

RECOMMENDATION ITU-R S.1523

Methodology for performing parametric evaluation studies of interference sensitivity for geostationary-satellite orbit fixed-satellite service systems* sharing spectrum in bands above 10 GHz

(Question ITU-R 236/4)

(2001)

The ITU Radiocommunication Assembly,

considering

- a) that geostationary-satellite orbit fixed-satellite service (GSO FSS) systems may operate, and many GSO FSS earth stations are located in urban areas;
- b) that GSO FSS systems share spectrum with other GSO FSS, non-GSO FSS and FS systems;
- c) that there is a need for the adequate protection of existing GSO FSS systems, and allow the development of new GSO technologies in both non-planned bands and bands where plans exist;
- d) that the short-term performance of links operating in bands above 10 GHz are primarily a function of rain fade and interference;
- e) that the performance of GSO FSS systems operating above 10 GHz is dependent on earth station location (altitude, rain rate, and elevation angle in the direction of the satellite), the receiver system temperature, the link availability, and the excess link margin;
- f) that to ensure a thorough consideration of the impact of GSO FSS systems it is necessary to take into account differences;
- g) that parametric studies may be useful for assessing the impact of interference on a variety of GSO links that are, or could be located in parts of the Earth in view of the GSO orbits;
- h) that in many situations the modelling of interference as thermal noise into GSO links is an acceptable approximation,

recommends

- 1** that for parametric studies of GSO FSS link budgets, interference should be modelled as additive thermal noise and that generic parameters can be used as shown in Annex 1;
- 2** that the development of a parametric study of GSO FSS link budgets could be based on links terminating in urban centres (see Annex 2);
- 3** that studies involving the assessment of time varying interference sources on GSO FSS systems should take into account the effects of rain fading by utilizing the methodologies described

* Such a system would consist of several GSO satellites, which together provide service and may or may not be connected via inter-satellite links. However, the methodology described herein may also be used for calculations involving a network including only one GSO satellite.

in Recommendation ITU-R S.1323. (This Recommendation is not intended to replace network-by-network frequency coordination);

4 that the performance objectives for GSO FSS links be calculated with and without interference to determine the percentage change in the unavailability due to the interference;

5 that in order to assess the impact of interference limits on all possible GSO FSS links the analysis should consider the effects in each separate rain region.

ANNEX 1

Methodology for conducting parametric studies of the effects of time varying interference on GSO FSS networks

Introduction

In many ITU studies, interference can be modelled as additive thermal noise. For these studies it is valid to use the reduced set of parameters, in *recommends 1*, to model the GSO FSS link.

This link description lends itself to parametric study because it requires few input parameters. These input parameters include:

- earth station altitude, latitude, rain rate, angle to the GSO satellite, receive antenna polarization (circular, vertical, or horizontal), receive system temperature, receive frequency and receive antenna diameter;
- short-term performance objective for the link;
- link margins that are required to meet the short-term performance objective of the link.

Sensitivity analysis can be performed on each input separately and the results compiled for a representative sample distribution of GSO links. This type of analysis provides a complete description of the impact of interference on the entire potential of the GSO FSS industry.

The system temperature is a total system temperature and includes all noise and interference contributions in the full link budget. For a calculation of uplink interference, into the GSO satellite, the earth station is the transmitter and the receiver is on the satellite. For a calculation of downlink interference the receiver is at the earth station. For processing satellites uplinks and downlinks can be analysed separately. For transparent satellite systems the downlink system temperature includes the uplink contribution.

Specifically, the calculation of the total noise temperature of the satellite (uplink), T_{sat} (K), and total noise earth station temperatures, $T_{e/s}$ (K), can be derived from the following equations:

$$T_{sat} = \frac{\left[\begin{array}{l} 10^{0.1\left(C_{\uparrow} - \left(\frac{C}{IM}\right)_{\uparrow}\right)} + 10^{0.1\left(C_{\uparrow} - \left(\frac{C}{TxXpol}\right)_{\uparrow}\right)} + 10^{0.1N_{\uparrow}} + 10^{0.1\left(C_{\uparrow} - \left(\frac{C}{RxXpol}\right)_{\uparrow}\right)} + \\ 10^{0.1\left(C_{\uparrow} - \left(\frac{C}{ASI}\right)_{\uparrow}\right)} + 10^{0.1\left(C_{\uparrow} - \left(\frac{C}{FS}\right)_{\uparrow}\right)} + 10^{0.1\left(C_{\uparrow} - \left(\frac{C}{FR}\right)_{\uparrow}\right)} \end{array} \right]}{k \cdot B} \quad \text{K} \quad (1)$$

