

RECOMMENDATION ITU-R BO.1517

Equivalent power flux-density limits, epfd_{\downarrow} , to protect the broadcasting-satellite service in the 12 GHz band from interference caused by non-geostationary fixed-satellite service systems

(Resolution 76 (WRC-2000))

(2001)

The ITU Radiocommunication Assembly,

considering

- a) that the bands 11.7-12.5 GHz in Region 1, 12.2-12.7 GHz in Region 2 and 11.7-12.2 GHz and 12.5-12.75 GHz in Region 3 are allocated to the broadcasting-satellite service (BSS);
- b) that the World Radiocommunication Conference (Geneva, 1997) (WRC-97) allocated the bands listed in *considering* a) to the non-geostationary fixed-satellite service (non-GSO FSS) (space-to-Earth) subject to the provisions of Resolution 538 (WRC-97);
- c) that emissions from the stations of non-GSO FSS satellite systems may result in interference to BSS networks and associated feeder links when these networks operate in the same frequency bands;
- d) that No. 22.2 of the Radio Regulations (RR) states that non-GSO satellite systems shall not cause unacceptable interference to GSO satellite systems in the FSS and BSS operating in accordance with these Regulations;
- e) that, in the bands listed in *considering* a), WRC-97 adopted the concept of single-entry epfd_{\downarrow} to quantify the level of interference from non-GSO FSS systems to protect GSO BSS systems and also adopted provisional values for epfd_{\downarrow} ;
- f) that, in the bands listed in *considering* a), the World Radiocommunication Conference (Istanbul, 2000) (WRC-2000) adopted single-entry epfd_{\downarrow} limits (see RR Article 22) that each non-GSO FSS system must meet;
- g) that in the bands listed in *considering* a), WRC-2000 also adopted aggregate epfd_{\downarrow} limits (see Resolution 76 (WRC-2000) and No. 22.5K of RR Article 22) that the combined interference from the non-GSO FSS systems operating in the band must meet in order to satisfy the criteria of Recommendation ITU-R BO.1444 for protection of GSO BSS networks,

further considering

- h) that ITU-R has developed a methodology to assess the impact of the aggregate interference from all non-GSO FSS systems to GSO satellite systems in the FSS and BSS;
- j) that ITU-R has developed criteria to protect GSO satellite systems in the BSS operating in accordance with the RR from the aggregate interference caused by all non-GSO FSS systems;
- k) that such a methodology and criteria are contained in Recommendation ITU-R BO.1444;
- l) that the epfd_{\downarrow} limits applicable to non-GSO FSS systems in the frequency bands listed in *considering a)* are single-entry limits;
- m) that there is a need to relate the level of interference caused by a single non-GSO FSS system to that caused by multiple systems into GSO BSS networks;
- n) that studies have concluded that the interference power from multiple non-GSO FSS systems aggregates in a certain manner (as shown in Annex 2);
- o) that ITU-R has defined the equivalent number, $N_{\text{effective}}$ (equal to 3.5) of systems to be considered for the purposes of studying the impact of aggregate interference from multiple non-GSO FSS systems operating in the bands listed in *considering a)*, under the assumption that each system operates at the single-entry epfd_{\downarrow} limits,

recommends

- 1 that, consistent with Resolution 76 (WRC-2000), the specific aggregate epfd_{\downarrow} limits of Annex 1 are appropriate to protect GSO BSS from non-GSO FSS interference;
- 2 that, in designing GSO BSS networks, administrations should take into account aggregate interference from non-GSO FSS systems produced at the levels in Annex 1 using the methodology and criteria contained in Recommendation ITU-R BO.1444;
- 3 that, the methodology described in Annex 2 should be used to derive single-entry epfd_{\downarrow} values from aggregate epfd_{\downarrow} values and vice versa (see Note 3).

NOTE 1 – The epfd_{\downarrow} values described in Annex 1 are based on reference BSS earth station antenna patterns found in Recommendation ITU-R BO.1443.

