

RESOLUTION 679 (WRC-23)

**Use of the frequency bands 18.1-18.6 GHz, 18.8-20.2 GHz
and 27.5-30 GHz by the inter-satellite service**

The World Radiocommunication Conference (Dubai, 2023),

considering

- a)* that there is a need for non-geostationary-satellite orbit (non-GSO) space stations to be able to relay data to the Earth, and that part of this need could be met by allowing such non-GSO space stations to communicate with inter-satellite service (ISS) space stations operating in the geostationary-satellite orbit (GSO) and in the non-GSO in the frequency bands 18.1-18.6 GHz, 18.8-20.2 GHz and 27.5-30 GHz, or parts thereof;
- b)* that the administration responsible for the notification of non-GSO space stations communicating with GSO or non-GSO space stations in the ISS at higher altitude does not need to be the same administration that has already notified assignments in the ISS;
- c)* that imposing the hard limits necessary to protect other services would provide regulatory certainty for notifying administrations both of non-GSO space stations communicating with ISS space stations and of potentially impacted services;
- d)* that there is growing interest in utilizing satellite-to-satellite links for a variety of applications;
- e)* that the ITU Radiocommunication Sector (ITU-R) has carried out studies on sharing and compatibility between incumbent services in the frequency bands 18.1-18.6 GHz, 18.8-20.2 GHz and 27.5-30 GHz and adjacent bands and satellite-to-satellite transmissions in the ISS;
- f)* that these studies were based on certain principles, including the limitation of the use of frequency bands to a specific direction, in accordance with the existing fixed-satellite service (FSS) allocations in these frequency bands, the use of power control and antenna steering capabilities, and compliance with applicable equivalent power flux-density (epfd), power flux-density (pfd) and off-axis equivalent isotropically radiated power (e.i.r.p.) limits to protect incumbent services;
- g)* that the frequency bands 18.1-18.6 GHz (space-to-Earth), 18.8-20.2 GHz (space-to-Earth) and 27.5-30 GHz (Earth-to-space) are also allocated to terrestrial and space services used by a variety of different systems, and these existing services and their future development need to be protected, without the imposition of additional constraints, from the operation of satellite-to-satellite links in the ISS;

h) that there are no protection criteria for evaluation of time-varying interference into non-GSO satellite systems established in ITU-R; therefore, the following protection criteria were used as a basis for sharing studies involving links between two non-GSO space stations and interfered-with non-GSO FSS systems: I/N of 0 dB not to be exceeded more than 0.02% of the time, –6 dB no more than 0.6% of the time and –10.5 dB no more than 20% of the time,

recognizing

a) that any course of action taken under this Resolution has no impact on the original date of receipt of the frequency assignments of the GSO FSS satellite network or the non-GSO FSS system with which non-GSO space stations communicate or on the coordination requirements of that satellite network;

b) that the protection of frequency assignments to GSO FSS satellite networks in the frequency bands 18.1-18.6 GHz, 18.8-20.2 GHz and 27.5-30 GHz, or parts thereof, is a fundamental and important issue due to the fact that those frequency bands are used for the telecommunication/information and communication technology (ICT) infrastructure of many countries, in particular developing countries,

resolves

1 that, for a non-GSO space station subject to this Resolution communicating with a GSO or non-GSO ISS space station within the frequency bands 18.1-18.6 GHz, 18.8-20.2 GHz, and 27.5-30 GHz, or parts thereof, the following conditions shall apply:

1.1 the non-GSO ISS space station transmitting in the frequency band 27.5-30 GHz and receiving in the frequency bands 18.1-18.6 GHz and 18.8-20.2 GHz, or parts thereof, shall only operate inter-satellite links when its apogee altitude¹ is lower than the minimum operational altitude² of the GSO or non-GSO space station with which it communicates and when the off-nadir angle between that GSO or non-GSO space station and the non-GSO space station with which it communicates is less than or equal to θ_{Max} (as defined in Annex 1 to this Resolution);

1.2 the GSO or non-GSO space station receiving in the frequency band 27.5-30 GHz and transmitting in the frequency bands 18.1-18.6 GHz and 18.8-20.2 GHz, or parts thereof, shall only operate inter-satellite links when its minimum operational altitude is higher than the apogee altitude of the non-GSO space station with which it communicates;

1.3 that the use of inter-satellite links by GSO or non-GSO space stations transmitting in the frequency bands 18.1-18.6 GHz and 18.8-20.2 GHz and receiving in the frequency band 27.5-30 GHz is limited to those with recorded assignments in the relevant FSS (space-to-Earth) and (Earth-to-space) allocations in those frequency bands;

¹ See item A.4.b.4.d of Appendix 4.

² See item A.4.b.4.f of Appendix 4.

