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Recommendation ITU-R S.2179-0

(10/2026)

S Series: Fixed-satellite service

Functional description to be used in developing software tools for determining conformity of non-geostationary-satellite orbit fixed-satellite service systems or networks in Q/V band (37.5-39.5 GHz, 39.5-42.5 GHz, 47.2-50.2 GHz and 50.4-51.4 GHz) with criteria contained in No. 22.5L of the Radio Regulations

Foreword

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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.2179-0*

Functional description to be used in developing software tools for determining conformity of non-geostationary-satellite orbit fixed-satellite service systems or networks in Q/V band (37.5-39.5 GHz, 39.5-42.5 GHz, 47.2-50.2 GHz and 50.4-51.4 GHz) with criteria contained in No. 22.5L of the Radio Regulations

(2026)

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

Abbreviation/Glossary

ACM	Adaptive coding and modulation
CCDF	Complementary cumulative distribution function
CDF	Cumulative distribution function
EPFD	Equivalent power flux-density
PDF	Probability distribution function

Related ITU-R Recommendation, 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

Recommendation ITU-R S.2157 – 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)

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* This Recommendation should be brought to the attention of the relevant Radiocommunication Study Groups and Working Parties.

The ITU Radiocommunication Assembly,

considering

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),

recognizing

a) that WRC-19 has adopted Radio Regulations 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;

b) 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;

c) that, in accordance with calculations utilizing Recommendation ITU-R S.1503, computation 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;

d) that the ITU-R has developed procedures, specified in Recommendation ITU-R S.2157, for assessment of compliance for any non-GSO system with No. **22.5L** of the Radio Regulations (RR) 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);

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

f) that Resolution **770 (Rev.WRC-23)** addresses the application of Article **22** of the Radio Regulations to the protection of geostationary fixed-satellite service and broadcasting-satellite service networks from the single-entry emissions of non-GSO fixed-satellite service systems in the frequency bands 37.5-39.5 GHz, 39.5-42.5 GHz, 47.2-50.2 GHz and 50.4-51.4 GHz,

recommends

1 that the functional description specified in Annex 1 should be used to develop software tools calculating the increase in unavailability and the decrease in the average spectral efficiency of the reference GSO space-to-Earth links produced by non-GSO FSS systems links emissions in the space to Earth direction;

2 that the functional description specified in Annex 2 should be used to develop software tools calculating the increase in unavailability and the decrease in the average spectral efficiency of the reference GSO Earth-to-space links produced by a non-GSO FSS systems emissions in the Earth-to-space direction;

3 that the software referenced in *recommends* 1 and 2 should be used to evaluate compliance with the limits contained in No. **22.5L** of the Radio Regulations.

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Annex 1

Recommendation ITU-R S.2157 Attachment 1 to Annex 1 implementation for use by the Radiocommunication Bureau in checking compliance of non-GSO FSS systems with RR No. 22.5L in Q/V band in the space-to-Earth direction

Detailed parameters are needed by the Radiocommunication Bureau in support of calculating the impact of a single non-GSO system into reference GSO valid space to Earth links following the methodology in Annex 1 of Recommendation ITU-R S.2157. The parameters are contained in Annex 1 to Resolution **770 (Rev.WRC-23)**. This Annex focuses on the specific values of such parameters needed to fulfil that requirement. The determination of such values is explained in §§ A1.1.1.1 to A1.1.1.10 and are provided in the Excel file attached in § A1.8. Those parameters are for each GSO reference link:

– The Earth station peak gain
– The free space path losses
– The carrier to noise ratio
– The margin available for precipitation
– The Rain attenuation curves
– The GSO reference link availability without interference
– The GSO reference link average spectral efficiency without interference
– The GSO reference link availability limit
– The GSO reference link average spectral efficiency limit
– The list of valid links.

A1.1 Determination of the GSO valid links and selection of the lowest $(C/N)_{threshold}$

The purpose of Recommendation ITU-R S.2157 is to calculate the single-entry interference impact from a non-GSO system on the availability and average spectral efficiency of a set of generic GSO links.

The first step is to determine the list of valid links presented in Table 1 of Annex 1 to Resolution **770 (Rev.WRC-23)** following the methodology in Annex 1 to Recommendation ITU-R S.2157. The C/N for the GSO generic reference link is calculated and compared with the $(C/N)_{threshold}$ and the difference is the rain attenuation margin (A_{rain}). The validity of the GSO is determined in two steps: If A_{rain} is less than a parameter called A_{min} set to 3 dB, the reference link is not valid. For the remaining valid links, the percentage of time associated to A_{rain}, p_{rain}, is calculated with Recommendation ITU-R S.2157 Annex 2. If p_{rain} is not within the range 0.01% to 10%, the GSO generic reference link is not valid in accordance with Step 0-10 of Attachment 1 to Annex 1 to Recommendation ITU-R S.2157.

There are four user cases for which the GSO parameters are given in Table 1 of Annex 1 to Resolution **770 (Rev.WRC-23)** (see below). All parameters are combined (users, e.i.r.p. density variation, elevation angle, C/N thresholds) and the wanted signal power (C) to the total noise power (Nt) is calculated using formulas in Step 0. The combination of all parameters leads to a generation of 36 links per user, 144 links in total without combining the rain attenuation parameters.

1	Generic GSO reference link parameters - service					Parameter
	Link type	User #1	User #2	User #3	Gateway	
1.1	e.i.r.p. density (dBW/MHz)	44	44	40	36	$eirp$
1.2	Equivalent antenna diameter (m)	0.45	0.6	2	9	D_m
1.3	Bandwidth (MHz)	1	1	1	1	B_{MHz}
1.4	ES antenna gain pattern	S.1428	S.1428	S.1428	S.1428	
1.5	Additional link losses (dB) This field includes non-precipitation impairments	3	3	3	3	L_o
1.6	Additional noise contribution including margin for inter-system interference (dB)	2	2	2	2	M_{0inter}
1.7	Additional noise contribution including margin for intra-system interference (dB) and non-time varying sources	1	1	1	1	M_{0intra}

2	Generic GSO reference link parameters - parametric analysis	Parametric cases for evaluation						
2.1	e.i.r.p. density variation	−3, 0, +3 dB from value in 1.1						$\Delta eirp$
2.2	Elevation angle (degree)	20			55		90	ε
2.3	Rain height (m) for specified latitude in item 2.4	5 000	3 950	1 650	5 000	3 950	5 000	h_{rain}
2.4	Latitude (1) (degree *N*)	0	±30	±61.8	0	±30	0	Lat
2.5	ES noise temperature (K)	340						T
2.6	0.01% rain rate (mm/hr)	10, 50, 100						$R_{0.01}$
2.7	Height of ES above mean sea level (m)	0, 500, 1 000						h_{ES}
2.8	Threshold *C*/*N* (dB)	−2.5, 2.5, 5, 10						$\left(\frac{C}{N}\right)_{Thr,i}$
2.9	Probability of non-zero rain attenuation	10						$p_{max}(\%)$

NOTE – For items 2.2, 2.3 and 2.4, these three groups of data are be considered as unique sets of data to be used in the larger, overall set of total possible permutations. For example, 20 degrees of elevation angle will consider three different latitudes of 0, 30 and 61.8 degrees while 90 degrees of elevation will only consider a latitude of 0 degrees and one possible rain height 5 km. The above parameters are chosen as representative propagation parameters for purposes of calculations of precipitation fade statistics. These precipitation fades are representative of other geographic locations.

(1) Latitude is evaluated as a single value representing the absolute value of the latitude.

A1.1.1 GSO generic reference link validity

In the following, as indicated in Recommendation ITU-R S.2157, the frequency 37.5 GHz is used except for § A1.3. The frequency that should be used in § A1.3 is determined by applying the methodology in Recommendation ITU-R S.1503 to the minimum frequency defined in the SRS grp table associated with the frequency assignment of the non-GSO system under consideration.

