

RECOMMENDATION ITU-R S.1324

**ANALYTICAL METHOD FOR ESTIMATING INTERFERENCE BETWEEN
NON-GEOSTATIONARY MOBILE-SATELLITE FEEDER LINKS
AND GEOSTATIONARY FIXED-SATELLITE NETWORKS
OPERATING CO-FREQUENCY AND CODIRECTIONALLY**

(Question ITU-R 206/4)

(1997)

The ITU Radiocommunication Assembly,

considering

- a) that the World Radiocommunication Conference (Geneva, 1995) (WRC-95) identified the need to develop, as a matter of urgency, criteria for determining the necessity to coordinate and calculation methods for determining levels of interference, as well as the required protection ratios between networks in the mobile-satellite service (MSS);
- b) that the WRC-95 allocated the frequency bands 19.3-19.6 GHz and 29.1-29.4 GHz for feeder links of non-geostationary-satellite orbit (GSO) networks in MSS in co-direction with GSO fixed-satellite service (FSS) systems;
- c) that WRC-95 Resolution 121 identified the need to undertake, as a matter of urgency, studies to develop coordination methodologies for GSO FSS networks and non-GSO MSS feeder links operating in the bands 19.3-19.6 GHz and 29.1-29.4 GHz on an equal basis;
- d) that there may be a need in general to develop a methodology that could be used to estimate interference between satellite networks;
- e) that the estimation of interference between non-GSO MSS feeder links and GSO FSS systems should be based on the interference power levels not to be exceeded for a specified percentage of time, the frequency of occurrence and the duration of single events,

recognizing

- a) that estimating interference between non-GSO MSS feeder links and GSO FSS systems based on computer methods of simulation features high accuracy of the obtained results but they may require considerable runtime and may not be commonly available;
- b) that interference between non-GSO MSS feeder links and GSO FSS systems may be estimated using time percentage for non-GSO satellites staying within an area into certain discrimination angles from a direction to a GSO satellite in relation to the earth station concerned;
- c) that the time percentage for a specified value of an angle between a GSO satellite and a non-GSO satellite in relation to the earth station concerned may be defined using either simulations or by the analytical method described in Recommendation ITU-R S.1257 or by using other methods,

recommends

- 1** that the method given in Annex 1 may be used for estimating interference between non-GSO MSS feeder links and GSO FSS systems co-frequency operating in the same direction.

ANNEX 1

**Description of analytical method for estimating interference
between non-GSO MSS feeder links and GSO FSS networks
operating co-frequency and codirectionally**

For estimating interference from non-GSO MSS feeder links and GSO FSS systems a criterion is specified according to which:

- interference power spectral density, I_0 , from feeder links of an non-GSO MSS network (in uplink from earth station and in downlink from satellite being a result of feeder link transmissions to and from all the satellites in a constellation) at the input of receiver of a GSO FSS earth station shall not exceed a certain fraction, x , of receiver thermal noise power spectral density, N_0 , within a specified time percentage, % t .

An example of criteria for interference from non-GSO MSS feeder links to GSO FSS receivers given in Table 1 are used in the example in Appendix 1.

TABLE 1

11-14 GHz		
	I_0	t (%)
1	$0.06 N_0$	0.87
2	$0.26 N_0$	0.119
3	N_0	0.029
4	$2.16 N_0$	0.0004

The present method provides an estimation of the time percentage, % t , based on acceptable interference power spectral density, I_0 , without using simulation methods.

For estimating interference between feeder links of non-GSO MSS networks and GSO FSS systems four cases of possible interference effects between earth and space stations of the networks discussed are analysed. They are:

Case 1: emissions from non-GSO MSS feeder-link earth stations interfering into GSO FSS receiving space stations (see Fig. 1).

Case 2: emissions from non-GSO MSS feeder-link space stations interfering into GSO FSS receiving earth stations (see Fig. 2).

Case 3: emissions from GSO FSS earth stations interfering into non-GSO MSS feeder-link receiving space stations (see Fig. 3).

Case 4: emissions from GSO FSS space stations interfering into non-GSO MSS feeder-link receiving earth stations (see Fig. 4).