2 that, for a non-GSO ISS space station transmitting in the frequency band 27.5-30 GHz, the following conditions shall apply:

2.1 this non-GSO ISS space station shall transmit only when within the cone whose apex is the GSO or non-GSO receiving space station and whose angle is θ_{Max} (as defined in Annex 1 to this Resolution);

2.2 the emissions of this non-GSO ISS space station shall remain within the envelope of the recorded characteristics of the associated transmitting FSS earth stations of the GSO FSS network or non-GSO FSS system with which it communicates;

2.3 this non-GSO space station shall comply with the limits contained in Article 21, Table 21-4, taking into account the provisions in Annex 2 to this Resolution for protection of terrestrial services in the frequency band 27.5-29.5 GHz and shall not cause unacceptable interference to or otherwise impose constraints on the operation or the development of terrestrial services; in the frequency band 29.5-30 GHz, with respect to the terrestrial services on the territory of administrations listed in footnote No. 5.542, the operation of inter-satellite links in the frequency band 29.5-30 GHz should not adversely impact the required protection of terrestrial services operated by the administrations listed in footnote No. 5.542;

2.4 the requirement not to cause unacceptable interference to terrestrial services shall not release the notifying administration from its obligation as contained in *resolves* 2.3 above;

2.5 this non-GSO space station shall not cause unacceptable interference to, or otherwise impose constraints on, the operation or the development of non-GSO FSS systems and shall comply with the provisions contained in Annex 4 to this Resolution;

2.6 this non-GSO space station shall not cause unacceptable interference to, or otherwise impose constraints on, the operation or development of FSS feeder links to non-GSO mobile-satellite service (MSS) systems operating in the frequency band 29.1-29.5 GHz; the conditions in section b) of Annex 4 to this Resolution shall apply;

2.7 the emission of this non-GSO space station shall not produce a pfd at any point in the GSO arc greater than the pfd produced by earth stations associated with the satellite network/system with which they communicate, and Annex 5 to this Resolution shall apply;

3 that for a space station transmitting in the frequency bands 18.1-18.6 GHz and 18.8-20.2 GHz or parts thereof, the following conditions shall apply:

3.1 this non-GSO or GSO space station shall transmit only when the non-GSO ISS receiving space station is within the cone whose apex is the GSO or non-GSO transmitting space station and whose angle is θ_{Max} (as defined in Annex 1 to this Resolution);

3.2 the transmissions shall remain within the envelope of the recorded characteristics of the transmitting GSO FSS or non-GSO FSS space station towards its associated FSS earth stations;

3.3 with respect to the Earth exploration-satellite service (EESS) (passive) operating in the frequency band 18.6-18.8 GHz, any non-GSO FSS system with an altitude of apogee of less than 20 000 km communicating with lower-orbiting non-GSO space stations in the frequency bands 18.3-18.6 GHz and 18.8-19.1 GHz and for which complete notification information has been received by the Radiocommunication Bureau after 1 January 2025 shall comply with the provisions indicated in Annex 3 to this Resolution;

4 that non-GSO ISS space stations receiving in the frequency bands 18.1-18.6 GHz and 18.8-20.2 GHz, or parts thereof, shall not claim protection from FSS and MSS networks and systems or meteorological-satellite service networks, or from terrestrial services operating in conformity with the Radio Regulations;

5 that the notifying administration for a non-GSO FSS system communicating with a non-GSO space station in the frequency bands 18.1-18.6 GHz, 19.7-20.2 GHz, 27.5-28.6 GHz and 29.5-30 GHz shall ensure that the epfd produced by the emissions from all combined operations of inter-satellite links in the ISS and Earth-to-space and space-to-Earth links in the FSS comply with the epfd limits contained in Article 22, Tables 22-1B, 22-1C and 22-2;

6 that the notifying administration for a non-GSO ISS system communicating with a non-GSO space station in the frequency bands 18.1-18.6 GHz and 19.7-20.2 GHz and receiving in the frequency bands 27.5-28.6 GHz and 29.5-30 GHz shall ensure that the epfd produced by the emissions from operations of inter-satellite links in the ISS comply with the epfd limits contained in Article 22, Tables 22-1B, 22-1C and 22-2;

7 that space stations receiving inter-satellite transmissions in the frequency band 27.5-30 GHz from non-GSO space stations shall not claim protection for inter-satellite links from FSS and MSS networks and systems or from terrestrial services operating in conformity with the Radio Regulations;

8 that assignments to inter-satellite links in the frequency bands 18.1-18.6 GHz, 18.8-20.2 GHz and 27.5-30 GHz shall not cause unacceptable interference to, or claim protection from, GSO FSS services operating in the frequency band allocated to the FSS,

further resolves

1 that, subject to this Resolution:

- a) the notifying administration for the non-GSO system choosing to operate inter-satellite links and receiving in the frequency bands 27.5-28.6 GHz and 29.5-30 GHz shall indicate to the Bureau its commitment that the epfd produced at any point in the GSO by emissions from all combined operations of inter-satellite links and associated earth station transmissions shall not exceed the limits given in Article 22, Table 22-2;
- b) the notifying administration for a non-GSO ISS space station transmitting in the frequency band 27.5-30 GHz towards a GSO network and receiving in the frequency bands 18.1-18.6 GHz and 18.8-20.2 GHz shall send the Bureau the relevant Appendix 4 advance publication information containing the characteristics of the non-GSO ISS space station and the name of the associated notified GSO FSS network with which it intends to communicate;