A1.1.1.1 Earth station peak gain (Step 0-1)

The peak gain of earth stations *(*Gr_{max}) is computed for each of the 144 links. It corresponds to column F in the "*C*/*N* and Arain" tab of the Excel file in § A1.8.

A1.1.1.2 Slant distance (Step 0-2)

The slant distance (dkm) is computed for each of the 144 links. It corresponds to column I in the "*C*/*N* and Arain" tab of the Excel file in § A1.8.

A1.1.1.3 Free-space path loss (Step 0-3)

The free-space loss (Lfs) is computed for each of the 144 links. It corresponds to column J in the "*C*/*N* and Arain" tab of the Excel file in § A1.8.

A1.1.1.4 Wanted signal power in a reference bandwidth including additional link losses (Step 0-4)

The wanted signal power (C) in the reference bandwidth accounting for additional link losses is computed for each of the 144 links. It corresponds to column L in the "*C*/*N* and Arain" tab of the Excel file in § A1.8.

A1.1.1.5 Total noise power in a reference bandwidth (Step 0-5)

The total noise power (NT) in the reference bandwidth is computed for each of the 144 links. It corresponds to column Q in the "*C*/*N* and A_{rain}" tab of the Excel file in § A1.8.

A1.1.1.6 Margin available for precipitation (A_{rain}) (Step 0-6)

The margin available for precipitation (A_{rain}) is computed for each of the 144 links. It corresponds to column T in the "*C*/*N* and A_{rain}" tab of the Excel file in § A1.8. The margin available for precipitation for each link is derived considering a range of $(C/N)_{threshold}$ in column S from −2.5 to 10 dB.

A1.1.1.7 Comparison of A_{rain} with A_{min} (Step 0-7)

For each link, A_{rain} obtained in § A1.1.1.6 is compared with a minimum margin (A_{min}) set to 3 dB in Recommendation ITU-R S.2157-0. If A_{rain} is lower than A_{min} (A note in ITU-R Recommendation S.2157-0 indicates that A_{min} = 3 dB), the link is not valid (*Step 0-7*). The result of the comparison is indicated in column U of the "*C*/*N* and Arain" tab of the Excel file in § A1.8. A "1" in column U indicates that A_{rain} is higher or equal to 3 dB and a "0" indicates that A_{rain} is lower than A_{min}.

A1.1.1.8 Percentage of time p_{raini} for which the rain attenuation is greater than A_{rain} (Step 0-8 and Step 0-9)

When combining the rain rate ($R_{0.01}$), ES height (h_{ES}), rain height (h_{rain}), ES latitude (Lat), elevation angle (Ɛ), 54 combinations of rain fade are obtained. They are presented in the "Rain" tab of the Excel file in § A1.8. For each of these 54 rain fade conditions, the values of p_1 and p_{min} available in Table 1 of Annex 2 to Recommendation ITU-R S.2157 have also been included.

The probability of non-zero rain attenuation is set to p_{max} = 10% as per 2.9 of Table 1 of Annex 1 to Resolution **770 (Rev.WRC-23)**.

The complementary cumulative distribution functions providing the probability to exceed a certain value of precipitation fade are computed for the 54 combinations with the precipitation model in Annex 2 to Recommendation ITU-R S.2157, which is based on Recommendation ITU-R P.618-13. The result is in the "Arain CCDF" tab of the Excel file in § A1.8. For each link with a link margin greater than $A_{\min}$, the percentage of time, p_{raini} associated to A_{rain} is computed using the above CCDFs (*Step 0-9*) and available in the "P_Rain" tab.

A1.1.1.9 Comparison of p_{raini} value with the range of 10% to 0.01% (Step 0-10)

For each GSO reference link under the relevant rain conditions, the associated p_{raini} is compared with values ranging from 10% to 0.01%. For rain conditions for which p_{raini} is outside this range, the reference GSO link is considered not valid and the cell corresponding to those rain conditions in the columns V to BW are set to 0 for the lines corresponding to that reference GSO link in the "P_Rain" tab of the Excel file in § A1.8.

A1.1.1.10 Selection of the lowest $(C/N)_{threshold}$ (Step 0-11)

If at least one $(C/N)_{threshold}$ among −2.5, 2.5, 5 and 10 dB meets the criteria in §§ A1.1.1.1 to A1.1.1.9, the lowest $(C/N)_{threshold}$ is used in the analysis and a value of "0" is set in the cells that do not correspond to the lowest $(C/N)_{threshold}$ for the lines of the same GSO link (same user, same e.i.r.p. density variation, same elevation, but with a higher $(C/N)_{threshold}$) in columns V to BW of the "P_Rain" tab of the Excel file in § A1.8.

A1.1.2 Example of a GSO valid links and summary of the GSO valid links and selection of the lowest $(C/N)_{threshold}$

For the case of link #1 where A_{rain} = 7.62 dB, under the rain conditions specified in the Excel spreadsheet in § A1.8 (Rain index: 1, Ɛ: 20, h_{rain} = 5 000, Lat:0, $R_{0.01\%}$:10, h_{ES}:0), the percentage of time (p_{rain}) during which the C/N threshold is not met is 0.558% and is within the range 10% to 0.01%. This link corresponds to a C/N threshold of −2.5 dB which is the lowest value within the range −2.5 to 10 dB. As the elevation of the link corresponds to the elevation of the rain condition index 1, the link is valid.

The same reasoning is applied to the 54 rain conditions for link #1 and is repeated for the 144 links.

A1.2 Generation of the precipitation fade complementary cumulative distribution function and probability distribution function

Step 1 describes the methodology to generate of the precipitation fade PDF.

In this section, the precipitation complementary cumulative distribution functions (CCDFs) are computed and transformed into the probability distribution functions (PDF) in order to apply the bins methodology from Recommendation ITU-R S.2157 and calculate the unavailability and spectral efficiency. The precipitation CCDF will be composed of N bins spaced by 0.01 dB.[1]

The complementary cumulative distribution functions providing the probability to exceed a certain value of precipitation fade have been generated under 54 rain conditions with the precipitation model described in Annex 2 to Recommendation ITU-R S.2157, which is based on Recommendation ITU-R P.618-13 (§ A1.1.1.9 and the "Arain CCDF" tab of the Excel file in § A1.8).

The GSO reference link #1 under rain condition #1 precipitation fade CCDF is presented in Fig. A1-1.

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[1] Recommendation ITU-R S.2157 indicates that the bins width should be 0.1 dB. However, it is proposed to use 0.01 dB as the error introduced by a 0.1 dB bins width does not seem negligeable compared to the criteria (3% of unavailability increase and 3% average spectrum efficiency degradation).

FIGURE A1-1

GSO reference link #1 under rain condition #1 precipitation fade CCDF
(A=7.619 dB and associated P_{rain1} = 0.558%)

