RECOMMENDATION ITU-R SF.1006*

DETERMINATION OF THE INTERFERENCE POTENTIAL BETWEEN EARTH STATIONS OF THE FIXED-SATELLITE SERVICE AND STATIONS IN THE FIXED SERVICE

(1993)

The ITU Radiocommunication Assembly,

considering

a) that when the coordination area of an earth station, as established by the methods given in Recommendation ITU-R SM.1448, includes territory of another administration, mutual consultation between the administrations concerned is required;

b) that each station in the fixed service within the coordination area must be examined to determine whether it will experience or cause more than a permissible amount of interference;

c) that Recommendation ITU-R P.452 provides the requisite propagation bases for individual point-to-point interference evaluation;

d) that experience has shown that, in many instances, separation distances as small as a few kilometres, when allowing for typical terrain and shielding, are achievable (see Fig. 1);

e) that the methodology for determining the level of interference is a matter for agreement between the administrations concerned;

f) that guidance to administrations on the detailed determination of these levels for performing a preliminary analysis may nonetheless be of value to some in the detailed coordination and interference evaluation,

recommends

1. that the methods described in Annex 1 may be used for assessing interference potential between earth stations and specific stations in the fixed service within the coordination area.

ANNEX 1

Determination of the interference potential between fixed satellite service earth stations and stations in the fixed service

The following method may be used for assessing whether interference between earth stations and specific terrestrial stations can be expected to exceed a pre-determined level.

1. Preliminary elimination procedure

The method of calculating coordination area as described in Recommendation ITU-R SM.1448 assumes certain reference values for the parameters of terrestrial stations. A very large percentage of the actual or planned terrestrial

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stations within a coordination area can be eliminated from further consideration when their actual or planned parameters are known, by using the auxiliary contours as defined in Appendix S7 of the Radio Regulations.

One set of contours is associated with values of the terrestrial station interference sensitivity factor, S which is defined as:

$$S = G_r - P_r(p) \qquad \text{dBW} \tag{1}$$

where:

G_r : net gain (dBi) (i.e. the gain of the antenna itself minus the feeder loss (dBi) relative to isotropic; where the feeder loss is not known, its value should be assumed to be 0 dB) of the receiving antenna of the terrestrial station in the direction of the earth station

$P_r(p)$: permissible interference power (dBW) in the reference bandwidth to be exceeded for no more than p percent of the time at the receiver input of a station suffering interference (in this case a terrestrial station).

The other set of contours is associated with values of terrestrial station e.i.r.p.:

$$E = P_{t'} + G_{t'} \qquad \text{dBW} \tag{2}$$

where:

P_t' : available transmitting power (dBW) in reference bandwidth B at the input to the antenna of an interfering station (in this case a terrestrial station)

G_t' : gain (dBi relative to isotropic) of the transmitting antenna of the terrestrial station in the direction of the earth station.

Each terrestrial station which is located within the coordination area may now be examined to determine whether it can be excluded from further considerations:

– for terrestrial stations which may be receiving interference from the earth station, the interference sensitivity factor in the direction of the earth station should be determined. If this value is less than that associated with the nearest contour outside which the station is located, then the station may be excluded. Otherwise, detailed calculations as described in § 2 must be carried out;

– for terrestrial stations which may be causing interference to the earth station, the actual e.i.r.p. in the direction of the earth station should be determined. If this value is less than that associated with the nearest contour outside which the terrestrial station is located, then the station may be excluded. Otherwise, detailed calculations as described in § 2 must be carried out.

The above method has been based on the assumption that the number of interference entries assumed in Recommendation ITU-R SM.1448 for the calculation of the auxiliary contours is not exceeded.

Terrestrial stations eliminated by the above procedure from further consideration with regard to great circle propagation mechanisms need, nevertheless, to be considered further with regard to rain scatter propagation, when they lie within the rain scatter coordination area.

2. Determination of interference potential due to great-circle propagation mechanisms, mode (1)

Terrestrial stations located within the coordination area, which cannot be eliminated from further consideration by the method described in § 1 must be subjected to a more detailed analysis.

For each terrestrial station it is necessary to compare the available basic transmission loss for the path and the minimum permissible basic transmission loss value, at which interference is negligible for two time percentages on the one hand equal to 20% of the time p_1, and on the other, a low percentage of the time (< 1%) designated p_2.

Interference is negligible when, for both time percentages, the available basic transmission loss for the path exceeds the minimum permissible basic transmission loss.

