

Recommendation ITU-R S.2157-0

(09/2023)

S Series: Fixed-satellite service

Procedures for the evaluation of interference from any non-geostationary-satellite system into a global set of the generic geostationary-satellite reference links in the frequency bands 37.5-39.5 GHz (space-to-Earth), 39.5-42.5 GHz (space-to-Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space)

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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Series of ITU-R Recommendations

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P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

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

Electronic Publication
Geneva, 2023

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RECOMMENDATION ITU-R S.2157-0

Procedures for the evaluation of interference from any non-geostationary-satellite system into a global set of the generic geostationary-satellite reference links in the frequency bands 37.5-39.5 GHz (space-to-Earth), 39.5-42.5 GHz (space-to-Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space)

(2023)

NOTE – Approval of this Recommendation should not be construed that ITU-R expressed any views, directly or indirectly, in favour of any of the Methods included in the CPM Report on WRC-23 agenda item 7, Topic G¹.

Scope

This Recommendation provides procedures for assessment of compliance for any non-geostationary-satellite orbit (non-GSO) system with No. 22.5L of the Radio Regulations (RR) in order to ensure the protection of geostationary-satellite orbit (GSO) satellite networks in the frequency bands 37.5-39.5 GHz (space-to-Earth), 39.5-42.5 GHz (space-to-Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space).

Keywords

Single-entry permissible interference, link performance degradation, adaptive coding and modulation, generic GSO reference links, availability and spectral efficiency, precipitation fade

Abbreviations/Glossary

ACM Adaptive coding and modulation

CDF Cumulative distribution function

EPFD Equivalent power flux-density

PDF Probability density function

Related ITU Recommendations, Reports

Recommendation ITU-R P.618 – Propagation data and prediction methods required for the design of Earth-space telecommunication systems

Recommendation ITU-R S.1503 – Functional description to be used in developing software tools for determining conformity of non-geostationary-satellite orbit fixed-satellite service systems or networks with limits contained in Article 22 of the Radio Regulations

Recommendation ITU-R S.2131 – Method for the determination of performance objectives for satellite hypothetical reference digital paths using adaptive coding and modulation

The ITU Radiocommunication Assembly,

considering

a) that geostationary-satellite orbit (GSO) and non-geostationary-satellite orbit (non-GSO) fixed-satellite service (FSS) networks may operate in the frequency bands 37.5-39.5 GHz (space-to-Earth), 39.5-42.5 GHz (space-to-Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space);

¹ Note by the Secretariat: This Note will be removed after WRC-23.

b) that WRC-19 has adopted Nos. **22.5L** and **22.5M**, which contain single-entry and aggregate limits for non-GSO FSS systems in the frequency bands 37.5-39.5 GHz (space-to-Earth), 39.5-42.5 GHz (space-to-Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space) to protect GSO networks operating in the same frequency bands,

recognizing

a) that the ITU Radiocommunication Sector (ITU-R) has developed a methodology, contained in Recommendation ITU-R S.1503, that results in the equivalent power flux-density (epfd) generated by any non-GSO FSS system considered;

b) that, in accordance with calculations utilizing Recommendation ITU-R S.1503, verification of the worldwide epfd interference of any non-GSO system can be carried out by a set of generic GSO reference link budgets having characteristics that encompass global GSO network deployments that are independent of any specific geographic locations;

c) that Resolution **769 (WRC-19)** addresses the protection of GSO networks from aggregate emissions from non-GSO systems,

recommends

that the procedures specified in Annexes 1 and 2 should be considered to assess compliance for any non-GSO system with No. **22.5L** of the Radio Regulations in order to ensure the protection of GSO satellite networks in the frequency bands 37.5-39.5 GHz (space-to-Earth), 39.5-42.5 GHz (space-to-Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space).

Annex 1

Procedure for use by the Bureau in checking compliance of non-GSO FSS systems with No. **22.5L** of the Radio Regulations in the frequency bands 37.5-39.5 GHz (space-to Earth), 39.5-42.5 GHz (space-to-Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space)

This Annex provides an overview of the process to validate compliance with the single-entry permissible interference of a non-GSO satellite system into GSO satellite networks using the generic GSO reference link parameters in Annex 1 to Resolution **770 (WRC-19)** and the interference impact using the latest version of Recommendation ITU-R S.1503. The procedure to determine compliance with the single-entry permissible interference relies on the following principles.

Principle 1: The two time-varying sources of link performance degradation considered in the verification are link fading (from rain) using the characteristics of the generic GSO reference link described in Resolution **770 (WRC-19)** and interference from a non-GSO system. The total C/N in the reference bandwidth for a given carrier is:

$$C/N = C/(N_T + I) \quad (1)$$

where:

C : wanted signal power (W) in the reference bandwidth, which varies as a function of fades and also as a function of transmission configuration

N : noise power (W) in the reference bandwidth

N_T : total system noise power (W) in the reference bandwidth

I : time-varying interference power (W) in the reference bandwidth generated by other networks.