- c) the notifying administration for a non-GSO ISS space station transmitting in the frequency bands 27.5-29.1 GHz and 29.5-30 GHz towards a non-GSO system and receiving in the frequency bands 18.1-18.6 GHz and 18.8-20.2 GHz shall send the Bureau the relevant Appendix 4 advance publication information containing the characteristics of the non-GSO ISS space station and the name of the associated notified non-GSO FSS system(s) with which it intends to communicate;
 - d) the notifying administration for a non-GSO system operating inter-satellite links and receiving in the frequency bands 27.5-29.1 GHz and 29.5-30 GHz or of a GSO network operating inter-satellite links and receiving in the frequency band 27.5-30 GHz is responsible for eliminating any case of unacceptable interference;
- 2 that the notifying administration for a GSO network/non-GSO system receiving in the frequency band 27.5-30 GHz shall submit, with the Appendix 4 data, a firm, objective, actionable, measurable and enforceable commitment that, in the event of reported unacceptable interference, it undertakes to immediately eliminate the interference or reduce it to an acceptable level, following the procedures in *further resolves* 3:
- a) that in case no action is taken with regard to the obligation referred to in *further resolves* 2 above, the Bureau shall send a reminder requesting the notifying administration for the GSO network/non-GSO system to comply with the requirements referred to in the commitment;
 - b) should the interference persist 30 days after the dispatch date of the above-mentioned reminder, the Bureau shall submit the case to the subsequent meeting of the Radio Regulations Board for review and the necessary actions (including suppression of the frequency assignment in question), as appropriate;
- 3 that in the event of unacceptable interference caused by a non-GSO ISS space station transmitting in the frequency band 27.5-30 GHz or parts thereof:
- a) the notifying administration for that non-GSO ISS space station shall cooperate with an investigation into the matter and provide the information on the operation of the transmitting space station needed to assess the interference and a point of contact to provide such information;
 - b) the notifying administration for the non-GSO ISS space station transmitting in the frequency band 27.5-30 GHz and the notifying administration for the GSO or non-GSO network or system with which the non-GSO transmitting space station communicates shall, jointly or individually, as the case may be, upon receipt of a report of unacceptable interference, take the required actions to eliminate or reduce the interference to an acceptable level;
- 4 that the notifying administration for the GSO or non-GSO FSS space station receiving inter-satellite transmissions in the frequency band 27.5-30 GHz shall ensure that:
- a) the non-GSO ISS space stations transmitting in this frequency band employ techniques to maintain pointing accuracy with the associated receiving space station and to avoid inadvertently tracking an adjacent GSO space station of any other notifying administration or a space station in a non-GSO system of any other notifying administration;

- b) all necessary measures are taken so that non-GSO ISS space stations transmitting in this frequency band are subject to permanent monitoring and control by a network Control and Monitoring Centre (NCMC) or equivalent facility and are capable of receiving and acting upon at least “enable transmission” and “disable transmission” commands from the NCMC or equivalent facility; and
- c) a permanent point of contact is provided for the purpose of tracing any cases of unacceptable interference from non-GSO ISS space stations transmitting in this frequency band and responding immediately to requests from the focal point;

5 that, upon examination of the information submitted by the notifying administration under *further resolves* 1b) or 1c), if no recorded frequency assignments with typical earth stations for the relevant frequency bands can be identified for the GSO FSS network or non-GSO FSS system with which the notifying administration for the non-GSO ISS space station intends to communicate, the Bureau shall return the information to the notifying administration,

invites the ITU Radiocommunication Sector

1 to develop a suitable methodology for calculating the epfd produced by the emissions from operations of all ISS links in the frequency bands 27.5-28.6 GHz and 29.5-30 GHz, within a given non-GSO ISS system, for use by the Bureau in examining whether the system is in compliance with the epfd limits contained in Article 22, Table 22-2;

2 to develop a suitable methodology for calculating the epfd produced by the emissions from operations of all ISS links in the frequency bands 18.1-18.6 GHz and 19.7-20.2 GHz, within a given non-GSO ISS system, for use by the Bureau in examining whether the system is in compliance with the epfd limits contained in Article 22, Tables 22-1B and 22-1C,

instructs the Director of the Radiocommunication Bureau

1 to take all necessary actions to facilitate the implementation of this Resolution, together with providing any assistance for the resolving of interference, if and when required;

2 to report to future world radiocommunication conferences on any difficulties or inconsistencies encountered in the implementation of this Resolution;

3 to use the methodology given in Annex 2 to this Resolution when assessing compliance with the pfd limits in Article 21, Table 21-4;

4 to use the methodology given in Appendices 1 to 3 to Annex 5 to this Resolution when assessing compliance with Annex 5;

5 not to examine, under No. 11.31, the conformity of non-GSO ISS systems with the provisions of *resolves* 3.3 of this Resolution in view of the fact that the detailed characteristics of non-GSO ISS system transmitters are not available;

6 that, until the methodology is developed according to *invites the ITU Radiocommunication Sector* 1 and 2 above, the Bureau shall issue a qualified favourable finding for examination under No. 11.31; when the methodology is available, the Bureau shall review its finding under No. 11.31.