2.1 Level of maximum permissible interference

The level of permissible interference power at the input of the receiver of a terrestrial or an earth station may, in the most general form, be expressed as the unwanted radio-frequency power P_r from any one of n sources of interference, in a reference bandwidth B, to be exceeded for not more than specified percentages of the time, p_i. For most practical purposes two such percentages of the time will be adequate; one, p_1, chosen to reflect normal (near median) conditions for which interference contributions from all interference sources may be assumed to occur simultaneously and to add on a power basis, given by:

$$P_r(p_1) = 10 \log (kT_r B) + J - W \qquad \text{dBW} \qquad (3)$$

and another p_2, chosen to reflect significantly enhanced (small percentages of the time) interference conditions, for which interference contributions from all interfering sources may be assumed to occur non-simultaneously and to add on a percentage-of-the-time basis, given by:

$$P_r(p_2 / n_2) = 10 \log (k\, T_r\, B) + 10 \log (10^{M_s / 10} - 1) + N_L - W \qquad \text{dBW} \qquad (4)$$

where:

- p_1, p_2 : percentages of the time during which the interference from all sources may exceed the permissible level; p_1 represents long-term ($p_1 \geq 1\%$) and p_2 short-term conditions ($p_2 \leq 1\%$)
- n_1 : effective number of expected simultaneous equal-level interference contributions, associated with p_1 (see Notes 1 and 2)
- n_2 : effective number of expected non-simultaneous equal-level and equal-percentage-of-time, interference contributions, associated with p_2 (see Note 1)
- k : Boltzmann's constant: 1.38×10^{-23} J/K
- T_r : noise temperature of receiving system (for earth stations under clear-sky conditions), (K)
- B : reference bandwidth (Hz) (bandwidth, of concern to the interfered-with system, over which the interference power can be averaged)
- J : ratio (dB) of the permissible long-term (20% of the time) interfering power from any one interfering source to the thermal noise power in the receiving system (see Note 2)
- M_s : fade margin of link (see Note 3)
- N_L : link noise contribution (see Note 4)
- W : a thermal noise equivalence factor (dB) for interfering emissions in the reference bandwith. It is positive when the interfering noise would cause more degradation than thermal noise (see § 2 and § 2.4 of Annex 2 to Recommendation ITU-R SM.1448).

Numerical values for these parameters are listed in Table 1.

TABLE 1

Values of parameters relating to equations (3) and (4)

Frequency range (GHz)		1-10		1-10	1-10		10-15		10-15		15-40	15-40
Service of interfering system		Fixed-satellite		Fixed-satellite	Fixed		Fixed		Fixed-satellite		Fixed	Fixed-satellite
Wanted system	Service	Fixed		Fixed	Fixed-satellite		Fixed-satellite		Fixed		Fixed-satellite	Fixed
	Station type	Radio-relay		Trans-horizon	Earth station		Earth station		Radio-relay		Earth station	Radio-relay
	Modulation	A	N	A	A	N	A	N	A	N	N	N
p_1 (%)		20	20	20	20	20	20	20	20	20	20	20
p_2 (%)		0.01	0.005	0.01	0.03	0.005	0.03	0.005	0.01	0.005	0.003	0.005
n_2		2	3	1	3	3	2	2	2	3	2	1
B (Hz)		4×10^3	10^6	4×10^3	10^6	10^6	10^6	10^6	4×10^3	10^6	10^6	10^6
J (dB)		9	–6	0 (1)	–10	–10	–8.5	–8.5	13	–2 (2)	–7	0 (2)
W (dB)		0	0	0	4	0	4	0	0	0	0	0
T_r (K) (3)		750	750	500	100	100	200	200	1 500	1 500	300	3 200
M_s (dB)		33	37	26	2	2	4	4	33	37	6	25
N_L (dB)		0	0	0	1	1	1	1	0	0	1	0

A: analogue

N: digital

(1) The trans-horizon systems are assumed to consist of a single hop.

(2) These values are appropriate to the general case of uncorrelated fading of wanted and unwanted signals. Where this fading (due to rainfall) can be assumed to be substantially correlated (i.e. when the interference follows the same path as the unwanted signal), values for J different from those shown above may be applicable.

(3) To be used in case the values are not available.

Note 1 – The number of possible interferers, n, must be apportioned between those likely to be nearby, n_1 and those likely to be beyond the horizon, n_2. For example, for terrestrial systems operating in the band 1-10 GHz, n is 8. According to Recommendation ITU-R SM.1448 $n_2 = 3$, and, consequently, $n_1 = 5$.

Note 2 – J is the ratio (dB) between permissible long-term interference from any one source and thermal noise in a given station. This parameter is dependent upon n_1. In the case of terrestrial systems, if 10% of the total amount of noise (analogue systems) or outage (digital systems) is permitted due to earth stations, of which half is due to nearby stations, and half to stations beyond the horizon, the value of J is given by:

– for analogue systems:

$$J = 10 \log (40 / n_1) \tag{5}$$

– for digital systems:

$$J = 10 \log \left(\sqrt{X} - 1\right) \tag{6}$$

where:

$$X = 1 + 3 / n_1 \tag{7}$$

With $n_1 = 5$, $J = 9$ dB for analogue and −6 dB for digital signals.

In the case of an earth station, assuming that the thermal noise amounts to no more than 70% of the total noise of the receiver, and allowing long-term interference to be 10% of the total noise (Recommendation ITU-R SF.558), $J = -8.5$ dB, assuming a single interfering source. However, if more than one entry is used, this figure is reduced by $10 \log n_1$. At < 10 GHz, n_1, can be assumed as being between 1 and 2.

At the higher frequencies, where some correlation between the fading of the wanted and interfering signals may be anticipated, an increase in interference allowance might be allowed. In such a case, a 25% allowance for interference instead of 10% may be assumed, and a total J of –4 dB is appropriate, or a J of –7 dB for each interference source.