Principle 2: The calculation of spectral efficiency is focused on satellite systems utilizing adaptive coding and modulation (ACM) by calculating the throughput degradation as a function of C/N , which varies depending on the propagation and interference impacts on the satellite link over the long term.

Principle 3: During a fading event in the downlink direction the interfering carrier would be attenuated by the same amount as the wanted carrier under the assumption of co-polarized carriers. This principle results in slight underestimation of the impact of the downlink interference.

Implementation of verification algorithm

The generic GSO reference link parameters described in Annex 1 to Resolution **770 (WRC-19)** should be used as described in the following algorithm to determine if a non-GSO FSS network is compliant with No. **22.5L** of the Radio Regulations.

Within the parametric analysis there are a range of values for each of the following parameters in section 2 of Tables 1 and 2 in Annex 1 to Resolution **770 (WRC-19)**:

- e.i.r.p. density variation
- elevation angle (degrees)
- rain height (m)
- latitude (degree)
- 0.01% rain rate (mm/hr)
- height of Earth station (m)
- Earth station noise temperature (K) or satellite noise temperature (K), as appropriate.

A set of generic GSO reference links should be created using one per service case identified in section 1 of Tables 1 and 2 in Annex 1 to Resolution **770 (WRC-19)**, and one value from each of the parametric analysis parameters in section 2 of Tables 1 and 2. Then, with this set of generic GSO reference links, the following process should be undertaken:

*The frequency that should be used in the following steps except for step 2 are 37.5 GHz for the space to Earth direction and 47.2 GHz in the Earth to space direction. The frequency f_{GHz} , that should be used in step 2 is determined by applying the methodology in Recommendation ITU-R S.1503 to the non-GSO system filed frequencies and the frequency bands for which No. **22.5L** of the Radio Regulations applies*

For each of the generic GSO reference links

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Step 0: Determine if this generic GSO reference link is valid and select the appropriate threshold.

If the generic GSO reference link is valid, then

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Step 1: Derive the probability density function (PDF) of the rain fade to use in the convolution

Step 2: Recommendation ITU-R S.1503 should be used to derive the PDF of the EPFD from the non-GSO FSS system

Step 3: Perform a modified convolution (space-to-Earth) or convolution (Earth-to-space) with the PDF of the rain fade and the PDF of the EPFD. This convolution yields a PDF of C/N and $C/(N_T+I)$

Step 4: Use the C/N and $C/(N_T+I)$ PDFs to determine compliance with No. 22.5L of the Radio Regulations

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If the non-GSO system under examination is found to comply with No. 22.5L of the Radio Regulations with respect to all generic GSO reference links, then the result of the evaluation is favourable finding otherwise it is an unfavourable finding.

Each of these steps are described further in Attachments 1 and 2 to this Annex for the space-to-Earth and Earth-to-space procedures, respectively.

Attachment 1 to Annex 1

Steps to be applied in the space-to-Earth direction in the frequency bands 37.5-39.5 GHz and 39.5-42.5 GHz to determine compliance with No. 22.5L of the Radio Regulations

By applying the following steps, the single-entry interference impact from a non-GSO system on the availability and spectral efficiency of a generic GSO reference link is determined. The generic GSO reference link parameters of Annex 1 to Resolution 770 (WRC-19) are used, considering all possible parametric permutations, in conjunction with the worst-case geometry (WCG) epfd output of the latest version of Recommendation ITU-R S.1503. The output of Recommendation ITU-R S.1503 is a set of interference statistics that a non-GSO system creates. These interference statistics are then used to determine the effect of the interference into each generic GSO reference link.

Step 0: Verification of the generic GSO reference link and selection of C/N threshold

The following steps should be used to determine if the generic GSO reference link is valid and if so, which of the thresholds $\left(\frac{C}{N}\right)_{Thr,i}$ should be used. It is assumed that $R_s = 6\,378.137$ km,

$R_{geo} = 42\,164$ km, $k_{dB} = -228.6$ dB(J/K) and $c = 2.99792458 \times 10^5$ km/s.

Note that the term “cumulative distribution function” is meant to include the concept of the complementary cumulative distribution function depending upon context.

- 1) Calculate the peak gain of the Earth station antenna in dBi using:
for $20 \leq D/\lambda \leq 100$

$$G_{max} = 20 \log \left(\frac{D}{\lambda} \right) + 7.7 \quad \text{dBi}$$

for $D/\lambda > 100$