

RECOMMENDATION ITU-R SF.1482

**MAXIMUM ALLOWABLE VALUES OF pfd PRODUCED AT THE EARTH'S
SURFACE BY NON-GSO SATELLITES IN THE FSS OPERATING IN
THE 10.7-12.75 GHz BAND**

(Questions ITU-R 237/4 and ITU-R 206/9)

(2000)

The ITU Radiocommunication Assembly,

considering

- a) that WRC-97 allocated the bands 11.7-12.5 GHz (in Region 1), 12.2-12.7 GHz (in Region 2), and 11.7-12.2 GHz (in Region 3) to the FSS (space-to-Earth) on a primary basis, limited to non-GSO satellite systems;
- b) that WRC-97 adopted provisional limits on the power flux-density (pfd) produced at the surface of the Earth by non-GSO satellites in the FSS (space-to-Earth) in the band 10.7-12.75 GHz;
- c) that Resolution 131 (WRC-97) requested the ITU-R to study, as a matter of urgency, the appropriate pfd values to be applied to non-GSO satellite systems in the FSS to ensure the protection of the FS without unduly constraining the development of either service;
- d) that Recommendation ITU-R F.1494 provides the aggregate FS protection criteria in the 10.7-12.75 GHz band;
- e) that GSO satellite interference is well below that of the non-GSO satellite in the FSS aggregate interference at the FS receivers;
- f) that the number of non-GSO FSS satellite constellations able to operate co-frequency in this frequency band is likely to be small;
- g) that the projected development of non-GSO FSS usage in these bands indicate that co-frequency systems will not be homogeneous,

recommends

- 1** that in the band 10.7-12.75 GHz, the maximum pfd at the surface of the Earth from any non-GSO satellite in the FSS should not exceed the values given in Table 1 in any 1 MHz band (see Notes 1 and 2);

TABLE 1

Frequency band	pfd limit (dB(W/m ²)) for angle of arrival, δ , above the horizontal plane		
	0°-5°	5°-25°	25°-90°
10.7-11.7 GHz	-126	$-126 + 0.5 (\delta - 5)$	-116
11.7-12.75 GHz (Regions 1 and 3) 11.7-12.7 GHz (Region 2)	-124	$-124 + 0.5 (\delta - 5)$	-114

- 2** that these values relate to the pfd which would be obtained under assumed free-space propagation conditions;

3 that the information contained in Annex 1 should be used as guidance for the use of this Recommendation.

NOTE 1 – The limits specified in this Recommendation are based on analyses of candidate pfd limits that would result in interference below permissible levels and enable satisfactory operation of satellite systems.

NOTE 2 – The specified pfd limits are based on analyses that assumed every satellite in the constellation produced emissions at the maximum levels allowed by the pfd limits for all angles of arrival. Analyses taking into account the actual operational characteristics of the non-GSO FSS network would lead to substantially lower aggregate power flux-density (apfd) levels produced.

ANNEX 1

Derivation of pfd limits applicable to non-GSO FSS space stations in the band 10.7-12.75 GHz

1 Characteristics of the FS system

The FS characteristics to be used for the purpose of simulations in order to derive pfd limits in the band 10.7-12.75 GHz are given in Table 2.

TABLE 2

Elevation angles (degrees)	0 and 0.2
Antenna height (m)	0
Antenna gain (dBi)	45 and 49
Antenna pattern	Recommendation ITU-R F.1245
Latitudes (degrees)	25, 45 and 60
Gaseous attenuation	Recommendation ITU-R SF.1395
Feeder loss (dB)	3
Polarization loss	Recommendation ITU-R F.1245 (Note 7)
Receiver thermal noise (dB(W/MHz))	-140

These characteristics are representative of a majority of links in that frequency range.