ANNEX 1 TO RESOLUTION 679 (WRC-23)

Determination of the off-nadir angle

1 A non-geostationary (non-GSO) inter-satellite service (ISS) space station transmitting in the frequency band 27.5-30 GHz and receiving in the frequency bands 18.1-18.6 GHz and 18.8-20.2 GHz shall communicate with a non-GSO space station only when the off-nadir angle between this non-GSO space station and the non-GSO space station with which it communicates is equal to or smaller than:

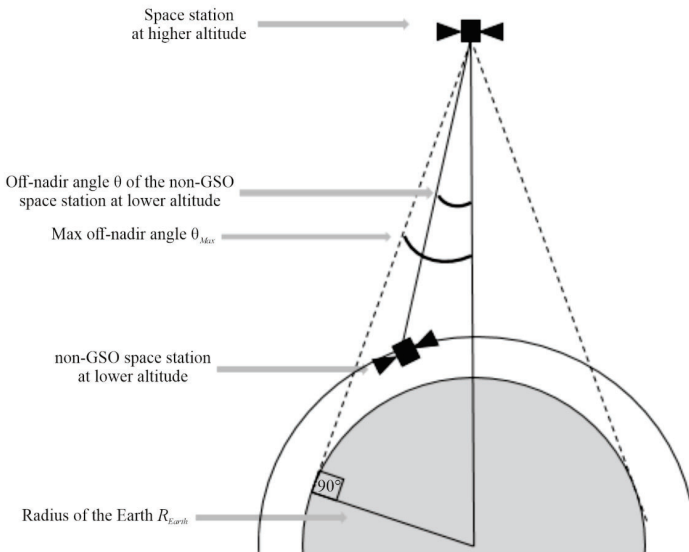
$$\theta_{Max} = \sin^{-1} \left(\frac{R_{Earth}}{R_{Earth} + Alt_{Higher}} \right)$$

where:

$$R_{Earth} = 6\,378 \text{ km}$$

Alt_{Higher} = altitude of the non-GSO space station at a higher orbital altitude in km.

FIGURE 1



2 A non-GSO ISS space station transmitting in the frequency band 27.5-30 GHz and receiving in the frequency bands 18.1-18.6 GHz and 18.8-20.2 GHz shall communicate with a geostationary (GSO) space station only when the off-nadir angle between this GSO space station and the non-GSO space station with which it communicates is equal to or smaller than:

- if the altitude of the non-GSO space station is less than 2 000 km:

$$\theta_{Max} = \sin^{-1} \left(\frac{R_{Earth} + Alt_{non-GSO}}{R_{Earth} + Alt_{GSO}} \right)$$

- if the altitude of the non-GSO space station is greater than or equal to 2 000 km:

$$\theta_{Max} = \sin^{-1} \left(\frac{R_{Earth}}{R_{Earth} + Alt_{GSO}} \right)$$

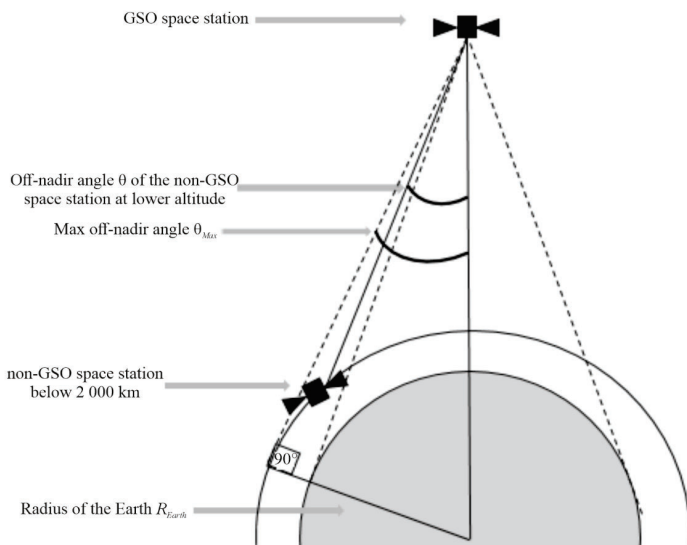
where:

$R_{Earth} = 6\,378$ km

Alt_{GSO} = altitude of the GSO space station in km

$Alt_{non-GSO}$ = altitude of the non-GSO space station in km.

FIGURE 2



3 If the altitude of the non-GSO space station transmitting in the frequency band 27.5-30 GHz and receiving in the frequency bands 18.1-18.6 GHz and 18.8-20.2 GHz is less than 2 000 km, the angle between the vector from this space station to the centre of the Earth and the vector between this space station and the GSO space station shall be at least 90°.