FIGURE 1
 Non-GSO MSS feeder link earth stations interfering into GSO FSS receiving space stations

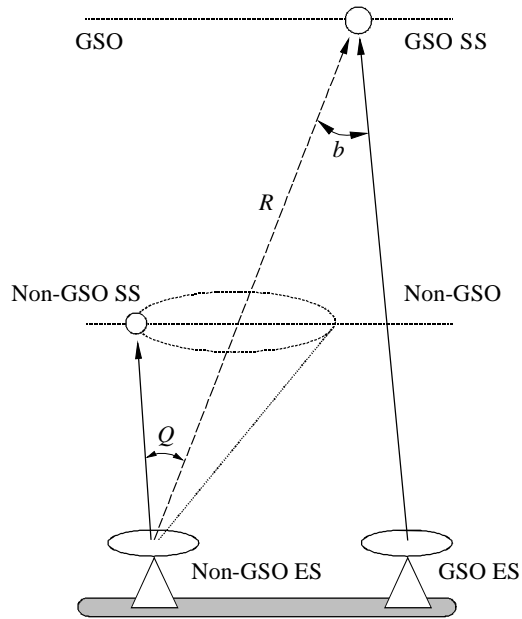


FIGURE 2
 Non-GSO MSS feeder link space stations interfering into GSO FSS receiving earth stations

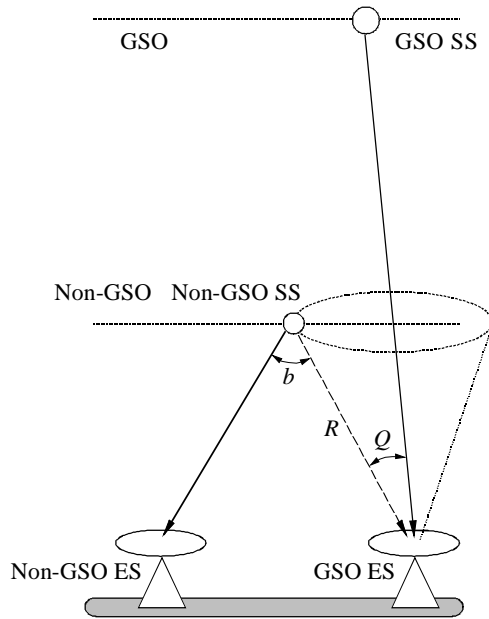


FIGURE 3
 GSO FSS earth stations interfering into non-GSO MSS feeder link receiving space stations

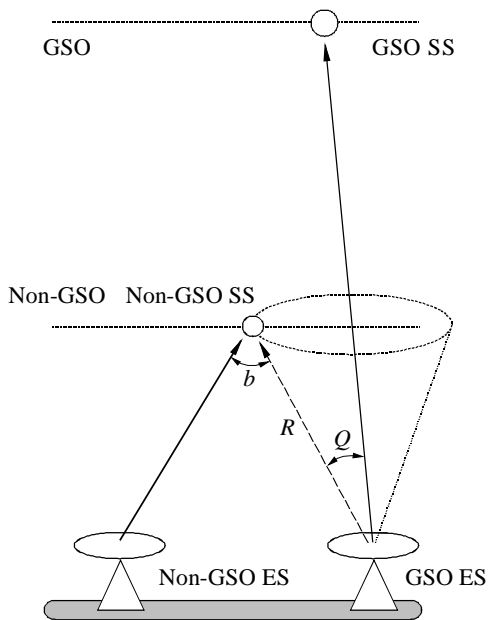
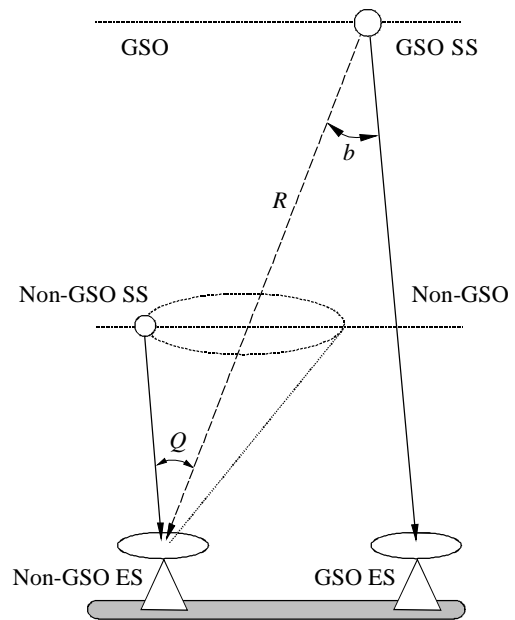


FIGURE 4
 GSO FSS space stations interfering into non-GSO MSS feeder link receiving earth stations



