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| **Radiocommunication Study Groups** |  |
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| Source: Document 4A/TEMP/202  Reference: Document 4A/317  Subject: WRC-12 Agenda item 1.13 | **Annex 14 to Document 4A/368-E** |
| **27 April 2010** |
| **English only** |
| Annex 14 to Working Party 4A Chairman’s Report  Working document on probability of harmful interference to fs receiving stations from transmitting gso bss satellites in the 21.4-22 GHz band | |

The March/April 2010 meeting of Working Party 4A received a study on the probability of harmful interference to FS terrestrial stations from geostationary BSS satellites in the 21.4-22 GHz frequency band (Document [**4A/317**](http://www.itu.int/md/R07-WP4A-C-0317/en)). Key conclusions of this study are included in the working document towards the development of draft CPM text on WRC-12 Agenda item 1.13. However, since it was felt that this document contained valuable information beyond what is reflected in these key conclusions, to facilitate further studies on the subject, the main body of the text of this document is provided in the Attachment to this Annex.

**Attachment:** 1

Attachment

(Source: Document [4A/317](http://www.itu.int/md/R07-WP4A-C-0317/en))

ESTIMATION OF PROBABILITY OF CAUSING HARMFUL INTERFERENCE TO FS TERRESTRIAL STATIONS FROM GEOSTATIONARY BSS SATELLITES IN THE FREQUENCY BAND 21.4-22.0 GHz

The number of documents containing the analysis for specific situations of BSS satellites interferences to terrestrial FS stations has been presented on WP 4А and WP 5С meetings. This document contains results of the study allowing estimating the averaged probability of causing interference exceeding permissible criterion to FS terrestrial station allocated at any point of the Earth’s surface.

These results should be taken into account at determination of power flux-density limits at the Earth’s surface produced by BSS satellites.

Basic statement for the study is the statement that antenna beam axis of any fixed service (FS) terrestrial stations (TS) allocated at any Earth’s surface point (between 81N and 81S) with elevation angle no more than limit value *em*, defined by the equation (1), necessarily intersects the geostationary orbit at two azimuth values.

*e*m = arcos (Rsinφ/√R2 + r2 – 2Rrcosφ) (1)

where R = 42 164.17 km – the radius of the geostationary orbit;

r = 6 378.136 km − the radius of the Earth;

φ − latitude of a FS TS allocation at the Earth’s surface.

Hence exist two areas δ of azimuth *A* in which the criterion of permissible long-term interference caused to FS terrestrial station by BSS satellites (I/N = −10dB) can be exceeded.

Assuming that for set of FS stations allocated at the Earth’s surface all antenna beam azimuth’s values are equiprobable within the limits of 0 − 360º, we shall define probability of criterion exceeding by the following equation:

Р(%) = (2δ/360)×100 (2)

The probability of permissible interference criterion exceeding for some FS station allocated at latitude ϕ will be precisely the same for any station with the same parameters, allocated at the same latitude and having the same separation angle α (from Earth center viewpoint) of antenna beam axis intersecting GSO relative to a direction of nearest eastward geostationary BSS satellite. Latitude, elevation angle and α values averaging allows to obtain averaged probability of interference criterion exceeding along the all Earth’s surface within the chosen latitude limits (for the certain parameters of TS).

At calculation of Р(%) following initial data have been accepted:

− Frequency - 21.7 GHz.

− The power flux-density produced by each BSS satellite at elevation angles from 0º up to   
5º - minus 115 dBW/m2/MHz.

− Parameters of FS TS used at calculations are as the following:

• Noise power N = 142 dBW/MHz, 135 dBW/MHz

(similarly to Documents 4А/252, 5С/269, Recommendation ITU-R F.758-4).

• Maximum FS TS antennae gain 32 dB, 39 dB, 42 dB, 46 dB.

• The FS TS antennae radiation pattern is described in the Recommendation ITU‑R F.1245-1.

FS TS with equal probability allocates at any point of the Earth’s surface within the limits  
of 66S … 66N.