$$T_{e/s} = \frac{\left[\begin{array}{l} 10^{0.1\left(C_{\downarrow} - \left(\frac{C}{IM}\right)_{\downarrow}\right)} + 10^{0.1\left(C_{\downarrow} - \left(\frac{C}{TxXpol}\right)_{\downarrow}\right)} + 10^{0.1N_{\downarrow}} + 10^{0.1\left(C_{\downarrow} - \left(\frac{C}{RxXpol}\right)_{\downarrow}\right)} + \\ 10^{0.1\left(C_{\downarrow} - \left(\frac{C}{ASI}\right)_{\downarrow}\right)} + 10^{0.1\left(C_{\downarrow} - \left(\frac{C}{FS}\right)_{\downarrow}\right)} + 10^{0.1\left(C_{\downarrow} - \left(\frac{C}{FR}\right)_{\downarrow}\right)} + 10^{0.1\left(C_{\downarrow} - \left(\frac{C}{AdjTr}\right)_{\downarrow}\right)} \end{array} \right]}{k \cdot B} \quad \text{K} \quad (2)$$

where:

- C_{\uparrow} : the power received at the satellite (dBW)
- $(C/IM)_{\uparrow}$: transmit carrier-to-intermodulation product ratio (dB) on the uplink
- $(C/TxXpol)_{\uparrow}$: transmit carrier-to-transmit cross-polarization isolation ratio (dB) on the uplink
- N_{\uparrow} : uplink thermal noise (dBW)
- $(C/RxXpol)_{\uparrow}$: carrier-to-receiver cross-polarization isolation ratio (dB) on the uplink
- $(C/ASI)_{\uparrow}$: carrier-to-adjacent satellite interference ratio (dB) on the uplink
- $(C/FS)_{\uparrow}$: carrier-to-fixed service interference ratio (dB) on the uplink
- $(C/FR)_{\uparrow}$: carrier-to-frequency reuse isolation ratio (dB) on the uplink
- C_{\downarrow} : the power received at the earth station (dBW)
- $(C/IM)_{\downarrow}$: transmit carrier-to-intermodulation product ratio (dB) on the downlink
- $(C/TxXpol)_{\downarrow}$: transmit carrier-to-transmit cross-polarization isolation ratio (dB) on the downlink
- N_{\downarrow} : downlink thermal noise (dBW)

- $(C/RxXpol)_\downarrow$: carrier-to-receiver cross-polarization isolation ratio (dB) on the downlink
- $(C/ASI)_\downarrow$: carrier-to-adjacent satellite interference ratio (dB) on the downlink
- $(C/FS)_\downarrow$: carrier-to-fixed service interference ratio (dB) on the downlink
- $(C/FR)_\downarrow$: carrier-to-frequency reuse isolation ratio (dB) on the downlink
- $(C/AdjTr)_\downarrow$: carrier-to-adjacent transponder isolation ratio (dB) on the downlink
- k : Boltzman's constant (W/(Hz · K))
- B : carrier bandwidth (Hz).

In the above equations the adjacent satellite and fixed service interference are assumed to be unfaded by rain. This is a worst-case assumption that over estimates the received system temperature.

For transparent satellites the total system link noise temperature, T_{sys} , (K) at the receive earth station including the contribution of the uplink is given by:

$$T_{sys} = T_{e/s} + \gamma \cdot T_{sat} \quad (3)$$

where γ is the transmission gain and is equal to the numerical ratio C_\uparrow/C_\downarrow .

Above 10 GHz the interference analysis should take into account the simultaneous effects due to fading and interference. Recommendation ITU-R S.1323 includes a variety of methods for combining rain fade and interference. The interference analysis results can be carried out in a variety of ways including:

- calculating the change in availability due to the interference as a function of rain rate;
- setting interference limits or assessing regional impact based on the percentage of links that have unacceptable interference as a function of rain rate;
- varying the link margin or antenna diameter to determine GSO system costs required to mitigate interference;
- calculating the impact of the interference versus population in urban centres.

An example of a distribution of rain rates for use in performing parametric studies is shown in Annex 2.

ANNEX 2

An example of a distribution of rain rates in urban areas for use in performing parametric studies

Links which are the most sensitive to non-GSO interference tend to have earth stations with the following characteristics:

- be located in regions with low rain fall and/or at high altitude;

- have low receive system noise temperatures; and
- can meet their performance requirement when having minimum clear-sky propagation margins.

