

RECOMMENDATION ITU-R S.1647

Methodology to determine the worst-case interference among certain types of non-GSO FSS systems in situations where no in-line interference exists

(Question ITU-R 231/4)

(2003)

The ITU Radiocommunication Assembly,

considering

- a) that, by adopting equivalent power flux-density (epfd) limits in certain frequency bands in Article 22 of the Radio Regulations, the introduction of FSS systems employing non-GSO satellites has been facilitated;
- b) that the use of the certain types of non-GSO orbit (see Note 1) typically results in the active arc being limited to distinct “windows” in the sky, and that these windows are often distinctly separate from the windows of other certain types of non-GSO orbit (see Note 1) systems thereby ensuring that no in-line interference exists;
- c) that in-line interference may also be avoided when the “windows” overlap, if it is possible to adjust the relative phasing of the two systems such that satellites from different systems do not simultaneously appear in the overlapping window;
- d) that it could be useful to determine whether in-line events occur or not in order to study the sharing between non-GSO FSS systems;
- e) that, in addition, it could be useful to identify the worst-case interference levels that occur when there are no in-line events;
- f) that, if worst-case interference is unacceptable, a full statistical characterization of the interference is required,

recommends

- 1 that the methodology in Annex 1 to be used by administrations for the calculation of worst-case co-directional interference between certain types of non-GSO (see Note 1) systems considered here in situations where no in-line interference exists;
- 2 that the methodology in Annex 3 to be used by administrations to confirm that in-line events do not occur between certain types of non-GSO (see Note 1) systems concerned.

NOTE 1 – The certain types of non-GSO systems covered in this Recommendation are those whose orbits fall into the following categories:

- 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°.

Annex 1

Methodology to calculate the worst-case co-directional interference between certain types of non-GSO FSS systems in situations where no in-line interference exists

The following methodology should be used to calculate the interference between non-GSO FSS systems operating co-frequency, where no in-line interference situations exist. This methodology is limited to co-directional transmission case.

The calculations shown in this Annex are to be performed for values of time, t , which generate all possible combinations of orbital locations of operating satellites as per Annex 2. The calculations are to be performed in accordance with the following sequence;

- to determine whether in-line events occur (see Annex 3);
- to identify the worst-case interference levels that occur when there are no in-line events.

Because certain types of non-GSO systems have repeating ground tracks and the limited portions of them are the active arcs, the number of these combinations is significantly smaller than that of interference between LEO/MEO type non-GSO systems.

In this Annex, the methodology to calculate the interference between one type of non-GSO-satellite system α and the other type of non-GSO-satellite system β is described.

1 Data concerning non-GSO system α

The following information is required for the calculation of interference between the non-GSO systems.

Earth-to-space transmissions of non-GSO system α

- $\theta_{U-min (NGSO\alpha)}$: minimum angular separation at the active earth station of non-GSO system α between the line-of-sight (LoS) to its associated satellite and the LoS of the satellite of non-GSO system β (degrees) (see Fig. 2a)).
- $\phi_{U-min (NGSO\alpha)}$: minimum angular separation at an active satellite of non-GSO system α between the LoS to the earth station of non-GSO system β and the LoS to the associated earth station of non-GSO system α (degrees) (see Fig. 2b)). For the transmitting earth station antenna, Recommendation ITU-R S.465 or ITU-R S.580 provides reference in this respect.
- $PFD_{U-NGSO\alpha-max}$: maximum pfd at the satellite of non-GSO system α caused by transmissions from the earth station of non-GSO system α (dB(W/(m² · Hz))).
- $PFD_{U-NGSO\alpha-\beta}$: maximum pfd at the satellite of non-GSO system β caused by transmissions from the earth station of non-GSO system α (dB(W/(m² · Hz))).
- $N_{U-NGSO\alpha-ES}$: maximum number of co-frequency earth stations of non-GSO system α transmitting towards the same satellites. (An indication of the number of such earth stations as a function of the percentage of time is needed.)

These values mentioned above can be obtained from the methodology described in Annex 2.

Receiving satellite sensitivity of non-GSO FSS system α . (The information required for the calculation of interference from non-GSO system β to non-GSO system α .)