- ← Wanted signal
- ←--- Interference
- SS: space station
- ES: earth station

The interference power spectral density at the receiver input can be calculated using the following expressions:

for the “uplink”:

$$I_0 = P1i + G1i(Q) - Lu + G2w(b) \quad \text{dB(W/Hz)} \quad (1)$$

for the “downlink”:

$$I_0 = P3i + G3i(b) - Ld + G4w(Q) \quad \text{dB(W/Hz)} \quad (2)$$

where:

$P1i$: interfering earth station’s transmit power spectral density (dB(W/Hz))

$P3i$: interfering space station’s transmit power spectral density (dB(W/Hz))

$G1i(Q)$: interfering earth station antenna gain in the direction of the wanted space station (dB)

$G2w(b)$: wanted space station antenna gain in the direction of the interfering earth station (dB)

$G3i(b)$: interfering space station antenna gain in the direction of the wanted earth station (dB)

$G4w(Q)$: wanted earth station antenna gain in the direction of the interfering space station (dB)

Lu : path loss from the interfering earth station to the wanted satellite (dB)

Ld : path loss from the interfering satellite to the wanted earth station (dB).

This method is based on defining a part of space limited by a circular conic surface with a vertex angle $2Q$ (see Figs. 1 to 4). The vertex of the cone coincides with either the interfering or interfered-with earth station location and the axis of the cone is always aimed at the GSO satellite.

For interference cases 1 and 4 the interference power spectral density into a receiver changes only as a function of angle Q which varies as the non-GSO satellite moves.

For interference cases 2 and 3 the interference power spectral density into a receiver changes as a function of angle Q , distance R and angle b . Analysis of variations in the interference power spectral density, I_0 , as a function of Q , b and R shows that a slight increase in angle Q leads to a sharp decrease in the interference power, I_0 , while small changes in distance R and angle b leads to virtually no change. Variations in $G2w(b)$, $G3i(b)$, Lu , Ld , that are functions of distance R and angle b , are therefore insignificant.

Based on these features it is appropriate to assume that $G2w(b)$, $G3i(b)$, Lu and Ld are constant. This assumption leads to an insignificant error of the interference estimates. Therefore for interference cases 2 and 3 the variations in the received interference power spectral density are mainly a function of the angle Q .

The time percentage, % t , that non-GSO satellites are within the cone $2Q$ is a function of the required separation angle Q . For the specified features of the satellite networks concerned, every value of angle Q corresponds to a certain value of I_0 at receiver’s input.

For the purpose of estimating the uplink interference, the interfering earth station antenna pattern is used, while for estimating the downlink interference, the wanted earth station antenna gain is used.

Step 1: An acceptable level of interference power spectral density for a specific earth station is derived using the following expression:

$$I_0 = 10 \log x + 10 \log(k T) \quad \text{dB(W/Hz)} \quad (3)$$

where:

x : fraction of the receiver thermal noise power spectral density within a specified time percentage, % t , criteria of Table 1

k : Boltzmann’s constant (J/K)

T : noise temperature of the wanted networks receiving station (K).

Step 2: Using expressions (1) or (2) (depending if it is uplink or downlink) and the earth station antenna pattern a value of angle Q , that corresponds to an acceptable interference power spectral density, I_0 , defined at Step 1, is calculated.

Step 3: Based on the analytical method presented in Recommendation ITU-R S.1257 or based on other methods, a time percentage $\% t_m(Q)$ that non-GSO satellites are within a cone with a vertex angle $2Q_m$ is calculated.

Step 4: Time percentage values calculated at Step 3 are compared with acceptable values (e.g. those given in Table 1). If the calculated value of time percentage $\% t(Q)_m$ does not exceed a specified $\% t_m$ then the interference is acceptable (based on the criteria used).

An example of the given algorithm's application for estimating interference between feeder links of a non-GSO MSS network and GSO FSS system is shown in Appendix 1.

APPENDIX 1

TO ANNEX 1

Example of estimating interference between non-GSO MSS feeder links and GSO FSS systems sharing the same frequency bands in the same direction

The example deals with a case of estimating interference from non-GSO MSS feeder links into a GSO FSS system. The assumptions used are characteristics of a LEO-G-type non-GSO satellite network ($h = 1\,500$ km, $i = 74^\circ$, $N = 48$) and typical GSO satellite parameters. Estimations are performed for wanted and interfering earth stations at latitudes of 0° and 60° , and with the satellite located at the same longitude as the earth station.

Estimation results for interference from the non-GSO MSS feeder links to the GSO FSS system are presented in Tables 2a) and 2b) for Earth-to-space and space-to-Earth directions respectively. The estimation sequence is as follows.

