71-76 | 81-86 |
| Peak Antenna Gain (dBi) | 34.1 | 40.9 to 61.3 | 25 to 45 | 35.4 to 72 | 59 | 30 to 70.5 | 35 to 60 | 35 to 71 | 39.4 to 55.9 | 41.9 to 68.3 |
| Antenna pattern | Rec S.1528 | Rec 580-6 | Rec S.1528 | AP8 | Rec S.1528 | Rec 580-6 | Rec S.1528 | AP8 | Rec S.1528 | AP8 |
| Beamwidth |  | 0.13 to 1.65 |  | 0.04 to 2.79 |  | 0.05 to 5.6 |  | 0.05 to 3 |  | 0.07 to 1.41 |
| Input Power Density (dBW/Hz) | −36.1 to −30.1 |  | −82.1 to −45.9 |  | −83 to −74 |  | −80 to −55 |  | −94.6 to −72.3 |  |

ATTACHMENT 3

**Proposed examples of MSS satellite systems to be considered  
for studies under WRC-27 agenda item 1.10**

Table 13

**Orbit configuration**

| **Parameter** | **System N** | **System O** | **System P** | **System Q** |
| --- | --- | --- | --- | --- |
| Perigee (km) | 21000 | 3800, 3000, 1776, 1215, 6400 | 540, 21028.6, 23136.8, 25245, 25245, 27353.2, 29461.4, 30726.3, 35786.1 | 340, 345, 350, 360, 525, 528, 530, 535, 540, 550, 560, 560, 570, 604, 614 |
| Apogee (km) | 21000 | 9000, 9800, 11024, 11585, 6400 | 540, 50543.5, 48435.2, 46327, 46327.1, 44218.9, 42110.6, 40845.7, 35786.1 | 340, 345, 350, 360, 525, 528, 530, 535, 540, 550, 560, 560, 570, 604, 614 |
| Number of planes | 6 | 31, 1, 9, 9, 9 | 9, 256, 256, 256, 1, 255, 512, 512, 128, 256, 128, 128 | 96, 96, 96, 60, 56, 28, 56, 56, 72, 72, 4, 6, 36, 24, 36 |
| Satellites per plane | 6 | 7, 7, 21, 21, 21 | 23, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1 | 110, 110, 110, 120, 120, 120, 120, 120, 22, 22, 43, 58, 20, 12, 18 |
| Inclination angle (deg) | 55 | 63, 64, 45, 50, 52 | 98, 63, 41, 46, 46, 46, 63, 63, 38, 42, 20, 25 | 53, 46, 38, 97, 53, 43, 43, 33, 53, 53, 98, 98, 70, 148, 116 |
| RAAN | Equally spaced | Equally spaced | Equally spaced | Equally spaced |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_**]**

1. Altitude 535 km, Inclination 33 deg, 24 planes with 28 satellites per plane and 4 planes with 27 satellites per plane. [↑](#footnote-ref-2)
2. Systems A and M are variations of the same system and as such, they shouldn’t be aggregated in studies. [↑](#footnote-ref-3)
3. This is an average input power spectral density meaning there could be higher and lower power spectral densities employed by the System C satellite. [↑](#footnote-ref-4)
4. The worst density is provided in the table. To scale for larger area, the density should be considered together with a factor of 0.65 to account for the fact that the worst density isn’t feasible on a wider scale. For instance, density of 10 in 2 million km2, if scaled to 10 million km2 is: 10 × 10 000 000/2 000 000 × 0.65 = 32.5 [↑](#footnote-ref-5)