NOTE 2 – The single-entry epfd_{\downarrow} values provided in Appendix 1 to Annex 2 have been derived from the aggregate epfd_{\downarrow} values in Annex 1 using the methodology described in Annex 2 and taking into account *further considering o)*. Appendix 1 to Annex 2 is provided for information purposes.

NOTE 3 – This methodology was developed by Radiocommunication Study Group 4.

ANNEX 1

**Aggregate $epfd_{\downarrow}$ limits to protect GSO BSS systems
from non-GSO FSS interference**

TABLE 1^{*,**}

**Limits on aggregate $epfd_{\downarrow}$ radiated by non-GSO FSS systems in certain frequency
bands for 30 cm, 45 cm, 60 cm, 90 cm, 120 cm, 180 cm, 240 cm and 300 cm BSS antennas**

Frequency band (GHz)	$epfd_{\downarrow}$ (dB(W/m ²))	Percentage of time during which $epfd_{\downarrow}$ level may not be exceeded	Reference bandwidth (kHz)	Reference antenna diameter, and reference radiation pattern ⁽¹⁾
11.7-12.5 in Region 1 11.7-12.2 and 12.5-12.75 in Region 3 12.2-12.7 in Region 2	-160.4	0	40	30 cm Recommendation ITU-R BO.1443, Annex 1
	-160.1	25		
	-158.6	96		
	-158.6	98		
	-158.33	98		
	-158.33	100		
	-170	0	40	45 cm Recommendation ITU-R BO.1443, Annex 1
	-167	66		
	-164	97.75		
	-160.75	99.33		
	-160	99.95		
	-160	100		
	-171	0	40	60 cm Recommendation ITU-R BO.1443, Annex 1
	-168.75	90		
	-167.75	97.8		
	-162	99.6		
	-161	99.8		
	-160.2	99.9		
	-160	99.99		
	-160	100		
-173.75	0	40	90 cm Recommendation ITU-R BO.1443, Annex 1	
-173	33			
-171	98			
-165.5	99.1			
-163	99.5			
-161	99.8			
-160	99.97			
-160	100			
-177	0	40	120 cm Recommendation ITU-R BO.1443, Annex 1	
-175.25	90			
-173.75	98.9			
-173	98.9			
-169.5	99.5			
-167.8	99.7			
-164	99.82			
-161.9	99.9			
-161	99.965			
-160.4	99.993			
-160	100			

TABLE 1^{*,**} (end)

Frequency band (GHz)	epfd _↓ (dB(W/m ²))	Percentage of time during which epfd _↓ level may not be exceeded	Reference bandwidth (kHz)	Reference antenna diameter, and reference radiation pattern ⁽¹⁾
11.7-12.5 in Region 1 11.7-12.2 and 12.5-12.75 in Region 3 12.2-12.7 in Region 2 (cont.)	-179.5	0	40	180 cm Recommendation ITU-R BO.1443, Annex 1
	-178.66	33		
	-176.25	98.5		
	-163.25	99.81		
	-161.5	99.91		
	-160.35	99.975		
	-160	99.995		
	-160	100		
	-182	0		
-180.9	33			
-178	99.25			
-164.4	99.85			
-161.9	99.94			
-160.5	99.98			
-160	99.995			
-160	100			
	-186.5	0	40	300 cm Recommendation ITU-R BO.1443, Annex 1
	-184	33		
	-180.5	99.5		
	-173	99.7		
	-167	99.83		
	-162	99.94		
	-160	99.97		
	-160	100		

* For BSS antenna diameters of 180 cm, 240 cm and 300 cm, in addition to the aggregate limits shown in this Table, the following latitude-dependent aggregate 100% of the time epfd_↓ limits also apply:

100% of the time epfd _↓ (dB(W/(m ² · 40 kHz)))	Latitude (North or South) (degrees)
-160	0 ≤ Latitude ≤ 57.5
-160 + 3.4 (57.5 - Latitude)/4	57.5 < Latitude ≤ 63.75
-165.3	63.75 < Latitude

** For each reference antenna diameter, the limit consists of the complete curve on a plot which is linear (dB) for the epfd_↓ levels and logarithmic for the time percentages, with straight lines joining the data points.