4 Where the notified service area of the GSO or non-GSO network/system at a higher orbital altitude is not global, the maximum off-nadir angle θ_{Max} will vary at each azimuth according to the notified service area and there will be a specific maximum off-nadir angle associated with each azimuth, based on the position in space of the FSS network/system at higher orbital altitude and the geographical coordinates (latitude, longitude) of the border of the notified service area at each azimuth, which are extracted from the Graphical Interference Management System (GIMS) database container that was submitted to the Bureau when notifying a specific non-global service area:

$$\theta_{Max} = \cos^{-1} \left(\frac{(R_{Earth} + Alt_{Higher})^2 + dist^2 - R_{Earth}^2}{2 \times (R_{Earth} + Alt_{Higher}) \times dist} \right)$$

with:

$$dist = \sqrt{(X_E - X_S)^2 + (Y_E - Y_S)^2 + (Z_E - Z_S)^2}$$

$$X_E = R_{Earth} \times \cos(lat_{sab}(\varphi)) \times \cos(lon_{sab}(\varphi))$$

$$Y_E = R_{Earth} \times \cos(lat_{sab}(\varphi)) \times \sin(lon_{sab}(\varphi))$$

$$Z_E = R_{Earth} \times \sin(lat_{sab}(\varphi))$$

$$X_S = (R_{Earth} + Alt_{Higher}) \times \cos(lat_{SS}) \times \cos(lon_{SS})$$

$$Y_S = (R_{Earth} + Alt_{Higher}) \times \cos(lat_{SS}) \times \sin(lon_{SS})$$

$$Z_S = (R_{Earth} + Alt_{SS}) \times \sin(lat_{Higher})$$

where:

$lat_{sab}(\varphi)$ = latitude of the service area border for the azimuth φ

$lon_{sab}(\varphi)$ = longitude of the service area border for the azimuth φ

lat_{SS} = latitude of the sub-satellite point of the GSO/non-GSO space station

lon_{SS} = longitude of the sub-satellite point of the GSO/non-GSO space station.

ANNEX 2 TO RESOLUTION 679 (WRC-23)

**Provisions for non-GSO ISS space stations transmitting in the
frequency band 27.5-30 GHz to protect terrestrial services
in the frequency band 27.5-30 GHz**

To check the compliance of non-geostationary-satellite (non-GSO) inter-satellite service (ISS) emissions with the power flux-density (pfd) mask described in Table 21-4, the following procedures shall be followed:

- 1 Parameter a is the orbital altitude (km) of the non-GSO ISS system identified in *further resolves 1b*) or in *further resolves 1c*) of this Resolution. PSD is the power spectral density in the reference bandwidth associated with the pfd limit. Compute the off-axis gain pattern $Gtx(\varphi)$, with φ being the off-axis angle in the direction of the terrestrial receiver. Assume the Earth is a sphere whose radius, R_e , is 6 378 km.
- 2 Compute the angle, as seen from the non-GSO ISS system transmitting in the frequency band 27.5-30 GHz (the user space station), between the centre of the Earth and the geostationary-satellite (GSO) network or non-GSO systems receiving in the frequency band 27.5-30 GHz (the service provider space station), assuming that the user is at the edge of the cone of coverage with the formula:

$$\delta = \arcsin \left(\frac{R_e}{R_e + a} \right)$$

- 3 Sweep the angle of arrival to the terrestrial station, θ , from 0° to 90° in 0.1° increments.
- 4 Compute the satellite angle $\gamma = \arcsin \left(\frac{\sin(90 + \theta)}{R_e + a} * R_e \right)$.
- 5 Compute the off-axis angle $\varphi = 180 - \delta - \gamma$.
- 6 Compute the gain Gtx in dBi towards the Earth point for each of the angles from Step 5, using the user space station transmit antenna pattern.
- 7 Compute the slant range $d = (R_e + a) \frac{\sin(90 - \gamma - \theta)}{\sin(90 + \theta)}$.
- 8 Compute the PFD on the ground:

$$PFD = PSD + Gtx(\theta) - 10 \times \log_{10} \left(4\pi d^2 \right)$$

ANNEX 3 TO RESOLUTION 679 (WRC-23)

**Provisions for non-GSO space station³ links in the frequency bands
18.3-18.6 GHz and 18.8-19.1 GHz towards non-GSO space stations
with respect to the Earth exploration-satellite service (passive)
in the frequency band 18.6-18.8 GHz**

Non-geostationary (non-GSO) space stations operating with an altitude of apogee of more than 2 000 km and less than 20 000 km in the frequency bands 18.3-18.6 GHz and 18.8-19.1 GHz, when communicating with a non-GSO inter-satellite service space station as described in *resolves* 1 of this Resolution, shall not exceed a power flux-density (pfd) produced at the surface of the oceans across the 200 MHz of the 18.6-18.8 GHz band of $-118 \text{ dB(W/(m}^2 \cdot 200 \text{ MHz))}$.

