



Recommendation ITU-R S.1673-1
(01/2010)

**Methodologies for the calculation
of the worst-case interference levels
from a non-geostationary HEO-type
fixed-satellite service system into
geostationary fixed-satellite service
satellite networks operating in the
10 to 30 GHz frequency bands**

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Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R S.1673-1

Methodologies for the calculation of the worst-case interference levels from a non-geostationary HEO-type fixed-satellite service system* into geostationary fixed-satellite service satellite networks operating in the 10 to 30 GHz frequency bands

(Question ITU-R 231/4)

(2003-2010)

Scope

This Recommendation provides methodologies to assess worst-case interference levels from a non-geostationary HEO-type system operating in the fixed-satellite service into a geostationary satellite network operating in the same service. The methodologies described in this Recommendation are applicable in the 10 to 30 GHz frequency bands. These methodologies use worst-case assumptions that overestimate the actual levels of interference.

The ITU Radiocommunication Assembly,

considering

- a) that many FSS frequency bands may be used for both GSO and non-GSO satellite networks in accordance with the Radio Regulations (RR);
- b) that non-GSO FSS systems shall not cause unacceptable interference to GSO FSS networks in accordance with the provisions of the RR;
- c) that in some FSS frequency bands, the level of acceptable interference from non-GSO systems to GSO networks has been quantified in terms of $\text{epfd}\uparrow$ and $\text{epfd}\downarrow$ limits and those limits are specified in RR Article 22 for particular frequency bands;
- d) that administrations may need to calculate the interference levels, including the worst-case interference level, that are generated from a non-GSO system into any GSO network in the FSS frequency bands other than those for which $\text{epfd}\uparrow$ and $\text{epfd}\downarrow$ limits are specified in the RR;
- e) that methodologies have been developed considering the provisions of the RR for the evaluation of interference levels from non-GSO systems to GSO networks;
- f) that the methodologies referred to in *considering* e) were based mainly on low- and medium-altitude circular orbit non-GSO FSS systems and a more simplified methodology might be appropriate for the calculation of interference from non-GSO HEO-type FSS systems (see Note 1), in which limited portions of the orbit are used as “active” arcs for operation which are spatially separated from the GSO, into GSO FSS networks,

recognizing

- a) that Section II of RR Article 22 addresses “Control of interference to geostationary-satellite systems”,

* See Recommendation ITU-R S.1758 for a characterization of high Earth orbit type (HEO-type) systems in the FSS.

noting

- a) that studies on implementation of non-GSO HEO-type FSS systems in the 10 to 30 GHz frequency range have also been made;
- b) that in frequency bands other than those referred to in *considering* c) above it is up to the affected administrations to determine whether a non-GSO FSS system is causing unacceptable interference to a GSO FSS network;
- c) that the non-GSO HEO-type FSS systems referenced in *noting* a) are characterized by the use of limited operational or “active” arcs that, while differing in size from system-to-system, are spatially separated from the GSO,

recommends

- 1 that the worst-case interference level, from a non-GSO HEO-type FSS system described in the *noting* above into a GSO FSS network, be calculated by considering that all co-frequency non-GSO satellites in such a system that are transmitting towards the same geographic region of the Earth are producing their maximum pfd levels;
- 2 that for non-GSO HEO-type FSS systems in some frequency bands between 10 and 30 GHz where $\text{epfd}\uparrow$ and $\text{epfd}\downarrow$ limits are not specified within the RR (see Note 2), 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 these non-GSO HEO-type FSS systems (see Notes 3, 4 and 5);
- 3 that for non-GSO HEO-type FSS systems in some frequency bands between 10 and 30 GHz where $\text{epfd}\uparrow$ and $\text{epfd}\downarrow$ limits are specified within the RR (see Note 2), the methodology in Annex 2 to this Recommendation should be used for the calculation of the worst-case levels of interference into GSO FSS networks from these non-GSO HEO-type FSS systems (see Notes 4 and 6).