Note 3 – M_s is the fade margin in the link. See Note 3 of § 2.3.1 of Annex 1 to Recommendation ITU-R SM.1448.

Note 4 – N_L is the noise contribution to the link by the satellite transponder, including the up-link noise, intermodulation, etc. Generally:

N_L = 1 dB for fixed-satellite links;

N_L = 0 dB for links in the fixed service.

2.2 Minimum permissible basic transmission loss

The minimum permissible basic transmission loss for 20% of the time is given by:

$$L_b(20) = P_{t'} + G_{t'} + G_r - P_r(20) \tag{8}$$

The minimum permissible basic transmission loss for p% of the time is given by:

$$L_b(p) = P_{t'} + G_{t'} + G_r - P_r(p) \tag{9}$$

where, $p = p_2 / n_2$ (from Table 1), $P_{t'}$ and $G_{t'}$ are the pertinent parameters of the interfering station on the path of minimum transmission loss, and G_r, P_r (p) and P_r (20) are the pertinent parameters of the station suffering interference on the path of minimum transmission loss.

2.3 Available basic transmission loss

A method of calculating the available basic transmission loss between an earth station and a terrestrial station is given in Recommendation ITU-R P.452.

3. Determination of interference potential in the presence of precipitation scatter, mode (2)

In cases where interference may be due to rain scatter propagation, the minimum permissible transmission loss:

$$L(p) = P_{t'} - P_r(p) \tag{10}$$

must be calculated and compared with the loss due to rain-scatter propagation. If the first value is less than the second, then interference due to scattering from precipitation is negligible. A method of calculating the available transmission loss between an earth station and a terrestrial station where the propagation mechanism is scattering due to precipitation, is given in Recommendation ITU-R P.452.

4. Summary

Interference between an earth station and a terrestrial station can be considered as negligible when the interference power level for great-circle propagation mechanisms does not exceed the maximum permissible level of interference for 20% of the time, and also when the interference power level for all propagation mechanisms combined (i.e., great-circle and rain-scatter propagation mechanisms) does not exceed the maximum permissible level of interference for a small agreed percentage of the time.

Nevertheless, the methodology for determining in detail the levels of interference is a matter of agreement between administrations concerned. The methods described above may be of value for guidance and preliminary evaluation leading to such detailed coordination.

APPENDIX 1

TO APPENDIX 1

Auxiliary contours associated with angular discrimination

Auxiliary contours assist in the evaluation of the large number of stations which are likely to be found in the coordination area.

There is a small probability that the main beam of a terrestrial radio-relay link will be directed towards an earth station so that for the assessment of propagation mode (1) cases, it is appropriate to take account of the angular directivity of the terrestrial link antenna. Figure 2 provides a series of contours consistent with 5 dB interval reductions in link antenna gain. A terrestrial station which does not point the main beam of its antenna towards the earth station may be eliminated from further consideration when its actual antenna gain (or that of a reference diagram) towards the earth station is less than that assumed for the determination of the coordination area by at least the gain reduction value that corresponds to the auxiliary contour (see Note 1) on which it is located.

Note 1 – Interpolation between contours is appropriate.

The use of propagation mode (2) auxiliary contours requires further validation to facilitate its implementation. The propagation mode (2) auxiliary contours represent angular departure φ from complete intersection of the main beams of the earth station and fixed service station and thus incorporate both azimuthal and elevation angular components.

The above assumes a reference antenna pattern of which the envelope of the side lobes is pessimistic. More accurate patterns should be used if they are available.

FIGURE 1

Model of mutually interfering satellite earth station and terrestrial radio system

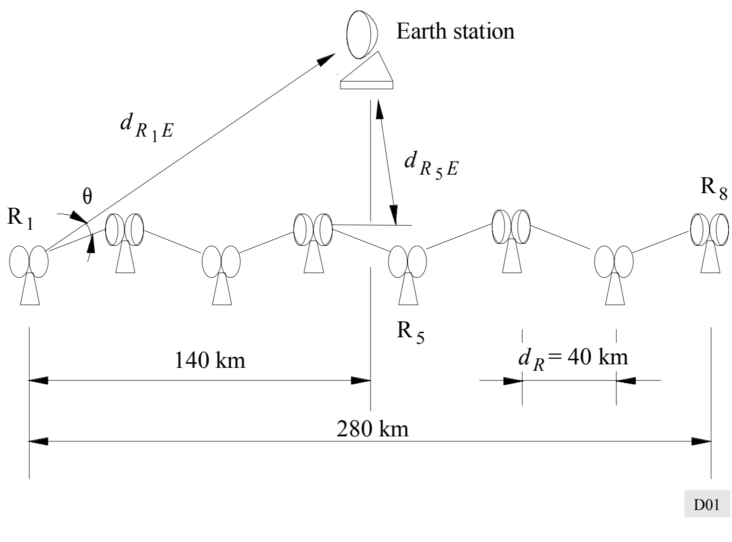

FIGURE 2

Example of auxiliary contours for propagation mode (1) (– – –)
and propagation mode (2) (—)