Non-GSO space stations operating with an altitude of apogee of less than 2 000 km in the frequency bands 18.3-18.6 GHz and 18.8-19.1 GHz, when communicating with a non-GSO space station as described in *resolves* 1 of this Resolution, shall not exceed a pfd produced at the surface of the oceans across the 200 MHz of the 18.6-18.8 GHz band of $-110 \text{ dB(W/(m}^2 \cdot 200 \text{ MHz))}$.

ANNEX 4 TO RESOLUTION 679 (WRC-23)

**Provisions for non-GSO inter-satellite links in the frequency band
27.5-30 GHz to protect non-GSO space stations**

The following conditions for non-geostationary (non-GSO) inter-satellite service (ISS) space stations transmitting in the frequency band 27.5-30 GHz shall apply for the protection of non-GSO space stations:

a) The emissions from any non-GSO ISS space station transmitting in the frequency bands 27.5-29.1 GHz and 29.5-30 GHz to communicate with a geostationary-satellite (GSO) fixed-satellite service (FSS) network shall not exceed the following on-axis equivalent isotropically radiated power (e.i.r.p.) spectral density limits:

- for non-GSO space station transmit on-axis antenna gains greater than or equal to 40.6 dBi: 52.5 dBW/10 MHz;
- for non-GSO space station transmit on-axis antenna gains less than 40.6 dBi: $52.5 - (40.6 - X) \text{ dBW/10 MHz}$;

where X is the on-axis gain of the non-GSO space station antenna in dBi, where the 10 MHz reference bandwidth is in any 10 MHz (e.g. adjacent but non-overlapping).

³ These provisions do not apply to non-GSO systems using orbits with an altitude of apogee of less than 2 000 km that employ a frequency reuse factor of at least 3.

b) To protect FSS feeder links to non-GSO mobile-satellite service systems, the following conditions for non-GSO space stations and systems transmitting in the frequency band 29.1-29.5 GHz shall apply:

- emissions from any non-GSO space station communicating with a GSO network shall not exceed a maximum power spectral density of -66 dBW/Hz at the input of the antenna of the non-GSO space station;
- any non-GSO space station communicating with a GSO network shall have a minimum antenna diameter of 0.3 m whose gain shall not exceed the gain envelope in the most recent version of Recommendation ITU-R S.580;
- non-GSO space stations communicating with a GSO network shall operate only in orbits with inclination between 75° and 105° ;
- non-GSO systems communicating with a GSO network shall not contain more than 100 satellites.

c) The emissions from any non-GSO space station transmitting in the frequency bands 27.5-29.1 GHz and 29.5-30 GHz to communicate with a non-GSO system with a minimum operational altitude higher than or equal to 2 000 km shall not exceed an on-axis e.i.r.p. spectral density of -20 dBW/Hz, and the total e.i.r.p. from any non-GSO space station shall not exceed:

Transmitting non-GSO space station operational altitude (km)	Maximum total e.i.r.p. (dBW) (brought into use on or before 31 December 2036)	Maximum total e.i.r.p. (dBW) (brought into use after 31 December 2036)
altitude < 450	63	66
$450 \leq \text{altitude} < 600$	61	64
$600 \leq \text{altitude} < 750$	58	58
$750 \leq \text{altitude} < 900$	55	55
$900 \leq \text{altitude} < 1\,350$	25	44
altitude $\geq 1\,350$	Not applicable	Not applicable

d) The emissions from any non-GSO space station transmitting in the frequency bands 27.5-29.1 GHz and 29.5-30 GHz to communicate with a non-GSO system with a minimum operational altitude lower than 2 000 km shall not exceed an on-axis e.i.r.p. spectral density of -28 dBW/Hz, and the total e.i.r.p. from any non-GSO space station shall not exceed:

Transmitting non-GSO space station operational altitude (km)	Maximum total e.i.r.p. (dBW) (brought into use on or before 31 December 2036)	Maximum total e.i.r.p. (dBW) (brought into use after 31 December 2036)
altitude < 375	61	64
375 ≤ altitude < 450	60	63
450 ≤ altitude < 600	58	61
600 ≤ altitude < 750	55	55
750 ≤ altitude < 900	53	53
900 ≤ altitude < 1 350	25	44
altitude ≥ 1 350	Not applicable	Not applicable

e) For off-axis angles greater than 3.5°, the off-axis e.i.r.p. emissions of a non-GSO space station transmitting in the frequency bands 27.5-29.1 GHz and 29.5-30 GHz to communicate with a non-GSO system with a minimum operational altitude higher than or equal to 2 000 km shall not exceed the envelope generated by the combination of an input power spectral density at the antenna flange of -62 dBW/Hz coupled with the following off-axis gain:

- 29-25 log(φ) dBi for angles between 3.5° and 4.9°;
- 11.71 dBi for angles between 4.9° and 9.5°;
- 43-32log(φ) dBi for angles between 9.5° and 20°.