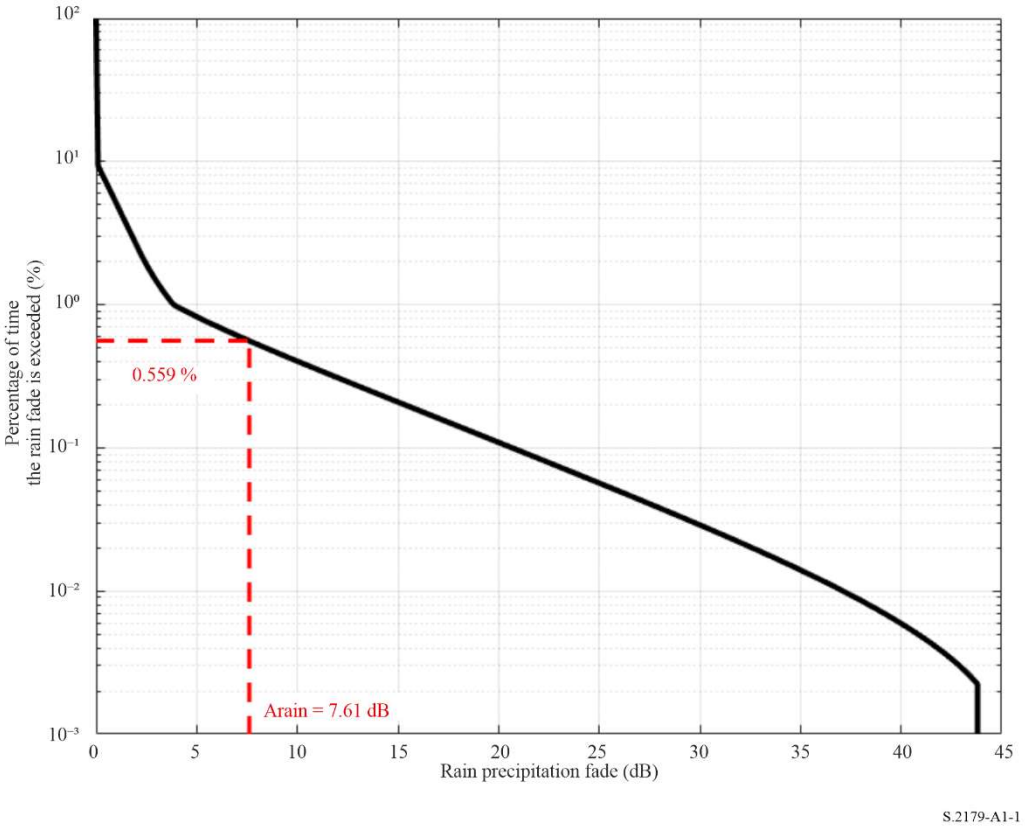
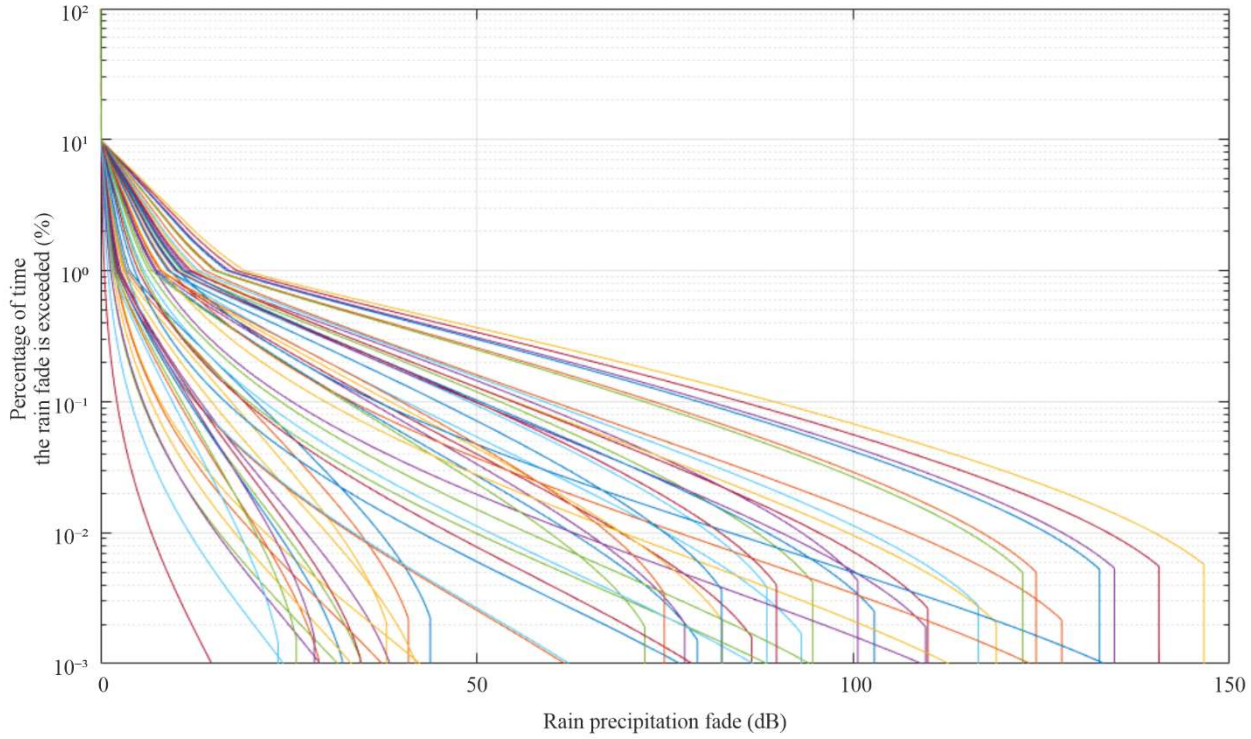


Figure A1-1 also indicates the percentage of time for which the rain attenuation is greater than 7.619 dB. Figure A1-2 provides the precipitation fade CCDFs for all 54 combinations of rain.

FIGURE A1-2

GSO reference links precipitation fade CCDFs with modified attenuation values for small percentages (54 GSO rain conditions)



When computing the PDFs from the CCDFs, two impulse functions have been implemented, to have a complete PDF. The first impulse function is added at the maximum precipitation fade and the second impulse function is added at the precipitation fade of 0 dB in order to obtain 100% when doing the summation of the probabilities of the PDF. This is in line with the methodology explained in Annex 2 to Recommendation ITU-R S.2157.

A1.3 Generation of epfd complementary cumulative distribution function and probability distribution function

As indicated in Recommendation ITU-R S.2157, Recommendation ITU-R S.1503 should be used to determine the epfd CCDF from the non-GSO FSS parameters and the frequency, dish size and Earth station antenna gain pattern. The epfd CCDF will be calculated at the worst-case geometry determined with the worst-case geometry algorithm from Recommendation ITU-R S.1503. The epfd CCDF will be composed of *N* bins spaced by 0.01 dB.

The epfd CCDF should then be converted into a PDF as follows:

1) Ensure that the percentage of time of the first bin of the epfd CCDF is 100% and the last bin is 0%.

2) For each of the bins, convert this CCDF into a PDF of epfd:

$$PDF_n = \frac{CCDF_n - CCDF_{n+1}}{100} \quad \text{for } n < N$$
$$PDF_n = 0 \quad \text{for } n = N$$

with: $\sum_{n=1}^{N} PDF_n = 1$.

Each bin of the epfd CCDF contains the probability that the epfd is at least X dB W/m^2 in the reference bandwidth. Each bin of the PDF contains the probability that the epfd is between X and X + 0.01 dB.