- $G_{NGSO\alpha-S-max}$: the assumed maximum gain of the receiving satellite of non-GSO system α in a direction of the earth station of non-GSO system α (dBi).
- $G_{NGSO\alpha-S-\beta}$: the assumed maximum off-axis gain of the receiving satellite of non-GSO system α in the direction corresponding to the minimum angular separation ($\Phi_{U-min}(NGSO\alpha)$) of the earth station of non-GSO system β (dBi). For the receiving satellite of non-GSO FSS system, Recommendation ITU-R S.672 provides a reference in this respect.
- $T_{U-NGSO\alpha}$: assumed clear-sky receive system noise temperature (including receive antenna noise) of the receiving satellite of non-GSO system α (K).

Space-to-Earth transmissions of non-GSO system α

- $\theta_{D-min}(NGSO\alpha)$: minimum angular separation at the earth station of non-GSO system α between the LoS to its associated satellite and the LoS to the transmitting satellite of non-GSO system β (degrees) (see Fig. 1b)).
- $\Phi_{D-min}(NGSO\alpha)$: minimum angular separation at an active satellite of non-GSO system α between the LoS to an earth station of non-GSO system β and the LoS to the associated earth station of non-GSO system α (degrees) (see Fig. 1a)). For the transmitting space station antenna, Recommendation ITU-R S.672 provides a reference in this respect.
- $PFD_{D-NGSO\alpha-max}$: maximum pfd at the location on the Earth's surface of the earth station of non-GSO system α caused by transmissions from the satellite of non-GSO system α in the constellation (dB(W/(m² · Hz))).
- $PFD_{D-NGSO\alpha-\beta}$: maximum pfd at the location on the Earth's surface of the earth station of non-GSO system β caused by transmissions from the satellite of non-GSO system α in the constellation (dB(W/(m² · Hz))).
- $N_{D-NGSO\alpha-S}$: maximum number of co-frequency satellites of non-GSO system α 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.)

These values mentioned above can be obtained from the methodology described in Annex 2.

Receiving earth station (ES) sensitivity of non-GSO FSS system α . (The information required for the calculation of interference from non-GSO system β to non-GSO system α .)

- $G_{NGSO\alpha-ES-max}$: the assumed maximum gain of the receiving earth station of non-GSO system α in a direction corresponding to the satellite of non-GSO system α (dBi).

- $G_{NGSO\alpha-ES-\beta}$: the assumed maximum off-axis gain of the receiving earth station of non-GSO system α in the direction corresponding to the minimum angular separation ($\theta_{D-min(NGSO\beta)}$) of the satellite of non-GSO system β when it is actively transmitting (dBi). For the receiving earth station of non-GSO FSS system, Recommendation ITU-R S.465 or ITU-R S.580 provides a reference in this respect.
- $T_{D-NGSO\alpha}$: assumed clear-sky receive system noise temperature (including receive antenna noise) of the receiving earth station of non-GSO system α . To err on the conservative side this need not include degradations caused to the overall link resulting from the uplink or from other internal or external sources of interference (K).

2 Data concerning non-GSO system β

The following information is required for the calculation of interference between the non-GSO systems.

Receive satellite sensitivity of non-GSO system β . (The information required for the calculation of interference from non-GSO FSS system α to non-GSO system β .)

- $G_{NGSO\beta-S-max}$: the assumed maximum gain of the satellite of non-GSO system β in a direction of the earth station of non-GSO system β (dBi).
- $G_{NGSO\beta-S-\alpha}$: the assumed maximum off-axis gain of the satellite of non-GSO system β in the direction corresponding to the minimum angular separation ($\phi_{U-min(NGSO\beta)}$) of the earth station of non-GSO system α (dBi). For the receiving satellite of a non-GSO FSS system, Recommendation ITU-R S.672 provides a reference in this respect.
- $T_{U-NGSO\beta}$: assumed clear-sky receive system noise temperature (including receive antenna noise) of the receiving satellite of non-GSO system β (K).