ANNEX 5 TO RESOLUTION 679 (WRC-23)

Provisions for non-GSO inter-satellite links in the frequency band 27.5-30 GHz bands to protect GSO space stations

1 In the frequency band 27.5-30 GHz, when a non-geostationary-satellite (non-GSO) system, as identified in *further resolves 1b*) of this Resolution, identifies an associated geostationary-satellite (GSO) network, as described in *further resolves 1b*), to operate inter-satellite links, the Radiocommunication Bureau shall perform the examination described in Appendix 1 to this Annex.

2 The notifying administration for the GSO network identified in § 1 above shall respect all coordination agreements that have already been recorded, noting the provisions of *further resolves 3* and 4 of this Resolution.

3 The notifying administration for the GSO network identified in § 2 above shall provide, upon any request from the notifying administration of a GSO network involved in the coordination agreements referred to above, additional information on how the relevant coordination agreements will be respected with regard to protection from inter-satellite links. This information shall be provided within 90 days after the receipt of the request.

4 In the frequency bands 27.5-29.1 GHz and 29.5-30 GHz, when a non-GSO system, as identified in *further resolves 1c*) of this Resolution, identifies a non-GSO system, as described in *further resolves 1c*), to operate inter-satellite links, the Bureau shall perform the examination described in Appendix 2 to this Annex.

5 The notifying administration for the receiving non-GSO network identified in § 3 above shall respect all coordination agreements that have already been recorded, noting the provisions of *further resolves 3 and 4* of this Resolution.

6 In the frequency bands 27.5-28.6 GHz and 29.5-30 GHz, the power flux-density (pfd) produced at any point in the geostationary-satellite orbit by a non-GSO space station, as mentioned in *further resolves 1c*), shall not exceed a pfd of -164 dB(W/m²) in any 40 kHz band. A computation methodology is provided in Appendix 3 to this Annex.

7 In cases where all of the conditions identified in Appendix 4 to this Annex are met, the notifying administration for frequency assignments to the GSO inter-satellite service (ISS) space stations shall seek agreement from the notifying administration for the GSO fixed-satellite service (FSS) or mobile-satellite service (MSS) network. In the absence of agreement, frequency assignments to the ISS space station shall operate under the express condition that the ISS space station does not cause harmful interference to, or claim protection from, frequency assignments to the GSO FSS or MSS network operating in accordance with the Radio Regulations.

7.1 The Bureau shall not perform an examination under § 7 of this Annex.

7.2 In the event of the harmful interference actually being caused by an ISS space station under § 7 of this Annex, for the case of ISS links between a non-GSO space station and a GSO space station, to any GSO FSS or MSS with recorded frequency assignments operating in accordance with the Radio Regulations, the notifying administration for the GSO ISS space station shall, upon receipt of a report providing the particulars relating to the harmful interference given in the form indicated in Appendix 10, immediately eliminate this harmful interference.

7.3 In the case of unresolved harmful interference under § 7 of this Annex, the Bureau shall submit the case to the subsequent meeting of the Radio Regulations Board for review and the necessary actions (including suppression of the frequency assignment in question), as appropriate.

7.4 The notifying administration for the GSO ISS space station shall inform the notifying administration for the non-GSO ISS space station of the status of the agreement being sought under § 7 of this Annex.

APPENDIX 1 TO ANNEX 5

The aim of this Appendix is to provide a method to be used by the Radiocommunication Bureau to assess whether the emissions from a non-geostationary (non-GSO) space station operating inter-satellite links with a geostationary (GSO) space station are within the envelope of the typical earth stations of the GSO network.

Step 1: For each group of the transmitting non-GSO notification.

Step 2: For each of the receiving GSO networks, as listed in *further resolves 1b*) of this Resolution.

Step 3: For each beam in the Earth-to-space direction of the receiving GSO network notification, compute the maximum equivalent isotropically radiated power (e.i.r.p.) produced in one hertz (*EIRPSD*).

Step 4: Compute the reduction in free-space loss at the altitude of the user using:

$$\Delta FSL = 20 \log_{10} \left(\frac{GSO_{alt}}{GSO_{alt} - NGSO_{alt}} \right)$$

where $NGSO_{alt}$ is the altitude of the transmitting non-GSO system space stations and $GSO_{alt} = 35\,786$ km. It should be noted that, if several altitudes are included in the notification, each altitude shall be tested.

Step 5: Compute the reduced e.i.r.p. spectral density as $EIRPSD_{reduced} = EIRPSD - \Delta FSL$.

Step 6: For all beams in the non-GSO system notification with a class of station ES, the e.i.r.p. spectral density mask is given in Appendix 4, data item A.27.e.

Step 7: For all emissions in the GSO network notification, compute the e.i.r.p. spectral density mask for all off-axis angles between 0° and 80°, with a step of 1°, and reduce it by ΔFSL . The e.i.r.p. spectral density mask computation should assume that the maximum gain is for an off-axis angle of 0°.