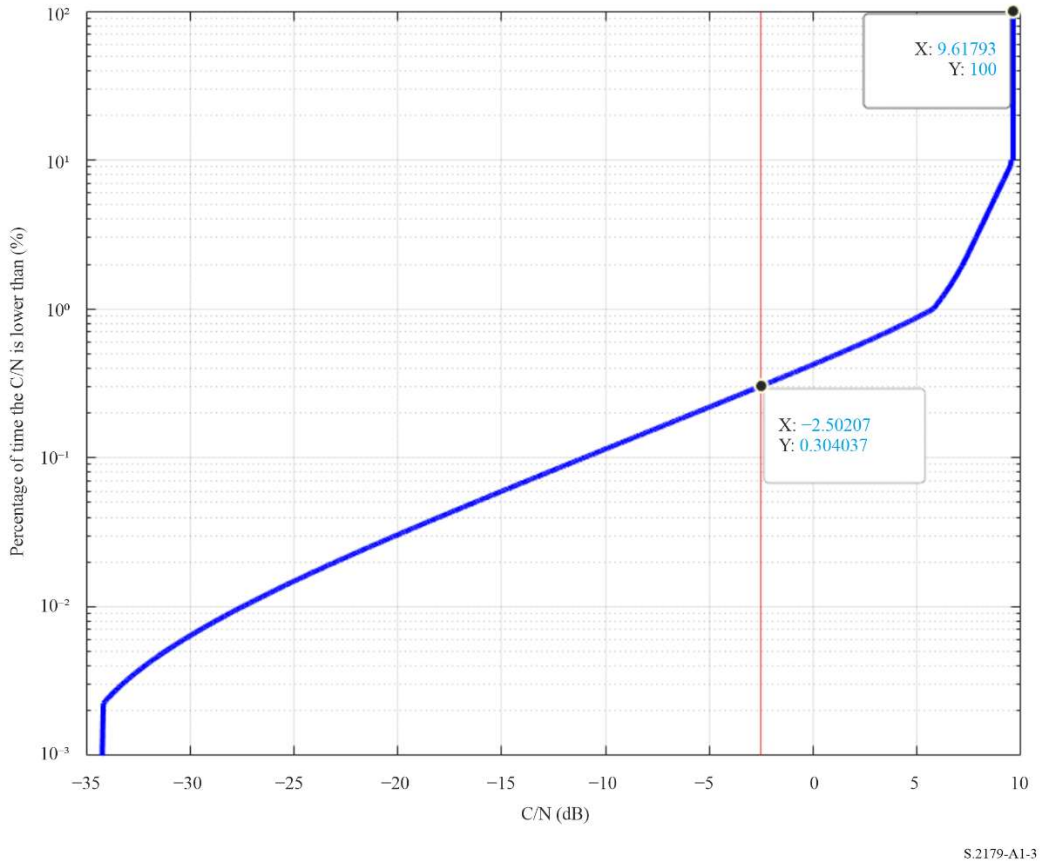
A1.4 *C/N* cumulative distribution function and probability distribution function

The *C/N* cumulative distribution function (described in Step 3[2]), under rain conditions without interference, is generated from the precipitation fade CCDFs transformed into PDFs in § A1.2 for all GSO valid links.

Figure A1-3 provides the result for link #37 under rain condition #1.

FIGURE A1-3

GSO reference link #37 under rain condition #1 *C/N* CDF assuming precipitation without interference (*C/N* = 9.61 dB with no precipitation and *C/N* threshold is equal to −2.5 dB)



A1.5 Spectral efficiency (SE) cumulative distribution function and probability distribution function

The spectral efficiency PDF is needed to perform Step 4B.

The spectral efficiency PDFs are computed for all valid links based on the *C/N* PDFs in § A1.4 with precipitation and without interference.

C/N is converted to a spectral efficiency via equation (3) of Recommendation ITU-R S.2131:

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[2] The *C/N* cumulative distribution function described in Step 3 does not consider *Mointer,* the maximum *C/N* value is shifted by *Mointer* dB compared to the *C/N* value indicated in column R of the "*C/N* and Arain" tab of the Excel file in § A1.8.

$SE(C/N) = 0$, for $C/N < -8.9$

$SE(C/N) = 0.030337\ C/N + 0.376643$, for $-8.9 \leq C/N < -2.5$

$SE(C/N) = 0.5933 + 0.1415\ C/N + 0.0096\ C/N^2$, for $-2.5 \leq C/N < 0$

$SE(C/N) = 0.5933 + 0.1388\ C/N + 0.003\ C/N^2$, for $0 \leq C/N < 25.02$

$SE(C/N) = 5.944$, for $C/N \geq 25.02$.

The SE versus C/N as per Recommendation ITU-R S.2131 is represented in Fig. A1-4.

FIGURE A1-4

Spectral efficiency versus *C/N*

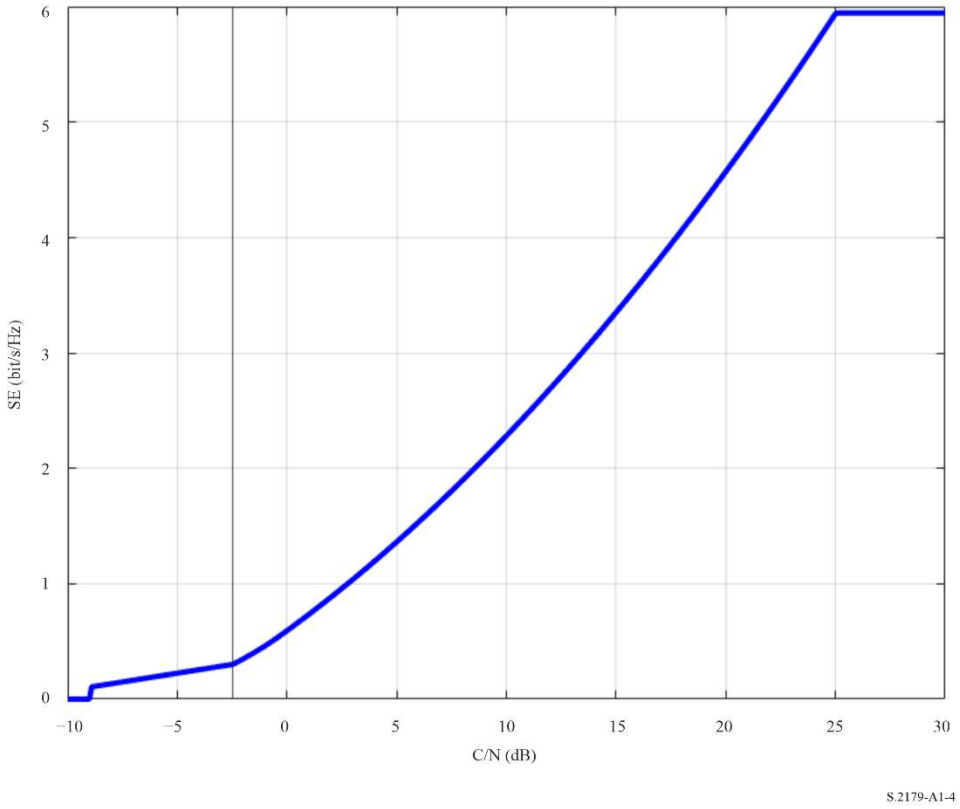
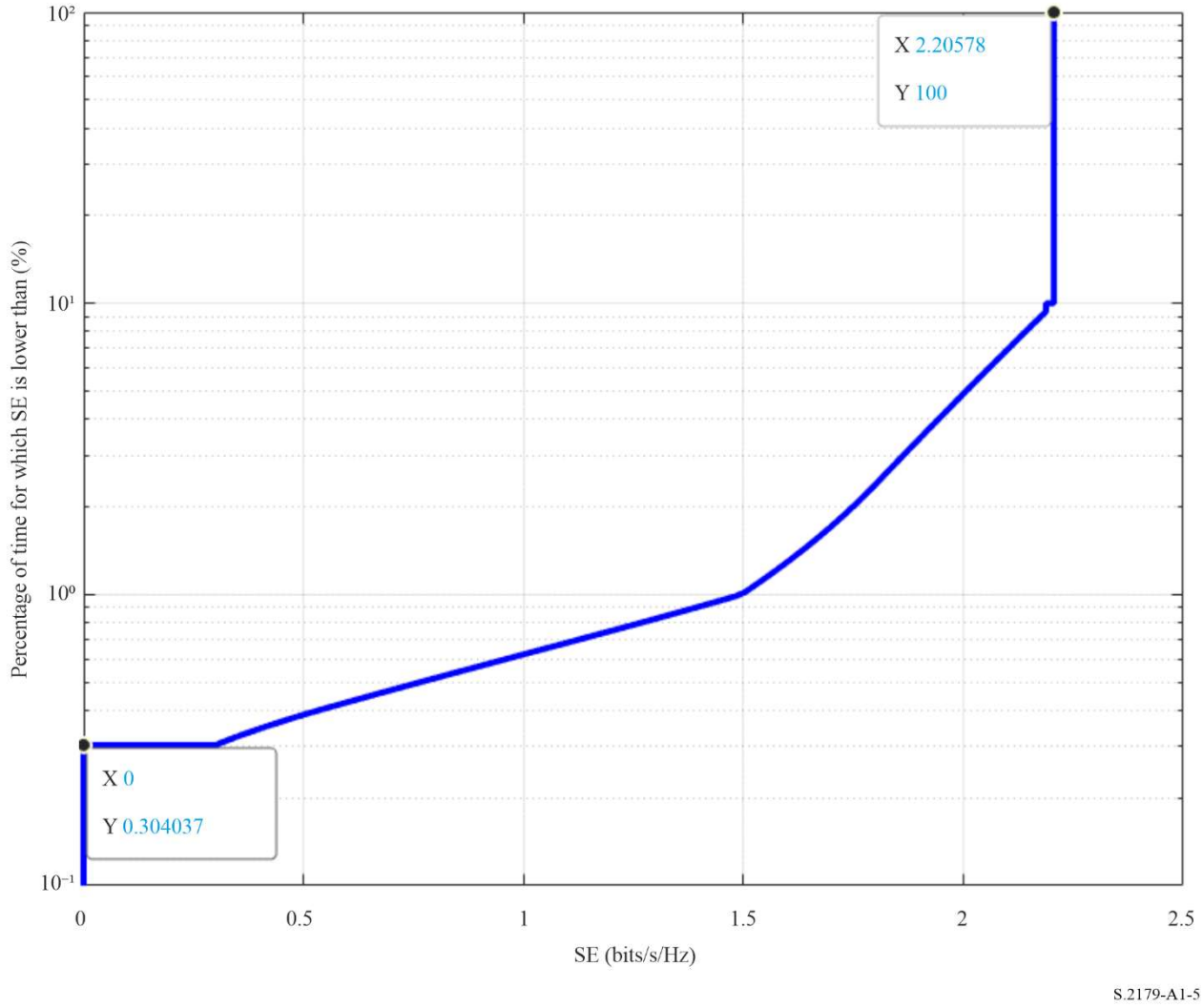