For BSS antenna of diameter 240 cm, in addition to the above aggregate 100% of the time epfd_↓ limit, a -167 dB(W/(m² · 40 kHz)) aggregate 100% of the time operational epfd_↓ limit also applies to receive antennas located in Region 2, west of 140° W, north of 60° N, pointing toward GSO BSS satellites at 91° W, 101° W, 110° W, 119° W and 148° W with elevation angles greater than 5°. This limit is implemented during a transition period of 15 years.

(1) Under this Table, reference patterns in Annex 1 to Recommendation ITU-R BO.1443 shall be used only for the calculation of interference from non-GSO FSS systems into GSO BSS systems.

ANNEX 2

Methodology to go from single-entry epfd_{\downarrow} masks to aggregate epfd_{\downarrow} masks or vice versa

Recommendation ITU-R BO.1444 – Protection of the BSS in the 12 GHz band and associated feeder links in the 17 GHz band from interference caused by non-GSO FSS systems describes performance objectives and interference apportionment based on a definition of an aggregate envelope of the interference that a GSO BSS carrier can tolerate. Since the criteria adopted in this Recommendation are based on aggregate interference levels, whereas the epfd_{\downarrow} limits appearing in RR Article 22 correspond to single-entry levels, there is a need to relate the level of interference caused by a single non-GSO system to that caused by multiple such systems.

1 Mechanism of aggregation

Studies performed in the case of multiple non-GSO FSS systems, have established the existence of three fairly distinct Zones (i.e. ranges of time percentage) in the cumulative distribution of the aggregate interference:

- Zone A: the interference contributions from the individual non-GSO systems will add in power.
- Zone B: the time percentages for which the same interference levels are contributed by each non-GSO system will add.
- Zone C: it will comprise time percentages at the lower end of the scale, the aggregate interference is dominated by the worst-case single entry.

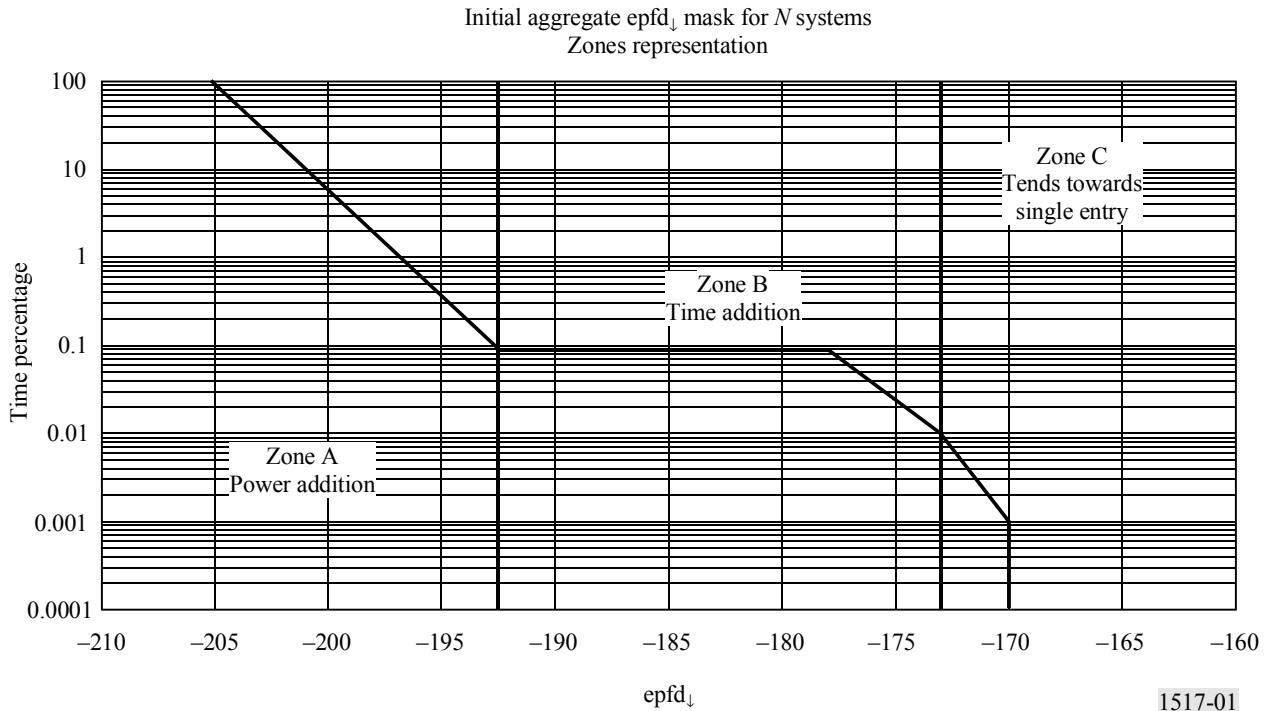
This methodology is very generic and applicable to all sizes of antennas. However, studies have highlighted that Zone C is relevant only for antenna diameters greater or equal to 10 m.