It is accepted that FS TS elevation angle possess the value *e* = 0º (with the weighing coefficient of 96.1% for angels from −1° to +1°, according to BR IFIC 2654 data (10.1/2009)), *e* = 2º (with the weighing coefficient of 1.7%), *e* = 3º (with the weighing coefficient of 0.7%), *e* = 5° (for angles 4° and more, with the weighing coefficient 0.9%), *e* = −2º (with the weighing coefficient of 0.6%). Interference from satellites visible at the elevation angle less than minus 1 degree was not taken into account.

BSS satellites are located in the geostationary orbit uniformly with an angular space separation γ = 4º or γ = 10º.

All α values were considered equiprobable.

Interference from 4 nearest satellites was taken into account.

It is important to note, that FS TS antenna beam deflection from exact pointing on GSO by azimuth *∆А* and the minimum angular separation of this beam from GSO ε are coupled by nonlinear and unsymmetrical dependence (regarding *A0*): ∆*A* = χ(ε*,*φ), depending from FS TS location latitude. For more accurate definition of data, contained in CCIR Report 393 and Recommendation ITU-R SF.765, this dependence has been recalculated (see Annex to Appendix).

Calculation of the minimum interfering BSS satellite signal attenuation in atmospheric gases is fulfilled at the atmosphere parameters pointed in the Recommendation ITU-R F.1404.

The effect of signal refraction in atmosphere was not considered.

Calculation of probability of permissible interference criterion exceeding was fulfilled for two cases:a)without assumption about FS TS antenna beam avoidance from exact pointing on GSO;b)in assumption that FS TS antenna beams should avoid an exact GSO direction for not less, than ε = 1,5º (similarly to Table 21-1 of RR Article No. 21). All other azimuth *A* values are equiprobable except for two prohibited sections χ(ε,φ), where ε = ±1,5º. In case b) equation (3) is used instead of the equation (2):

P(%) = [((δ+ – χ(ε+,φ)) + (δ- – χ(ε-,φ))) / (360 − 2 χ(ε,φ))]×100 (3)

where values δ+ and δ- are defined as angular TS antenna beam deflection by azimuth from direction of exact GSO intersection necessary for complying with protection criterion, and indices + and − correspond to east and west beam deflection from exact guidance to GSO (ε + = 1.5,  
ε - = −1.5).

Calculation results are shown in Tables 1 and 2.

Table 1

Probability of interference criterion exceeding, % (N = −142 dBW/MHz)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Satellite separation | FS TS antenna gain state | 32 dB | 39 dB | 42 dB | 46 dB |
| 4° | without initial avoidance | 2.48% | 2.04% | 1.87% | 1.65% |
| 4° | with avoidance 1.5° | 0.92% | 0.64% | 0.53% | 0.31% |
| 10° | without initial avoidance | 1.25% | 0.95% | 0.84% | 0.71% |
| 10° | with avoidance 1.5° | 0.37% | 0.22% | 0.17% | 0.12% |

Table 2

Probability of interference criterion exceeding, % (N= −135 dBW/MHz)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Satellite separation | FS TS antenna gain state | 32 dB | 39 dB | 42 dB | 46 dB |
| 40 | without initial avoidance | 0,97% | 0,71% | 0,63% | 0,55% |
| 40 | with avoidance 1.5° | 0,07% | 0,04% | 0,03% | 0,02% |
| 100 | without initial avoidance | 0,38% | 0,28% | 0,25% | 0,21% |
| 100 | with avoidance 1.5° | 0,02% | 0,01% | 0,007% | 0,004% |

Conclusion

The probability of exceeding of long-term interference criterion without the mandatory FS TS antenna beam GSO avoidance varies from 2.48% to 0.21%.

In assumption that the FS TS antennae beam should be avoided from an exact GSO direction by not less than 1.5º the probability of excess interference, i.e. a share of the stations, that will get interference, varies from 0.92% to 0.004%.

It is necessary to take into consideration that the given estimation is overestimated as the majority of FS stations operate with margin of signal to noise ratio and also because in calculation were not considered interfering signal rain attenuation and its correlation with wanted signal attenuation on FS link.