Earth-to-space transmissions of non-GSO system β

- $\theta_{U-min(NGSO\beta)}$: minimum angular separation at the earth stations of non-GSO system β between the LoS to its associated satellite and the LoS to the receiving satellite of non-GSO system α (degrees) (see Fig. 2b)).
- $\phi_{U-min(NGSO\beta)}$: minimum angular separation at the satellite of non-GSO system β between the LoS to the earth station of non-GSO system α and the LoS to the associated earth station of non-GSO system β (degrees) (see Fig. 2a)). For the transmitting earth station antenna, Recommendation ITU-R S.465 or ITU-R S.580 provides a reference in this respect.
- $PFD_{U-NGSO\beta-max}$: maximum pfd at the satellite of non-GSO system β caused by transmissions from the earth station of non-GSO system β ($\text{dB(W/(m}^2 \cdot \text{Hz))}$).
- $PFD_{U-NGSO\beta-\alpha}$: maximum pfd at the satellite of non-GSO system α caused by transmissions from the earth station of non-GSO system β ($\text{dB(W/(m}^2 \cdot \text{Hz))}$).
- $N_{U-NGSO\beta-ES}$: maximum number of co-frequency earth stations of non-GSO system β transmitting towards the same satellites. (An indication of the number of such earth stations as a function of the percentage of time is needed.)

Receive earth station sensitivity of non-GSO system β . (The information required for the calculation of interference from the non-GSO system α to non-GSO FSS system β .)

- $G_{NGSO\beta-ES-max}$: the assumed maximum gain of the earth station of non-GSO system β in the direction corresponding to the satellite of non-GSO system β (dBi).
- $G_{NGSO\beta-ES-\alpha}$: the assumed maximum off-axis gain of the earth station of non-GSO system β in the direction corresponding to the minimum angular separation ($\theta_{D-min(NGSO\alpha)}$) of the satellite of non-GSO system α when it is actively transmitting (dBi). For the receiving earth station of non-GSO FSS system, Recommendation ITU-R S.465 provides a reference in this respect.
- $T_{D-NGSO\beta}$: assumed clear-sky receive system noise temperature (including receive antenna noise) of the non-GSO system β downlink. To err on the conservative side this need not include degradations caused to the overall link resulting from the uplink or from other internal or external sources of interference (K).

Space-to-Earth transmissions of non-GSO system β

- $\theta_{D-min(NGSO\beta)}$: minimum angular separation at the earth station of non-GSO system β between the LoS to its associated satellite and the LoS in the direction to the transmitting satellite of non-GSO system α and its associated satellite (degrees) (see Fig. 1a)).
- $\varphi_{D-min(NGSO\beta)}$: minimum angular separation at an active satellite of non-GSO system β between the LoS to the earth station of non-GSO system α and the LoS to the associated earth station of non-GSO system β (degrees) (see Fig. 1b)). For the transmitting space station antenna, Recommendation ITU-R S.672 provides a reference in this respect.
- $PFD_{D-NGSO\beta-max}$: maximum pfd at the location on the Earth's surface of the earth station of non-GSO system β caused by transmissions from the satellite in the constellation of non-GSO system β (dB(W/(m² · Hz))).
- $PFD_{D-NGSO\beta-\alpha}$: maximum pfd at the location on the Earth's surface of non-GSO system α caused by transmissions from the satellite in the constellation of non-GSO system β (dB(W/(m² · Hz))).
- $N_{D-NGSO\beta-S}$: maximum number of co-frequency satellites of non-GSO system β 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.

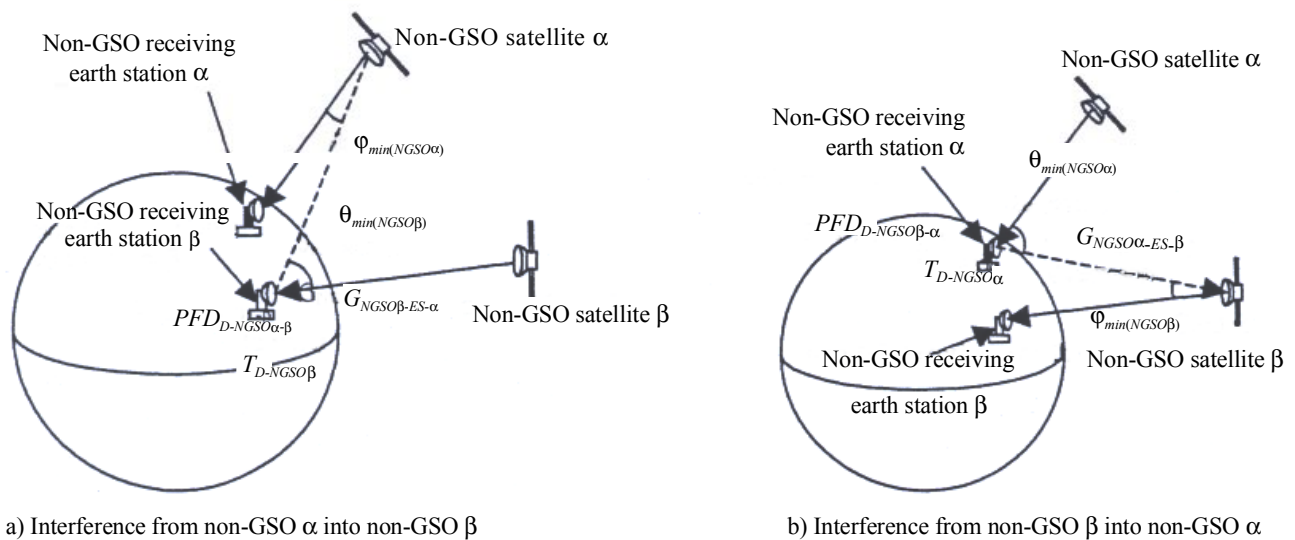
These values mentioned above can be obtained from the methodology described in Annex 2.