The relationship between these zones is illustrated schematically in Fig. 1. Power addition occurs at the higher time percentages, time addition at somewhat lower time percentages, and the aggregate curve merges with the worst-case single entry curve at the very low time percentages¹. Studies have shown that, when considering interference from the many possible combinations of non-GSO systems, the boundaries between these zones cannot be defined at specific values for either time percentage or epfd_{\downarrow} .

¹ When the time percentage is expressed as the per cent of time during which the interfering signal epfd_{\downarrow} level may be exceeded, as is done in Figs. 1 and 2. Note that the values in Tables 1 and 2 are expressed as the percentage of time during which epfd_{\downarrow} level may **not** be exceeded.

FIGURE 1

Schematic illustration of zones



2 Single entry to aggregate

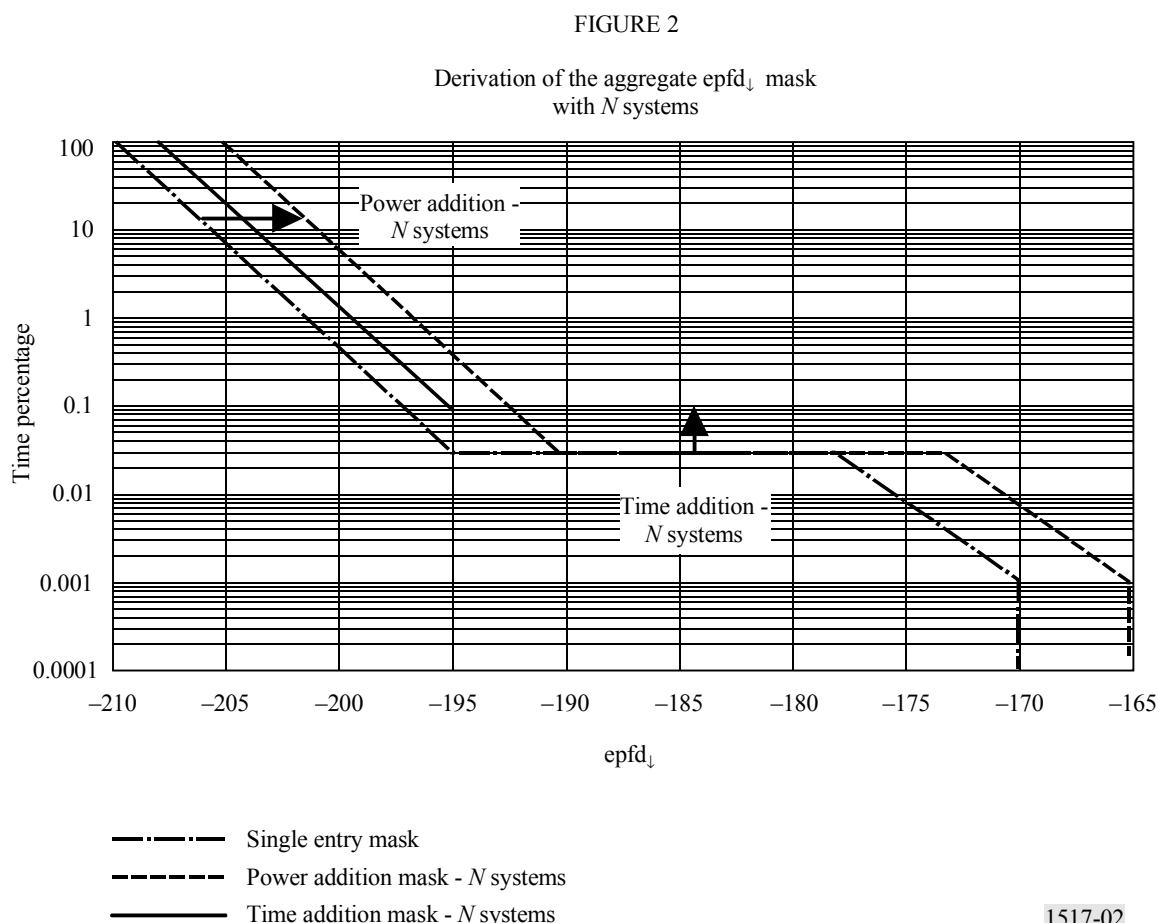
The derivation of the aggregate epfd_\downarrow mask is done by using the mechanisms driving the aggregation of the interference from several non-GSO FSS systems into GSO networks and is highlighted in Section 1.

