

RECOMMENDATION ITU-R S.1560

Methodology for the calculation of the worst-case interference levels from a particular type of non-geostationary fixed-satellite service system using highly-elliptical orbits into geostationary fixed-satellite service satellite networks operating in the 4/6 GHz frequency bands

(Question ITU-R 236/4)

(2002)

The ITU Radiocommunication Assembly,

considering

- a) that many fixed-satellite service (FSS) frequency bands, including the 4/6 GHz bands, may be used for both geostationary (GSO) satellite networks and non-GSO satellite systems in accordance with the Radio Regulations (RR);
- b) in the 4/6 GHz bands non-GSO systems shall not cause unacceptable interference to GSO FSS networks in accordance with the provisions of RR No. 22.2;
- c) that administrations may need to calculate the worst-case interference level that is generated from a non-GSO system into any GSO network in the 4/6 GHz frequency bands;
- d) that the 4/6 GHz FSS frequency bands are heavily used by existing and planned GSO FSS networks,

noting

- a) that information relating to non-GSO systems using highly-elliptical orbits in the FSS in frequency bands below 10 GHz has been received by the Radiocommunication Bureau;
- b) that RR No. 22.2 is an operational provision which is to be applied between administrations, and it is up to the affected GSO FSS administration to determine whether a non-GSO FSS system is causing unacceptable interference to a GSO FSS network;
- c) that the types of highly-elliptical orbit non-GSO FSS systems referenced in *noting* a) are characterized by the use of limited operational or “active” arcs that are spatially separated from the GSO as seen from the earth station,

recommends

1 that the worst-case interference level, from a non-GSO FSS system of a type described in the *notings* above using highly-elliptical orbits into a GSO FSS network, be calculated by considering that all co-frequency non-GSO satellites from such a system that are transmitting towards the same geographic region of the Earth are producing their maximum power flux-density (pfd) levels;

2 that for non-GSO FSS systems operating in highly-elliptical orbits in the 4/6 GHz frequency bands, the methodology in Annex 1 to this Recommendation should be used for the calculation of the worst-case levels of interference into GSO FSS networks from non-GSO FSS

systems where no transmissions to or from any non-GSO satellite are made within 40° of the GSO as viewed from any point on the Earth's surface;

3 that this methodology may be used by administrations in assessing whether a non-GSO FSS system of a type described in the *notings* above would cause unacceptable interference to a GSO FSS network.

NOTE 1 – Annex 2 gives an example of the use of the methodology of this Recommendation for a non-GSO FSS system of a type described in the *notings* above operating in sub-synchronous inclined elliptical orbits.

NOTE 2 – Further work is required to assess the aggregate interference from such non-GSO systems into GSO networks.

NOTE 3 – The methodology uses worst-case assumptions that overestimate the actual levels of interference. More refined analysis techniques could be used to assess the interference profiles in more detail.

NOTE 4 – The inclination of the GSO satellite should be taken into account in the methodology of Annex 1.

ANNEX 1

Methodology for the calculation of the worst-case interference levels from a particular type of non-GSO FSS system using highly-elliptical orbits into GSO FSS networks operating in the 4/6 GHz frequency bands

The following methodology should be used for the calculation of the potential levels of interference into GSO networks operating in the 4/6 GHz frequency bands resulting from the co-frequency operation of particular types of non-GSO FSS system.

The calculation methodology described in this Annex could overestimate the actual levels of interference. In particular, for the downlink interference assessment, it is assumed that each of the transmitting non-GSO FSS satellites is located at the minimum angular separation from the line-of-sight (LoS) between the GSO earth station and its associated GSO satellite. In a realistic situation, if one of the non-GSO satellites is located at this minimum angular separation, the other non-GSO satellites will be located at some larger angular separation and the interference contributions from these other satellites will be lower. Hence, the overall calculated $\Delta T/T$ degradation would be less than those calculated using this methodology. For both the uplink and the downlink interference assessments, the number of transmitting satellites or earth stations used in this analysis of maximum interference is at the time when a handoff is occurring. This handoff will only occur for short periods of time (generally, about 0.1%) and will result in an overestimation of the maximum interference that would occur for the majority of the time. More refined analysis techniques could be used to assess the interference profiles in more detail.