Figure A1-5 provides the result for link #37 and the rain condition number #1.

FIGURE A1-5

GSO reference link #37 under rain condition #1 *SE* CDF assuming precipitation and no interference (*SE* max is equal to 2.20578 bits/s/Hz without precipitation)



It should be noted that the spectral efficiency is set to 0 when C/N is lower than the $(C/N)_{threshold}$ as indicated in Step 4B. This corresponds to time percentage lower than 0.30404% in the case of link #37 and rain condition number #1.

A1.6 Spectral efficiency average (SE_R)

The spectral efficiency average (SE_R) is computed from the spectral efficiency PDFs in § A1.5 using the following equation under rain conditions and with no interference:

$$SE_R = \frac{\sum_{n=1}^{N}(SE_n \times P_n)}{\sum_{n=1}^{N} P_n}$$

where:

N : number of bins in the SE PDF

P_n : time percentage corresponding to a specific SE_n using the SE PDF from § A1.5. This is done for all SEs for which the associated C/N value is higher than the C/N threshold, as per Recommendation ITU-R S.2157.

The result is presented in the “SER_prain” tab in the Excel file in § A1.8.

A1.7 GSO link unavailability and average spectral efficiency limits

Step 4 indicates that the *C*/*N* and *C*/*(N+I)* distributions should be used to check the compliance with unavailability and the average spectral efficiency criteria in RR No. **22.5L**.

RR No. **22.5L** mentions that:

A non-GSO in FSS in Q/V bands shall not exceed:

– a single-entry increase of 3% of the time allowance for the *C*/*N* associated with the shortest percentage of time specified in the short-term performance objective of the generic GSO reference links;

and

– a single-entry permissible allowance of at most 3% reduction in the time-weighted average spectral efficiency calculated on an annual basis for the generic GSO reference links using ACM.

In view of RR No. **22.5L**, the methodology to determine the maximum level of interferer that will not cause interference to a GSO system will be studied considering two parameters:

– increase of link unavailability and its limit "UR_{I_Limit}" (see § A1.7.1);

– reduction of the average spectral efficiency and its limit "SE_{RI_Limit}" (see § A1.7.2).

A1.7.1 GSO link unavailability limit

The maximum unavailability (U_{RI_Limit}) assuming the precipitation and the interference is computed in accordance with Step 4A:

$$U_{RI_Limit} = 1.03 \times U_R$$

For the case of GSO link #37 under rain condition #1 for which U_R is 0.30404%, an unavailability increase of 3% would lead to a U_{RI_Limit} equal to 0.31316% in the presence of a non-GSO system interferer.

The result of U_{RI_limit} for all valid links is presented in the "URI_limit" tab in the Excel file in § A1.8.

A1.7.2 GSO link average spectral efficiency limit

The minimum average spectral efficiency (SE_{RI_Limit}) assuming the precipitation and the interference is computed in accordance with *Step 4B*:

$$SE_{RI_Limit} = (1 - 0.03) \times SE_R$$

For the case of GSO link #37 under rain condition #1 the average spectrum efficiency SE_R is 2.17131 bits/s/Hz and SE_{RI_Limit} is 2.10617 bits/s/Hz.

The result of SE_{RI_limit} for all valid links is presented in the "SERI_limit" tab in the Excel file in § A1.8.

A1.8 Excel file provided all specific values of input parameter to be used

Specific values of the detailed input parameters needed by the BR in support of calculating the impact of a single non-GSO system into reference GSO valid space to Earth links following the methodology in Attachment 1 to Annex 1 to Recommendation ITU-R S.2157 are provided in the attached Excel file at 37.5 GHz (Excel file Part 1).


Part 1.xlsx

A1.9 Example of interference calculation from a non-GSO system to generic GSO reference links

This example is based on a pre-existing filing example available within the ITU tool Gibc. It can be found in the folder epfd/Test of the Gibc installation folder. The files have been adapted to include the Q/V bands but the characteristics and masks of the system have not been modified.