In order to use these results when deriving the aggregate mask, three epfd_\downarrow masks are represented in Fig. 2:

- the single-entry mask;
- the mask corresponding to the power addition of N systems (single-entry $\text{epfd}_\downarrow + 10 \log(N)$);
- the mask corresponding to the time addition of N systems (single-entry time percentage $\times N$).

The aggregate mask is obtained by taking in Zone A (power addition) and in Zone B (time addition) the envelope of these two masks and in Zone C by converging towards the single-entry mask. This methodology is very generic and applicable to all sizes of antennas. However, as previously noted, studies have highlighted that Zone C is relevant only for antenna diameters greater or equal to 10 m. Since the BSS earth station antenna sizes are less than 10 m, the methodology to be applied in the frequency bands allocated to the BSS is restricted to Zones A and B.

In this case, the aggregate mask is obtained by taking in Zone A (power addition) and in Zone B (time addition) the envelope of the two masks.



3 Aggregate to single entry

Starting from the aggregate mask, the single-entry mask is obtained by the reverse process described above. Two masks:

- aggregate $\text{epfd} - 10 \log(N)$ (power division);
- aggregate time percentage/ N (time division),

must be assessed. The envelope of these two masks will give the single-entry mask. In those cases where the time shifted and the power shifted curves do not intersect, the following procedure is applied:

Step 1: A point P close to the 1% of time on the original curve is selected.

Step 2: The point P on the time shifted and the point P on the power shifted are connected.

Step 3: The single-entry curve consists of the power shifted portion in Zone A, the segment created in Step 2 and the time shifted segment in Zone B.

Step 4: The procedure described in Section 3 is used to derive a new aggregate mask from the single-entry mask obtained in Step 3. The new aggregate mask is then verified to ensure that it is close and below the original aggregate mask. If this condition is not met, a new point P is chosen and Steps 2 to 4 are repeated.

APPENDIX 1

TO ANNEX 2

TABLE 2 *, **, ***, ****

Single entry limits to the epfd_{\downarrow} radiated by a non-GSO FSS system in certain frequency bands for 30 cm, 45 cm, 60 cm, 90 cm, 120 cm, 180 cm, 240 cm and 300 cm BSS antennas