1 Data concerning the non-GSO system

The following information is required concerning the non-GSO system:

1.1 Space-to-Earth transmissions

- θ_{D-min} : Minimum angular separation of the active transmitting non-GSO satellites from the LoS between the GSO earth station and its associated GSO satellite (degrees).
- $pfd_{D-non-GSO-max}$: Maximum pfd at the Earth's surface caused by transmissions from each non-GSO satellite in the constellation (dB(W/(m² · 1 Hz))).
- N_D : Maximum number of co-frequency non-GSO satellites transmitting towards the same geographic region of the Earth, as well as an indication of the number of such satellites as a function of the percentage of time.

1.2 Earth-to-space transmissions

- θ_{U-min} : Minimum angular separation of the GSO from the LoS between the transmitting non-GSO earth station and its associated non-GSO satellite (degrees).
- $e.i.r.p.-non-GSO-max$: Maximum off-axis equivalent isotropically radiated power (e.i.r.p.) spectral density from the transmitting non-GSO earth station corresponding to the minimum angular separation, θ_{U-min} (dB(W/Hz)).
- N_U : Maximum number of co-frequency transmitting non-GSO earth stations within a geographic region of the Earth that is likely to be received by a single GSO satellite receive beam.

2 Data concerning the GSO network

The following information is required concerning the GSO network:

2.1 Receive earth station sensitivity

- $G_{GSO-ES-max}$: Assumed maximum off-axis gain of the GSO receive earth station in a direction corresponding to the minimum angular separation, θ_{D-min} , of the non-GSO satellite when it is actively transmitting (dBi). Recommendation ITU-R S.465 provides guidance in this respect.
- T_{GSO-ES} : Assumed clear-sky receive system noise temperature (including receive antenna noise) of the GSO downlink. To err on the conservative side this need not include degradations caused to the overall link resulting from the uplink (K).

2.2 Satellite receive sensitivity

- $G_{GSO-SS-max}$: Assumed maximum GSO satellite receive antenna gain (dBi).
- T_{GSO-SS} : Assumed clear-sky receive system noise temperature of the GSO uplink. To err on the conservative side this need not include the overall link including downlink (K).

3 Calculation of downlink interference into the GSO network

The following three Steps are performed to calculate the degradation to the GSO network downlink receive system noise temperature from one non-GSO satellite system:

Step D1: calculate the maximum interfering signal power spectral density (PSD), I_{0-ES} , from a single non-GSO satellite at the GSO earth station antenna output:

$$I_{0-ES} = pfd_{D-non-GSO-max} + G_{GSO-ES-max} + 10 \log \left(\frac{\lambda^2}{4\pi} \right) \quad \text{dB(W/Hz)} \quad (1)$$

where λ is the wavelength.

Step D2: calculate the noise PSD, N_0 , at the GSO earth station antenna output:

$$N_{0-ES} = 10 \log (k T_{GSO-ES}) \quad \text{dB(W/Hz)} \quad (2)$$

where k is Boltzmann's constant.

Step D3: calculate the degradation to downlink receive system noise temperature ($\Delta T/T_D$) from the constellation of non-GSO satellites:

$$\Delta T/T_D = N_D 10^{\left(\frac{I_{0-ES} - N_{0-ES}}{10} \right)} \quad (3)$$

4 Calculation of uplink interference into the GSO network

The following four Steps are performed to calculate the degradation to the GSO network uplink receive system noise temperature from one non-GSO satellite system:

Step U1: calculate the maximum pfd spectral density at the GSO space station ($pfd_{U-non-GSO-max}$) from a single non-GSO transmitting earth station. Note that this equation assumes that the non-GSO transmitting earth station is located at the minimum distance from a GSO satellite. It should be noted that at this earth station location, the resultant separation angle will be greater than the minimum separation angle that is used in the analysis. However, since even the minimum separation angle will be greater than 40° , the reduction in the side lobe gain of the non-GSO earth station's antenna is unlikely to fully compensate for reduction in interference path loss. Thus, this will probably overestimate the interference that is received.

$$pfd_{U-non-GSO-max} = e.i.r.p_{non-GSO-max} - 10 \log (4\pi(35\,786)^2) \quad (4)$$

Step U2: calculate the interfering signal PSD, I_{0-SS} , at the GSO space station antenna output:

$$I_{0-SS} = pfd_{U-non-GSO-max} + G_{GSO-SS-max} + 10 \log \left(\frac{\lambda^2}{4\pi} \right) \quad (5)$$

where λ is the wavelength.