In order to identify where sensitive links might exist throughout the world, an international database of urban population areas located by: latitude, longitude, rain rate and average altitude was created. The urban population information used to create the file was derived from data provided by the Population Division, Department of Economic and Social Affairs of the United Nations. Average altitude information was taken from topographical data available from the United States of America National Oceanic and Atmospheric Administration.

The resulting file provides population, location, rain rate and altitude information for over 2700 urban population centres. The minimum population for classification as an urban centre was limited to 75 000 people (except for some few smaller island locations). The total population of the urban areas represented in the file represents about 40% of the total world population.

Figure 1 graphically summarizes population in urban centres by rain rate, and Fig. 2 graphically illustrates the number of urban areas having each rain rate. For reference, Table 1 shows the variation in urban centre altitude versus rain rate. The figures demonstrate that there are a significant number of cities with populations greater than 75 000 distributed with low rain rates. It has to be presumed that these urban areas will have satellite communication requirements similar to those of the rest of the world.

FIGURE 1
Urban population as a function of rain rate

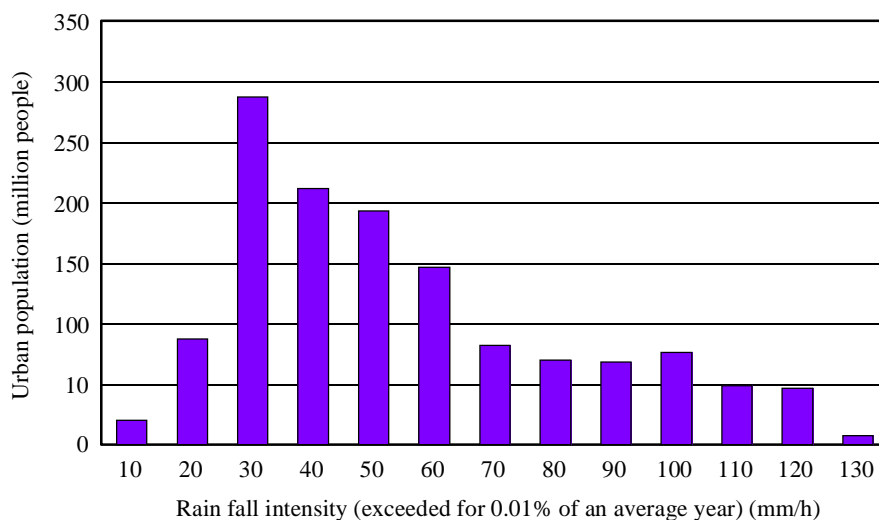
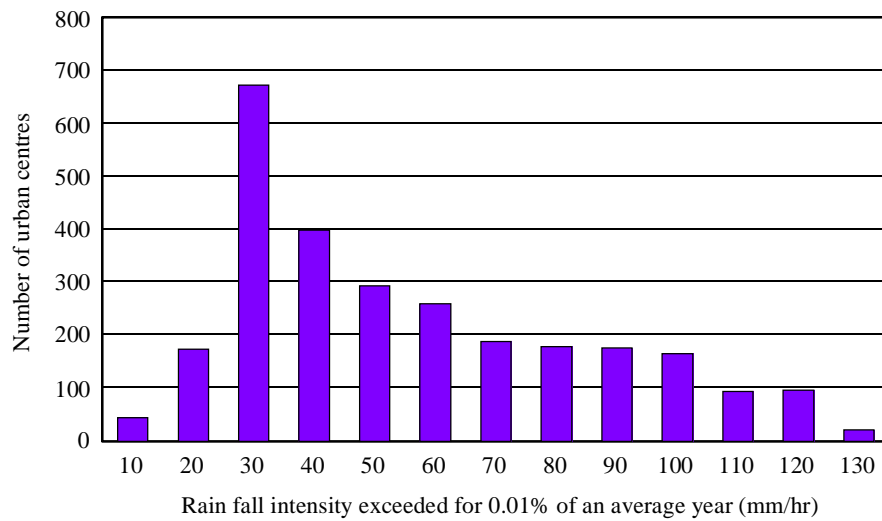


FIGURE 2

Number of urban centres as a function of rain rate



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TABLE 1

Means of the altitudes of the urban centres for each rain rate

Rain rate (mm/h)	Mean (m)
10	648
20	16
30	25
40	35
50	45
60	55
70	65
80	75
90	85
100	95
110	104
120	4
130	124