Frequency band (GHz)	epfd_{\downarrow} (dB(W/m ²))	Percentage of time during which epfd_{\downarrow} level may not be exceeded	Reference bandwidth (kHz)	Reference antenna diameter and reference radiation pattern ⁽¹⁾
11.7-12.5 in Region 1 11.7-12.2 and 12.5-12.75 in Region 3 12.2-12.7 in Region 2	-165.841	0	40	30 cm Recommendation ITU-R BO.1443, Annex 1
	-165.541	25		
	-164.041	96		
	-158.6	98.857		
	-158.6	99.429		
	-158.33	99.429		
	-158.33	100		
	-175.441	0	40	45 cm Recommendation ITU-R BO.1443, Annex 1
	-172.441	66		
	-169.441	97.75		
	-164	99.357		
	-160.75	99.809		
	-160	99.986		
	-160	100		
	-176.441	0	40	60 cm Recommendation ITU-R BO.1443, Annex 1
	-173.191	97.8		
-167.75	99.371			
-162	99.886			
-161	99.943			
-160.2	99.971			
-160	99.997			
-160	100			
-178.94	0	40	90 cm Recommendation ITU-R BO.1443, Annex 1	
-178.44	33			
-176.44	98			
-171	99.429			
-165.5	99.714			
-163	99.857			
-161	99.943			
-160	99.991			
-160	100			

TABLE 2 ^{*}, ^{**}, ^{***}, ^{****} (end)

Frequency band (GHz)	epfd _↓ (dB(W/m ²))	Percentage of time during which epfd _↓ level may not be exceeded	Reference bandwidth (kHz)	Reference antenna diameter and reference radiation pattern ⁽¹⁾
11.7-12.5 in Region 1 11.7-12.2 and 12.5-12.75 in Region 3 12.2-12.7 in Region 2 (cont.)	-182.44	0	40	120 cm Recommendation ITU-R BO.1443, Annex 1
	-180.69	90		
	-179.19	98.9		
	-178.44	98.9		
	-174.94	99.5		
	-173.75	99.68		
	-173	99.68		
	-169.5	99.85		
	-167.8	99.915		
	-164	99.94		
	-161.9	99.97		
	-161	99.99		
	-160.4	99.998		
	-160	100		
	-184.941	0		
	-184.101	33		
	-181.691	98.5		
	-176.25	99.571		
	-163.25	99.946		
	-161.5	99.974		
	-160.35	99.993		
	-160	99.999		
	-160	100		
	-187.441	0	40	240 cm Recommendation ITU-R BO.1443, Annex 1
	-186.341	33		
	-183.441	99.25		
	-178	99.786		
	-164.4	99.957		
	-161.9	99.983		
	-160.5	99.994		
	-160	99.999		
	-160	100		
	-191.941	0	40	300 cm Recommendation ITU-R BO.1443, Annex 1
	-189.441	33		
	-185.941	99.5		
	-180.5	99.857		
	-173	99.914		
	-167	99.951		
	-162	99.983		
	-160	99.991		
-160	100			

Notes relative to Table 2:

- * For BSS antenna diameters of 180 cm, 240 cm and 300 cm, in addition to the single-entry limits shown in this Table, the following latitude-dependent single-entry 100% of the time epfd_\downarrow limits also apply in the frequency bands listed in the first column:

100% of the time epfd_\downarrow (dB(W/(m² · 40 kHz)))	Latitude (North or South) (degrees)
-160	0 ≤ Latitude ≤ 57.5
-160 + 3.4 (57.5 - Latitude)/4	57.5 < Latitude ≤ 63.75
-165.3	63.75 < Latitude

- ** For each reference antenna diameter, the limit consists of the complete curve on a plot which is linear (dB) for the epfd_\downarrow levels and logarithmic for the time percentages, with straight lines joining the data points.
- *** For a BSS earth station antenna diameter of 240 cm, in addition to the single-entry 100% of the time epfd_\downarrow limit specified in Note * to this Table, a single-entry 100% of the time operational epfd_\downarrow limit is specified in Table 22-4C, of RR Article 22.
- **** In meeting these limits, the administrations intending to develop such systems shall ensure that the assignments appearing in the Plans of Appendix 30 of the RR will be fully protected.
- (1) Under this Table, reference patterns of Annex 1 to Recommendation ITU-R BO.1443 shall be used only for the calculation of interference from non-GSO FSS systems into GSO BSS systems.
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