A1.9.1 Non-GSO system parameters

TABLE A1-1

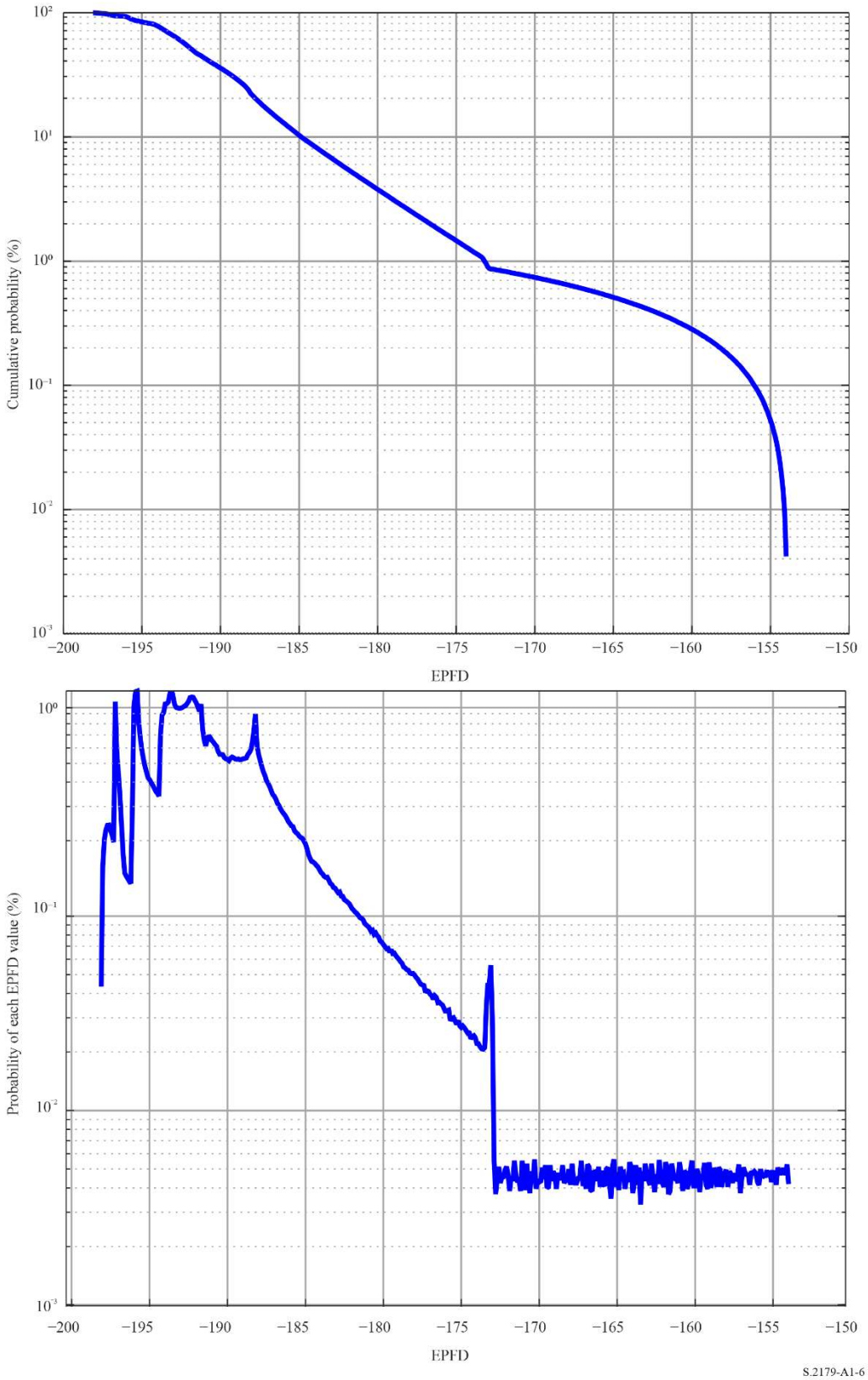
Number of planes	20
Satellites per plane	4
Inclination (degree)	53
Altitude (km)	1 469.155
Minimum elevation angle (degree)	10

A1.9.2 NGO satellite system epfd CCDF

The CCDF of epfd has been calculated using a GSO terminal of 0.6 m.

FIGURE A1-6

Non-GSO system epfd CCDF and PDF comuted for a GSO terminal of 0.6 m



NOTE – Recommendation ITU-R S.2157 contains the methodology. It indicates that "*Recommendation ITU-R S.1503 should be used to determine the epfd CDF from the non-GSO FSS parameters and the frequency, dish size and Earth station antenna gain pattern. The epfd CDF will be calculated at the worst-case geometry*

from Recommendation ITU-R S.1503. The epfd CDF will be composed of N bins spaced by 0.1 dB". It is therefore assumed that the GSO earth station diameter to be used when generating the epfd CCDF with Recommendation ITU-R S.1503 is the same as the one indicated in Resolution **770 (Rev.WRC-23)** (e.g. 60 cm for link #37).

In this example, only one GSO earth station with an antenna size of 0.6 m has been used to generate the epfd CDF, and has been validated against the valid links associated to the same antenna diameter.

A1.9.3 Calculation of U_{RI} and SE_{RI} including interference

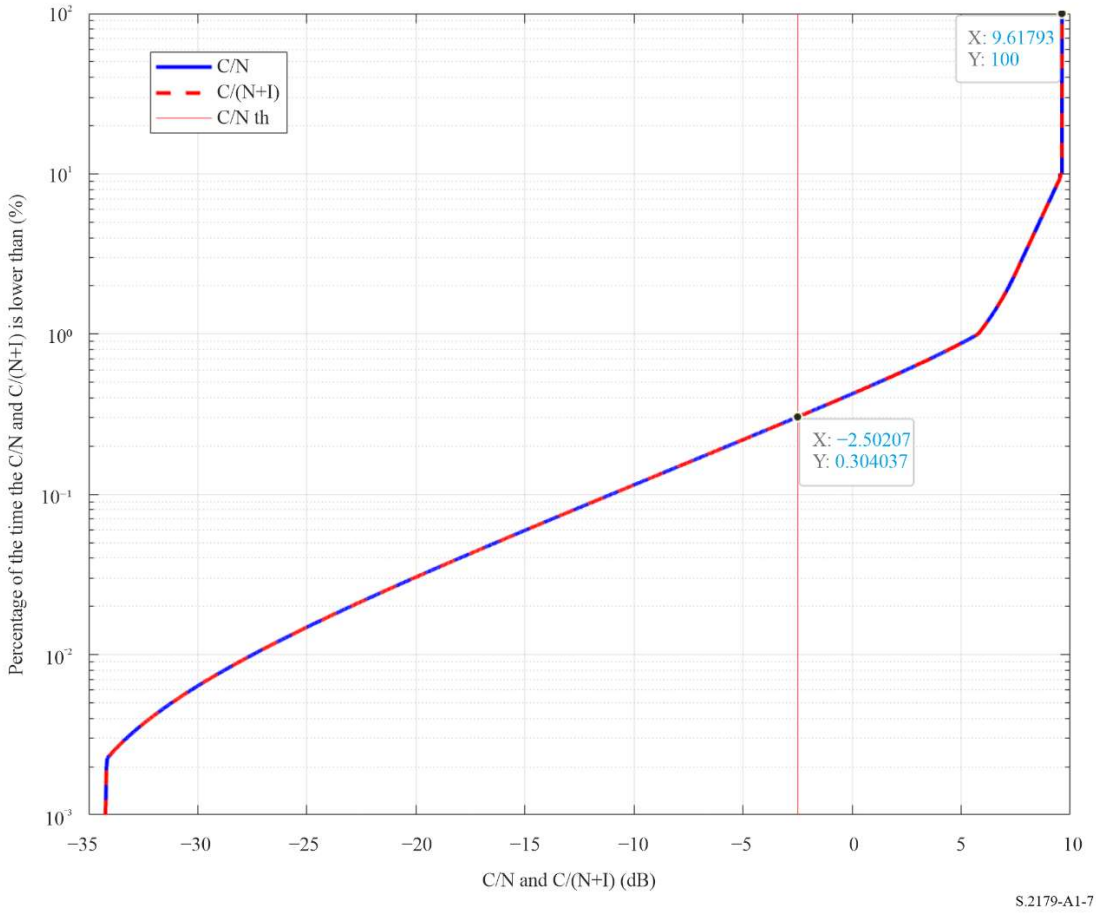
A1.9.3.1 Computation of *C*/*N*, *C*/(*N*+*I*) CDF and U_{RI}

Following the procedure explained in Step 4 of Recommendation ITU-R S.2157, and as explained for the *C*/*N* in § A1.4, the *C*/(*N*+*I*) PDFs are calculated using the bins methodology and the modified discrete convolution for all the valid links. The resulting U_{RI} are presented in the "URI" tab of the Excel file in § A1.8.

Figure A1-7 provides the result for link #37 under rain condition #1.

FIGURE A1-7

GSO reference link #37 under rain condition #1 *C*/(*N*+*I*) CDF assuming precipitation and interference (*C*/(*N*+*I*) = 9.61 dB with no precipitation and no interference, *C*/*N* threshold is equal to −2.5 dB)



U_{RI} is then calculated for each valid link as the sum of probabilities from all bins for which the *C*/(*N*+*I*) is lower than the *C*/*N* threshold. For link #37 under rain condition #1, U_{RI} is 0.30404%.