Step 8: Frequency assignments to non-GSO systems shall receive a favourable finding with respect to Annex 5 if, for all beams:

- the maximum value of the e.i.r.p. spectral density mask from Step 6 does not exceed the $EIRPSD_{reduced}$ quantity, computed at the same altitude; and
- the e.i.r.p. spectral density mask of the transmitting non-GSO space station from Step 6 is less than the reduced e.i.r.p. spectral density mask, compared in one hertz, from Step 7 for all angles for at least one emission in the GSO network notification.

Otherwise, the assignments shall receive an unfavourable finding.

APPENDIX 2 TO ANNEX 5

The aim of this Appendix is to provide a method to be used by the Radiocommunication Bureau to assess whether the emissions from a non-geostationary (non-GSO) space station operating inter-satellite links with a non-GSO space station are within the envelope of the typical earth stations of the non-GSO system.

Step 1: For each group of the transmitting non-GSO notification.

Step 2: For each of the receiving non-GSO systems, as listed in *further resolves 1c)* of this Resolution.

Step 3: For each beam in the Earth-to-space direction of the receiving non-GSO system notification, compute the maximum equivalent isotropically radiated power (e.i.r.p.) produced in one hertz (*EIRPSD*).

Step 4: Compute the reduction in free-space loss at the altitude of the user using:

$$\Delta FSL = 20 \log_{10} \left(\frac{GSO_{alt}}{GSO_{alt} - NGSO_{alt}} \right)$$

where $NGSO_{alt}$ is the altitude of the transmitting non-GSO system space stations and $GSO_{alt} = 35\,786$ km. It should be noted that if several altitudes are included in the notification, each altitude shall be tested.

Step 5: Compute the reduced e.i.r.p. spectral density as $EIRPSD_{reduced} = EIRPSD - \Delta FSL$.

Step 6: For all beams in the non-GSO system notification with a class of station ES, the e.i.r.p. spectral density mask is given in Appendix 4, data item A.27.e.

Step 7: For all emissions in the receiving non-GSO network notification, compute the e.i.r.p. spectral density mask for all off-axis angles between 0° and 80° , with a step of 1° , and reduce it by ΔFSL . The e.i.r.p. spectral density mask computation should assume that the maximum gain is for an off-axis angle of 0° .

Step 8: Frequency assignments to non-GSO systems shall receive a favourable finding with respect to Annex 5 if, for all beams:

- the maximum value of the mask from Step 6 does not exceed the $EIRPSD_{reduced}$ quantity, computed at the same altitude; and
- the e.i.r.p. spectral density mask of the transmitting non-GSO space station from Step 6 is less than the reduced e.i.r.p. spectral density mask from Step 7 for all angles.

Otherwise, the assignments shall receive an unfavourable finding.

APPENDIX 3 TO ANNEX 5

To check the compliance of non-geostationary-satellite (non-GSO) emissions with the power flux-density (pfd) limit given in Annex 5, § 6, the following procedure shall be followed.

Step 1: For each of the latitudes in the equivalent isotropically radiated power (e.i.r.p.) spectral density mask given in Appendix 4 data item A.27.e, select the corresponding value to the geostationary-satellite (GSO) arc avoidance and denote it as $eirpa$. If the mask is non-monotonic, select the largest value in the e.i.r.p. mask considering all angles greater than or equal to the GSO arc avoidance angle as given in Appendix 4, data item A.27.d.

Step 2a: compute the slant distance to the GSO arc as:

$$d = \sqrt{(6378 + alt)^2 + 42164^2 - 2 \times (6378 + alt) \times 42164 \times \cos(latitude)}$$

where alt is the altitude of the transmitting non-GSO space station, in km, and latitude is at the nadir of the non-GSO space station.

Step 2b: Compute the *PFD* on the GSO arc using:

$$PFD = eirp_{\alpha} - 10 \log \left(4\pi (d \times 1000)^2 \right)$$

Step 3: Frequency assignments to non-GSO systems shall receive a favourable finding with respect to Annex 5, § 6, if all pfd values calculated in Step 2b are below the threshold given in Annex 5, § 6.

APPENDIX 4 TO ANNEX 5

§ 7 of this Annex applies when all of the following conditions are met between frequency assignments for the notifying administration for a geostationary-satellite (GSO) fixed-satellite service (FSS) or mobile-satellite service (MSS) network and frequency assignments to the GSO inter-satellite service (ISS) space station receiving in the frequency band 27.5-30 GHz and transmitting in the frequency bands 18.1-18.6 GHz and 18.8-20.2 GHz:

- the date of receipt under No. **9.6** of the frequency assignments to the GSO FSS or MSS network is before the date of recording of the ISS frequency assignments in the Master International Frequency Register, and
- frequency overlap, and
- orbital separation of less than or equal to 2°, and
- the maximum off-axis equivalent isotropically radiated power (e.i.r.p.) spectral density of the non-GSO ISS space station towards the affected GSO FSS or MSS space station exceeds $-65 + 29 - 25 * \log(\theta)$ dBW/Hz, where θ is the topocentric angular separation between the notified affected GSO FSS or MSS space station and the notified GSO ISS space station, and
- the service area of the potentially affected GSO FSS or MSS network includes the territory of its notifying administration.