3 Interference geometry

Figure 1 shows the downlink interference geometry described in Section 2. Fig. 1a) shows the interference geometry for the calculation of the interference from the satellite of non-GSO system α to the receive earth station of non-GSO system β . Fig. 1b) shows the interference geometry for the calculation of the interference from the satellite of non-GSO system β to the receiving earth station of non-GSO system α .

FIGURE 1

The interference geometry for calculation of interference between non-GSO system α and non-GSO system β (downlink)

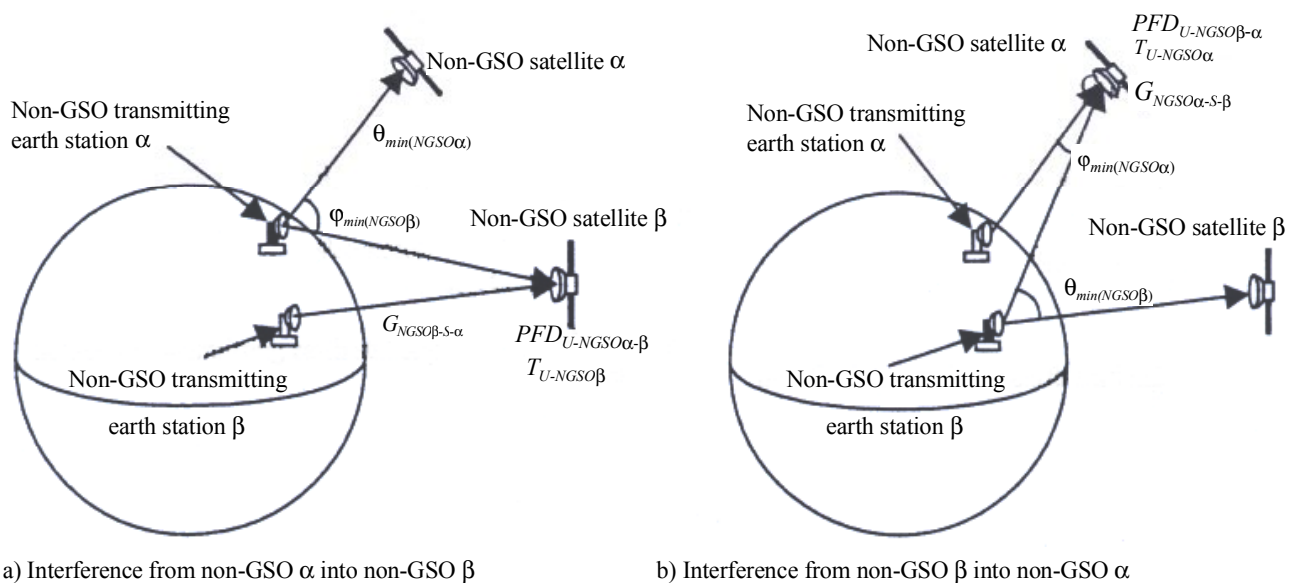


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Figure 2 shows the uplink interference geometry described in Section 2. Fig. 2a) shows the interference geometry for the calculation of the interference from the earth station of non-GSO system α to the receive satellite of non-GSO system β . Fig. 2b) shows the interference geometry for the calculation of the interference from the earth station of non-GSO system β to the receiving satellite of non-GSO system α .

FIGURE 2

The interference geometry for calculation of interference between non-GSO system α and non-GSO system β (uplink)



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