A1.9.3.2 Calculation of SE_{RI}

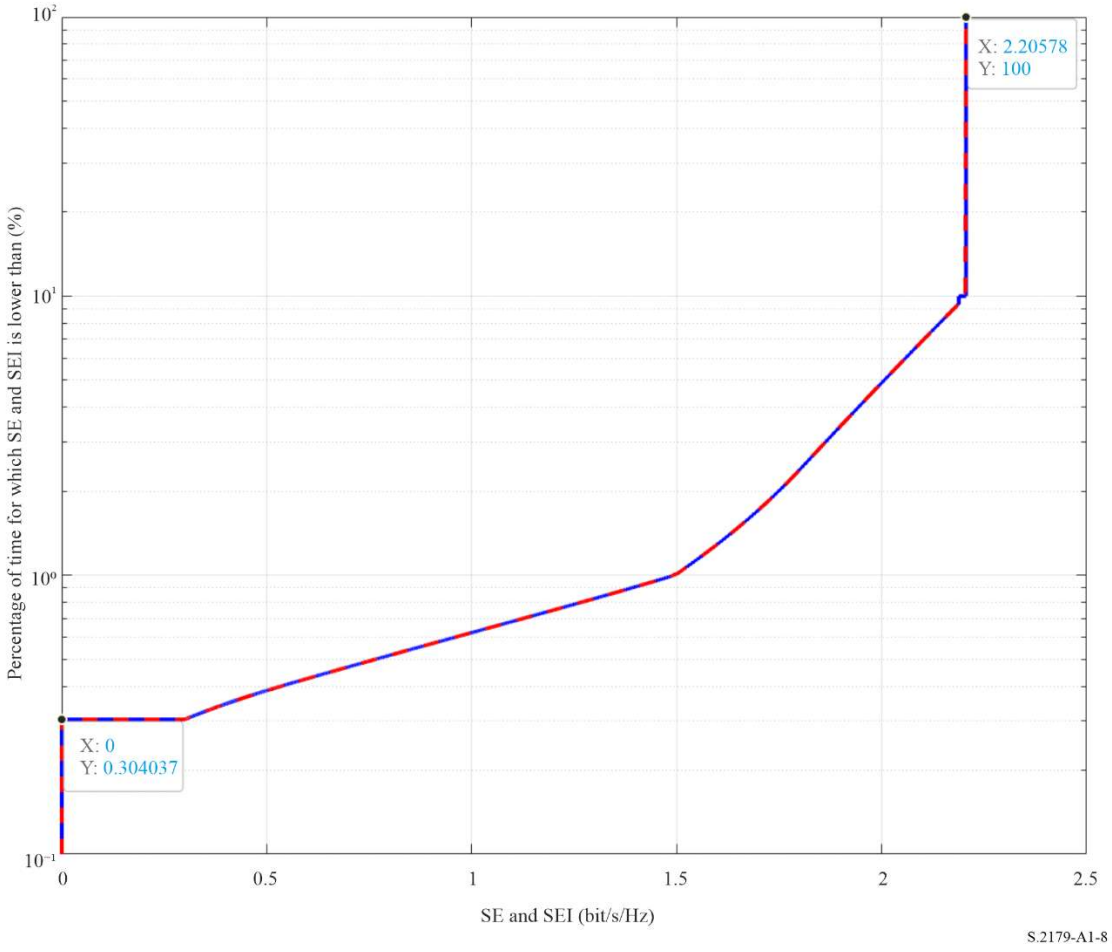
The spectral efficiency PDFs, as explained in § A1.5, is calculated for all valid links based on the *C*/(*N*+*I*) PDFs with precipitation and interference. The resulting SE_{RI} are presented in the "SERI" tab of the Excel file in § A1.8.

C/(*N*+*I*) is converted to a spectral efficiency via equations presented in § A1.5.

Figure A1-8 provides the result for link #37 and the rain condition number #1.

FIGURE A1-8

GSO reference link #37 under rain condition #1 SE and SEI CDF assuming precipitation and interference (SE is equal to 2.20578 bits/s/Hz without precipitation and interference)



The spectral efficiency is set to 0 when *C*/(*N*+*I*) is lower than the $(C/N)_{threshold}$ as indicated in Step 4B. This corresponds to time percentage lower than 0.30404% in the case of link #37 and rain condition number #1.

For the case of GSO link #37 under the rain conditions number #1 and considering interferences, the average spectrum efficiency SE_{RI} is 2.17129 bits/s/Hz.

A1.9.4 Non-GSO system compliance

For each link both conditions related to UR and SER have to be fulfilled:

$$U_{RI} \leq U_{R,Limit}$$

$$SE_{RI} \geq SE_{R,Limit}$$

In the tabs "URI" and "SERI", all valid links are in green and in red when the above conditions are not met.

For link #37 under rain condition #1, the interferences are acceptable as:

– URI is 0.30404% which is lower than the limit, which was set to 0.31316%.

– SERI is 2.17129 bits/s/Hz which is higher than the limit, which was set to 2.10617 bits/s/Hz.

Annex 2

Recommendation ITU-R S.2157-0 Attachment 2 to Annex 1 implementation for use by the Radiocommunication Bureau in checking compliance of non-GSO FSS systems with RR No. 22.5L in Q/V band in the Earth-to-space direction

A2.1 Determination of the GSO valid links and selection of the lowest $(C/N)_{threshold}$

The purpose of Recommendation ITU-R S.2157 is to calculate the single-entry interference impact from a non-GSO system on the availability and average spectral efficiency of a set of generic GSO links.

The first step is to determine the list of valid links presented in Table 2 of Annex 1 to Resolution **770 (Rev.WRC-23)** following the methodology in Annex 2 to Recommendation ITU-R S.2157. The C/N for the GSO generic reference link is calculated and compared with the $(C/N)_{threshold}$ and the difference is the rain attenuation margin (A_{rain}). The validity of the GSO is determined in two steps: If A_{rain} is less than a parameter called A_{min} set to 3 dB, the reference link is not valid. For the remaining valid links, the percentage of time associated to A_{rain}, p_{rain}, is calculated with Recommendation ITU-R S.2157 Annex 2. If p_{rain} is not within the range 0.01% to 10%, the GSO generic reference link is not valid in accordance with Step 0-10 of Attachment 2 to Annex 1 to Recommendation ITU-R S.2157.

There are four user cases for which the GSO parameters are given in Table 2 of Annex 1 to Resolution **770 (Rev.WRC-23)** (see below). All parameters are combined (users, e.i.r.p. density variation, elevation angle) and the wanted signal power (C) to the total noise power (Nt) is calculated using formulas in Step 0. The combination of all parameters leads to a generation of 72 links per user, 288 links in total without combining the rain attenuation parameters.

1	**Generic GSO reference link parameters - service**					
	Link type	Link #1	Link #2	Link #3	Gateway	
1.1	ES e.i.r.p. density (dBW/MHz)	49	49	49	60	*eirp*
1.2	Bandwidth (MHz)	1	1	1	1	B_{MHz}
1.3	Half-power beamwidth (degree)	0.2	0.3	1.5	0.3	
1.4	ITU-R S.672 sidelobe level (dB)	−25	−25	−25	−25	
1.5	Satellite antenna peak gain (dBi)	58.5	54.9	38.5	54.9	$G_{\max}$
1.6	Additional link losses (dB) This field includes non-precipitation impairments	4.5	4.5	4.5	4.5	L_o
1.7	Additional noise contribution including margin for inter-system interference (dB)	2	2	2	2	M_{0inter}
1.8	Additional noise contribution including margin for intra-system interference (dB) and non-time varying sources	1	1	1	1	M_{0intra}

2	**Generic GSO reference link parameters - parametric analysis**	**Parametric cases for evaluation**						
2.1	e.i.r.p. density variation	−6, 0, +6 dB from value in 1.1						$\Delta eirp$
2.2	Elevation angle (degree)	20			55		90	ε
2.3	Rain height (m) for specified latitude in item 2.4	5 000	3 950	1 650	5 000	3 950	5 000	h_{rain}
2.4	Latitude (1) (degree *N*)	0	±30	±61.8	0	±30	0	Lat
2.5	0.01% rain rate (mm/hr)	10, 50, 100						$R_{0.01}$
2.6	Height of ES above mean sea level (m)	0, 500, 1 000						h_{ES}
2.7	Satellite noise temperature (K)	500, 1 600						*T*
2.8	Threshold *C*/*N* (dB)	−2.5, 2.5, 5, 10						$\left(\frac{C}{N}\right)_{Thr,i}$
2.9	Probability of non-zero rain attenuation	10						$p_{max}(\%)$

NOTE – For items 2.2, 2.3 and 2.4, these three groups of data are be considered as unique sets of data to be used in the larger, overall set of total possible permutations. For example, 20 degrees of elevation angle will consider three different latitudes of 0, 30 and 61.8 degrees while 90 degrees of elevation will only consider a latitude of 0 degree and one possible rain height 5 km. The above parameters are chosen as representative propagation parameters for purposes of calculations of precipitation fade statistics. These precipitation fades are representative of other geographic locations.