Stage 1: The first stage is the estimation of the acceptable interference level expressed in fraction, x , of a specific receiver noise power spectral density, N_0 , within the time percentage, $\% t_m$, specified for the given frequency band.

The following formula was used:

$$I_0 = 10 \log x + 10 \log(k T) \quad \text{dB(W/Hz)}$$

In Tables 2a) and 2b) the specified time percentage $\% t_m$ (column 2) have appropriate values of N_0 (column 4), x (column 5) and an estimated threshold interference value $(xN_0)_m$ (column 6).

Stage 2: At the second stage, using expressions (1) or (2) (depending if it is uplink or downlink) and the earth station antenna pattern, the values of angle (Q_m) corresponding to an acceptable noise power spectral density $(xN_0)_m$ defined at the first stage was calculated. The values of Q_m are presented in column 11 of Tables 2a) and 2b).

Stage 3: At the third stage a time percentage $\% t(Q)_m$ of non-GSO satellites being within a cone with a vertex angle $(2Q_m)$ calculated using the analytical method presented in the Recommendation ITU-R S.1257 (see column 12).

Stage 4: At the fourth stage the calculated time percentage values were compared with acceptable values (those given as an example only in Table 1).

The estimation results presented in Tables 2a) and 2b) show that the interference levels from the non-GSO MSS feeder link stations into the GSO FSS stations would not comply with the short-term criteria $(xN_0)_m$ using in this example.

TABLE 2

The interference level of satellite systems resulting from computation based on results of possible interference duration (time statistics)
in case of non-GSO MSS network interference into FSS network

a) Uplink

LEO-G
INTELSAT (Beam S1R)

Satellite system creating the interference – *i*

Satellite system subjected to the interference – *w*.

Latitude of earth station (degrees)	% <i>t</i> (%)	<i>T</i> (K)	<i>N</i> ₀ (dB(W/Hz))	<i>x</i>	<i>xN</i> ₀ (dB(W/Hz))	<i>P</i> _{1<i>i</i>} (dB(W/Hz))	<i>Lu</i> (dB)	<i>G</i> _{2<i>w</i>(<i>b</i>)} (dB)	<i>G</i> _{1<i>i</i>(<i>Q</i>)} (dB)	<i>Q</i> (degrees)	% <i>t</i> (<i>Q</i>) (%)
1	2	3	4	5	6	7	8	9	10	11	12
0	0.87	766	-199.8	0.06	-212	-64.6	206.6	37.2	22.0	2.10	0.0372
	0.119			0.26	-205.7				28.3	1.54	0.024
	0.029			1.00	-199.8				34.2	1.11	0.012
	0.0004			2.16	-196.5				37.5	0.81	0.0068
60	0.87	766	-199.8	0.06	-212	-64.6	207.4	37.2	22.8	2.10	0.2308
	0.119			0.26	-205.7				29.1	1.48	0.118
	0.029			1.00	-199.8				35.0	1.06	0.068
	0.0004			2.16	-196.5				38.3	0.71	0.0268

b) Downlink

LEO-G
INTELSAT (Earth station Standard E)

Satellite system creating the interference – *i*

Satellite system subjected to the interference – *w*.

Latitude of earth station (degrees)	% <i>t</i> (%)	<i>T</i> (K)	<i>N</i> ₀ (dB(W/Hz))	<i>x</i>	<i>xN</i> ₀ (dB(W/Hz))	<i>P</i> _{3<i>i</i>} (dB(W/Hz))	<i>G</i> _{3<i>i</i>(<i>b</i>)} (dB)	<i>L</i> _{<i>d</i>} (dB)	<i>G</i> _{4<i>w</i>(<i>Q</i>)} (dB)	<i>Q</i> (degrees)	% <i>t</i> (<i>Q</i>) (%)
1	2	3	4	5	6	7	8	9	10	11	12
0	0.87	309	-203.7	0.06	-215.9	-78.6	5.0	177.3	35.0	0.60	0.004
	0.119			0.26	-209.6				41.3	0.45	0.0012
	0.029			1.00	-203.7				47.2	0.26	0.001
	0.0004			2.16	-200.4				50.5	–	0
60	0.87	309	-203.7	0.06	-215.9	-78.6	15.0	182.8	30.5	1.15	0.076
	0.119			0.26	-209.6				36.8	0.56	0.012
	0.029			1.00	-203.7				42.7	0.42	0.0092
	0.0004			2.16	-200.4				46.0	0.31	0.008