2 FS protection criteria

The aggregate FS protection criteria in the 10.7-12.75 GHz range are given as follows in Recommendation ITU-R F.1494:

- maximum $I/N = +20$ dB
- long-term interference:

D_{HEPO} or FDP (see Recommendation ITU-R F.1108) of 10%

where:

$$D_{IEPO} = \left(0.89 \times \int_{10^{-6}}^1 \frac{I(t)}{N} dt \right) \times 100\%$$

D_{IEPO} : error performance objective degradation due to long-term interference

FDP: fractional degradation of performance

$I(t)/N$: interference-to-noise ratio that could be exceeded during no more than t fraction at any month time.

These aggregate FS interference criteria have been derived from considerations of the allowable degradation of error performance objective (EPO) due to interference from systems operating co-primary, on typical FS links using automatic transmitter power control (ATPC) features.

3 Methodologies used to assess the adequacy of the limits to protect the FS

A pfd mask analysis has been used for assessing the adequacy of the pfd limits for the protection of the FS; the statistics of the aggregate power levels received at an FS station are calculated by applying pfd limits under consideration to each visible satellite of the non-GSO FSS constellation (see Note 1).

In the derivation of the pfd limits defined in *recommends* 1, it was determined that if the calculated FDP results exceed the criteria of § 2 by no more than a few per cent, this does not mean that the FS links would actually be impaired. It must be noted that the pfd mask analysis is overly conservative in that it computes interference (both long-term and short-term) that exceeds what would be produced by an operating non-GSO FSS system. This is because the analysis assumes that all the visible satellites of the non-GSO FSS satellite constellation radiate simultaneously the maximum pfd limit in the direction of the FS system under consideration, which is unrealistic. In addition, such an assumption does not take into account the patterns of real satellite antennas, or the restrictions that self-interference would impose on a non-GSO FSS system.

Calculations are made assuming that the FS receiver antenna is pointing in the direction of the worst-case azimuth for the non-GSO constellation under consideration, since in that pointing direction, the long-term and short-term power levels generated by the non-GSO constellation into the FS receivers are maximum.

Studies in other bands, that have considered a more realistic modelling of a similar problem, have produced results providing further evidence supporting that the pfd limits in *recommends* 1 are adequate. The method used takes into account some fundamental operational constraints of non-GSO FSS systems by using more realistic downlink models developed to generate pfd distribution profiles for a range of arrival angles which are used in place of the maximum-allowed pfd mask.

NOTE 1 – Annex 1 of Recommendation ITU-R F.1108 provides guidance on the calculation of visibility statistics of space stations operating in circular non-GSO orbits as seen by a terrestrial station.

4 Aggregation of multiple non-GSO FSS constellations

On a first approach, it can be assumed that the FS aggregate interference criteria given in Recommendation ITU-R F.1494 can be applied for each single non-GSO FSS satellite constellation. These conclusions are justified by the following considerations:

- the projected development of non-GSO FSS usage in these bands indicates that co-frequency systems will not be homogeneous, and therefore the worst-case azimuths will be different for each of the non-GSO FSS systems;
- the simulations for each given constellation are run in its worst-case azimuth which is different for each constellation since they are non-homogeneous;

- based on the information available, the expected number of co-frequency non-GSO FSS systems is expected to be small;
- based on discussions, it is agreed that these results would remain valid if the number of non-homogeneous, non-GSO FSS systems were in the range 3 to 5;
- the methodology used for the simulations applied the full pfd mask for each satellite in view. This assumption is overly conservative (see § 3) in that all the satellites from the co-frequency constellations cannot be expected to transmit simultaneously the full power limits of the pfd mask in all directions;
- the pfd value is highly dependent on the FS azimuth and leads to a sharp peak around the worst-case azimuth; a slight off-set from this worst-case azimuth (of the order of 1°) leads to a large decrease of the pfd value.

5 Conclusion

Extensive studies have provided ample technical justification that the pfd limits of *recommends* 1 are certainly adequate to protect the FS from aggregate interference from the satellites of multiple, co-frequency non-GSO FSS systems operating in the 10.7-12.75 GHz band. Therefore the pfd limits of *recommends* 1 are acceptable in that they protect the FS without unduly constraining the development of non-GSO FSS networks.
