

## RECOMMENDATION ITU-R M.1583-1\*

**Interference calculations between non-geostationary mobile-satellite service or radionavigation-satellite service systems and radio astronomy telescope sites**

(Question ITU-R 236/8)

(2002-2007)

**Scope**

This Recommendation describes a methodology to be used to calculate the amount of data loss due to interference produced by a non-GSO mobile-satellite or radionavigation-satellite service system at a radio astronomy site. This methodology is based on the calculation of the epfd produced by the considered active system at the radio astronomy site.

The ITU Radiocommunication Assembly,

*considering*

- a) that, in some cases, the radio astronomy service and space services (space-to-Earth) have been allocated to adjacent or nearby frequency bands;
- b) that the radio astronomy service is based on the reception of emissions at much lower power levels than are generally used in other radio services;
- c) that, due to these low received power levels, the radio astronomy service is generally more susceptible to interference from unwanted emissions than other services;
- d) that due to the characteristics of non-geostationary (non-GSO) satellite systems, and in particular to the time-varying nature of interference, the level of interference from such satellites into radio telescopes cannot be evaluated in the same way as for the case of GSO satellites,

*recommends*

- 1 that the determination of unwanted emission levels produced by a non-GSO radionavigation-satellite service (RNSS) or a mobile-satellite service (MSS) systems on radio astronomy sites should be based on the method described in Annex 1;
- 2 that when performing this determination, the antenna pattern described in Recommendation ITU-R RA.1631 should be used to model radio astronomy antennas;
- 3 that the percentage of time during which an equivalent power flux-density (epfd) threshold level is exceeded should also be determined in accordance with the method described in Annex 2.

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\* This Recommendation should be brought to the attention of Radiocommunication Study Group 7.

## Annex 1

### Calculation of unwanted emission levels produced by a non-GSO RNSS or an MSS system at radio astronomy sites

The methodology described here, based on the “equivalent power flux-density” (epfd) concept, is intended for use in calculating the power flux-density (pfd) levels produced by unwanted emissions of a non-GSO satellite system into radio telescopes, taking into account the characteristics of both the satellite system and the radio telescope antenna. The value of the epfd is the aggregate of the contributions from all satellite emissions expressed as the pfd of a single equivalent source on the boresight (peak of main beam) of the radio telescope.

#### 1 Required parameters

Due to the particular characteristics of non-GSO satellite systems, it is clear that the level of the interference from such satellites into a radio telescope cannot be evaluated in the same way as for GSO satellites. A statistical approach is needed which takes into account the dynamic aspect of non-GSO satellites.

The evaluation of interference resulting from the satellites at the radio telescope during the integration time (2 000 s) should be based on statistical calculations and should take into account the parameters of both the satellites and the radio telescope.

Non-GSO satellite system parameters:

- the number of satellites visible in the sky at the radio astronomy station;
- the detailed orbital characteristics of the satellites;
- the pfd radiated by each satellite at the radio telescope within the radio astronomy band considered, which may be estimated using a model of unwanted emissions mask.

Radio telescope parameters:

- the antenna location;
- the antenna pattern and antenna gain;
- the practical range of pointing directions;
- the boresight pointing direction;
- the off-axis angles between the boresight of the antenna of the radio astronomy station and the directions of the transmitting satellites;
- the integration time (2 000 s).

#### 2 Calculation of epfd at radio astronomy sites

The receiving gain of a radio telescope in the direction of a non-GSO satellite (as opposed to GSO) varies with time chiefly because of the movement of the satellite and the fine angular structure of the radio telescope’s side-lobe pattern. There will be times when the telescope gain in the direction of a satellite is much higher than 0 dBi, and other times when it is less.

In addition, in the case of multiple satellites of a non-GSO system, all their contributions must be included and properly taken into account.

This may be done using the concept of epfd originally defined to assess possible sharing conditions between GSO and non-GSO systems. In the section below the concept is developed for the case of a radio astronomy station subject to interference from non-GSO satellites.

## 2.1 Definition of epfd

When an antenna receives power, within its reference bandwidth, simultaneously from transmitters at various distances, in various directions and at various levels of incident pfd, the epfd is that pfd which, if received from a single transmitter in the far field of the antenna in the direction of maximum gain, would produce the same power at the input of the receiver as is actually received from the aggregate of the various transmitters.

The instantaneous epfd is calculated using the following formula:

$$epfd = 10 \log_{10} \left[ \sum_{i=1}^{N_a} 10^{\frac{P_i}{10}} \cdot \frac{G_t(\theta_i)}{4\pi d_i^2} \cdot \frac{G_r(\varphi_i)}{G_{r,max}} \right] \quad (1)$$

where:

$N_a$ : number of non-GSO space stations that are visible from the radio telescope

$i$ : index of the non-GSO space station considered

$P_i$ : RF power of the unwanted emission at the input of the antenna (or RF radiated power in the case of an active antenna) of the transmitting space station considered in the non-GSO system (dBW) in the reference bandwidth

$\theta_i$ : off-axis angle (degrees) between the boresight of the transmitting space station considered in the non-GSO system and the direction of the radio telescope

$G_t(\theta_i)$ : transmit antenna gain (as a ratio) of the space station considered in the non-GSO system in the direction of the radio telescope

$d_i$ : distance (m) between the transmitting station considered in the non-GSO system and the radio telescope

$\varphi_i$ : off-axis angle (degrees) between the pointing direction of the radio telescope and the direction of the transmitting space station considered in the non-GSO system

$G_r(\varphi_i)$ : receive antenna gain (as a ratio) of the radio telescope, in the direction of the transmitting space station considered in the non-GSO system (see Recommendation ITU-R RA.1631)

$G_{r,max}$ : maximum gain (as a ratio) of the radio telescope

$epfd$ : instantaneous equivalent power flux-density (dB(W/m<sup>2</sup>)) in the reference bandwidth at the radio telescope.

The epfd calculation in equation (1) assumes that the pfd due to all interfering sources is directed at the boresight of the receiving antenna, where the antenna gain is maximum. However, radio astronomy protection criteria are based on a 0 dBi contour of the radio astronomy antenna. Using the approach in equation (1), the pfd due to all interfering sources directed at the 0 dBi gain of the receiving antenna, can be determined as follows:

$$epfd_{G_r=0 \text{ dBi}} = 10 \log_{10} \left[ \sum_{i=1}^{N_a} 10^{\frac{P_i}{10}} \cdot \frac{G_t(\theta_i)}{4\pi d_i^2} \cdot G_r(\varphi_i) \right] \quad (2)$$