NOTE 1 – For the purpose of this Recommendation a satellite system using either of the following orbits is categorized as a non-geostationary HEO-type satellite system. Satellites in the system are operational only in the active arc:

- an orbit with an eccentricity of at least 0.05, an inclination between 35° and 145°, an apogee of at least 18 000 km, and a period that is the geosynchronous period (23 h, 56 min) multiplied by m/n where m and n are integers (the ratio m/n may be less than, equal to, or greater than one); or
- a circular orbit (with an eccentricity of at most 0.005), with the geosynchronous period (23 h, 56 min) and an inclination between 35° and 145°.

NOTE 2 – The frequency bands for which $\text{epfd}\uparrow$ and $\text{epfd}\downarrow$ limits are specified in the RR are 10.7-13.25, 13.75-14.5, 17.3-18.6, 19.7-20.2, 27.5-28.6 and 29.5-30.0 GHz.

NOTE 3 – The methodology in Annex 1 is complementary to the methodology in Recommendation ITU-R S.1560 for the 4 and 6 GHz frequency bands.

NOTE 4 – The methodologies in this Recommendation use worst-case assumptions that overestimate the actual levels of interference. For some systems, especially those with variations in beam pointing, frequency, power, path loss, and/or number of satellites simultaneously illuminating a service area, the overestimation could be considerable. More refined analysis techniques could be used to assess the interference profiles in more detail in order to determine realistic interference levels and their associated probabilities of occurrence.

NOTE 5 – Annex 3 gives an example of the use of the methodology in *recommends* 2 for a non-GSO HEO-type FSS system.

NOTE 6 – Annex 4 gives an example of the use of the methodology in *recommends* 3 for a non-GSO HEO-type FSS system.

Annex 1

Methodology for the calculation of the worst-case interference levels from a non-geostationary HEO-type FSS system into geostationary FSS networks operating in some frequency bands between 10 and 30 GHz where $\text{epfd}\uparrow$ and $\text{epfd}\downarrow$ limits are not specified in the RR

The following methodology should be used for the calculation of the potential levels of interference from the co-frequency operation of non-GSO HEO-type FSS systems into GSO FSS networks operating in some frequency bands between 10 and 30 GHz where $\text{epfd}\uparrow$ and $\text{epfd}\downarrow$ limits are not specified in the RR.

1 Data concerning the non-GSO FSS system

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

Space-to-Earth transmissions

- $\theta_{D-\min}$: Minimum angular separation at a GSO FSS earth station between the LoS to the active transmitting non-GSO satellites and the LoS to the associated GSO satellite (degrees).
- $\text{pfd}_{D-\text{non-GSO-max}}$: Maximum pfd at the location on the Earth's surface of the earth station of the GSO FSS network caused by transmissions from each non-GSO satellite in the constellation ($\text{dB(W/(m}^2 \cdot \text{Hz))}$).
- N_D : Maximum number of co-frequency non-GSO satellites in a satellite system using HEOs transmitting towards the same geographic region of the Earth. An indication of the number of such satellites as a function of the percentage of time is needed.

Earth-to-space transmissions

- $\theta_{U-\min}$: Minimum angular separation at a transmitting non-GSO FSS earth station between the LoS to the GSO orbit and the LoS to the associated non-GSO satellite (degrees).
- $\text{e.i.r.p.}_{\text{non-GSO-max}}$: Maximum off-axis e.i.r.p. spectral density from the transmitting non-GSO earth station corresponding to the minimum angular separation ($\theta_{U-\min}$) (dB(W/Hz)).
- N_U : Maximum number of co-frequency transmitting non-GSO earth stations in a satellite system using HEOs 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 FSS network

The following information is required concerning the GSO network:

Receive earth station sensitivity

$G_{GSO-ES-max}$: The assumed maximum off-axis gain of the GSO receive earth station in the direction corresponding to the minimum angular separation (θ_{D-min}) of the non-GSO satellite when it is actively transmitting (dBi).

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).

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 (m).

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:

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