(1) Latitude is evaluated as a single value representing the absolute value of the latitude.

A2.1.1 GSO generic reference link validity

In the following, as indicated in Recommendation ITU-R S.2157, the frequency 47.2 GHz is used except for § A2.3. The frequency that should be used for § A2.3 is determined by applying the

methodology in Recommendation ITU-R S.1503 to the minimum frequency defined in the SRS grp table associated with the frequency assignment of the non-GSO system under consideration.

A2.1.1.1 Slant distance (Step 0-1)

The slant distance (dkm) is computed for each of the 288 links. It corresponds to column G in the "*C*/*N* and Arain" tab of the Excel file in § A2.8.

A2.1.1.2 Free-space path loss (Step 0-2)

The free-space loss (Lfs) is computed for each of the 288 links. It corresponds to column H in the "*C*/*N* and Arain" tab of the Excel file in § A2.8.

A2.1.1.3 Wanted signal power in a reference bandwidth including additional link losses (Step 0-3)

The wanted signal power (C) in the reference bandwidth accounting for additional link losses is computed for each of the 288 links. It corresponds to column K in the "*C*/*N* and Arain" tab of the Excel file in § A2.8.

A2.1.1.4 Total noise power in a reference bandwidth (Step 0-4)

The total noise power (NT) in the reference bandwidth is computed for each of the 288 links. It corresponds to column P in the "*C*/*N* and Arain" tab of the Excel file in § A2.8.

A2.1.1.5 Margin available for precipitation (A_{rain}) (Step 0-5)

The margin available for precipitation (A_{rain}) is computed for each of the 288 links. It corresponds to column S in the "*C*/*N* and Arain" tab of the Excel file in § A2.8. The margin available for precipitation for each link is derived considering a range of $(C/N)_{\text{threshold}}$ from −2.5 to 10 dB.

A2.1.1.6 Comparison of A_{rain} with $A_{\min}$ (Step 0-6)

For each link, A_{rain} obtained in § A2.1.1.5 is compared with a minimum margin ($A_{\min}$) set to 3 dB in Recommendation ITU-R S.2157. If A_{rain} is lower than 3 dB, the link is not valid (Step 0-6). The result of the comparison is indicated in column T of the "*C*/*N* and Arain" tab of the Excel file in § A2.8. A "1" in column T indicates that A_{rain} is higher or equal to 3 dB and a "0" indicates that A_{rain} is lower than 3 dB.

NOTE – This section needs to be amended depending on WRC-23 decision regarding the lower value of p_{rain} in the framework of Resolution **770 (WRC-19)**.

A2.1.1.7 Percentage of time p_{raini} for which the rain attenuation is greater than A_{rain} (Step 0-7 and Step 0-8)

When combining the rain rate ($R_{0.01}$), ES height (h_{ES}), rain height (h_{rain}), ES latitude (Lat), elevation angle (Ɛ), 54 combinations of rain fade are obtained. They are presented in the "Rain" tab of the Excel file in § A2.8. For each of these 54 rain fade conditions, the values of p_1 and p_{min} available in Table 2 of Annex 2 to Recommendation ITU-R S.2157 have also been included.

The probability of non-zero rain attenuation is set to $p_{\max}$ = 10% as per 2.9 of Table 2 of Annex 1 to Resolution **770 (Rev.WRC-23)**.

The complementary cumulative distribution functions providing the probability to exceed a certain value of precipitation fade are computed for the 54 combinations with the precipitation model in Annex 2 to Recommendation ITU-R S.2157, which is based on Recommendation ITU-R P.618-13. The result is in the "Arain CDF" tab of the Excel file in § A2.8.

For each links with a link margin greater than 3 dB, the percentage of time, p_{raini} associated to A_{rain} is computed using the above CDFs (*Step 0-1 step 0-8*) and available in the "P_Rain" tab.

A2.1.1.8 Comparison of p_{raini} value with the range of 10% to 0.01% (Step 0-9)

For each GSO reference link under the relevant rain conditions, the associated p_{raini} is compared with values ranging from 10% to 0.01%. For rain conditions for which p_{raini} is outside this range, the reference GSO link is considered not valid and the cell corresponding to those rain conditions in the columns U to BV are set to 0 for the lines corresponding to that reference GSO link in the "P_rain" tab of the Excel file in § A2.8.

A2.1.1.9 Selection of the lowest $(C/N)_{threshold}$ (Step 0-10)

If at least one $(C/N)_{threshold}$ among −2.5, 2.5, 5 and 10 dB meets the criteria in §§ A2.1.1.1 to A2.1.1.8, the lowest $(C/N)_{threshold}$ is used in the analysis and a value of "0" is set in the cells which do not correspond to the lowest $(C/N)_{threshold}$ for the lines of the same GSO link (same user, same e.i.r.p. density variation, same elevation, but with a higher $(C/N)_{threshold}$) in columns U to BV of the "P_rain" tab of the Excel file in § A2.8.

A2.1.2 Example of a GSO valid links and summary of the GSO valid links and selection of the lowest $(C/N)_{threshold}$

For the case of link #1 where A_{rain} = 17.24 dB, under the rain conditions specified the Excel file in § A2.8 (Rain index: 1, Ɛ: 20, h_{rain} = 5 000, Lat:0, $R_{0.01\%}$:10, h_{ES}:0), the percentage of time (p_{rain}) is 0.301% during which the C/N threshold is not met and is within the range 10% to 0.01%. This link corresponds to a C/N threshold of −2.5 dB which is the lowest value within the range −2.5 to 10 dB. As the elevation of the link corresponds to the elevation of the rain condition index 1, the link is valid.

The same reasoning is applied to the 54 rain conditions for link #1 and is repeated for the 288 links.

A2.2 Generation of the precipitation fade cumulative distribution function

Step 1 describes the methodology to generate of the precipitation fade PDF.

In this section and the following ones, the precipitation complementary cumulative distribution functions (CCDFs) are computed and later transformed into probability distribution function (PDF) in order to apply the bins methodology from Recommendation ITU-R S.2157 and calculate the unavailability and spectral efficiency probabilities. The precipitation CCDF will be composed of N bins spaced by 0.01 dB[3].

The complementary cumulative distribution functions providing the probability to exceed a certain value of precipitation fade have been generated under 54 rain conditions with the precipitation model described in Annex 2 to Recommendation ITU-R S.2157, which is based on Recommendation ITU-R P.618-13 (§ A2.1.1.8 and the "Arain CDF" tab of the Excel file in § A2.8).

The GSO reference link #1 precipitation fade CCDF is presented in Fig. A2-1.

[3] Recommendation ITU-R S.2157 indicates that the bins width should be 0.1 dB. However, it is proposed to use 0.01 dB as the error introduced by a 0.1 dB bins width does not seem negligeable compared to the criteria (3% of unavailability increase and 3% average spectrum efficiency degradation).

FIGURE A2-1

GSO reference link #1 precipitation fade CCDF
(A = 17.24 dB and associated P_{rain1} = 0.301%)

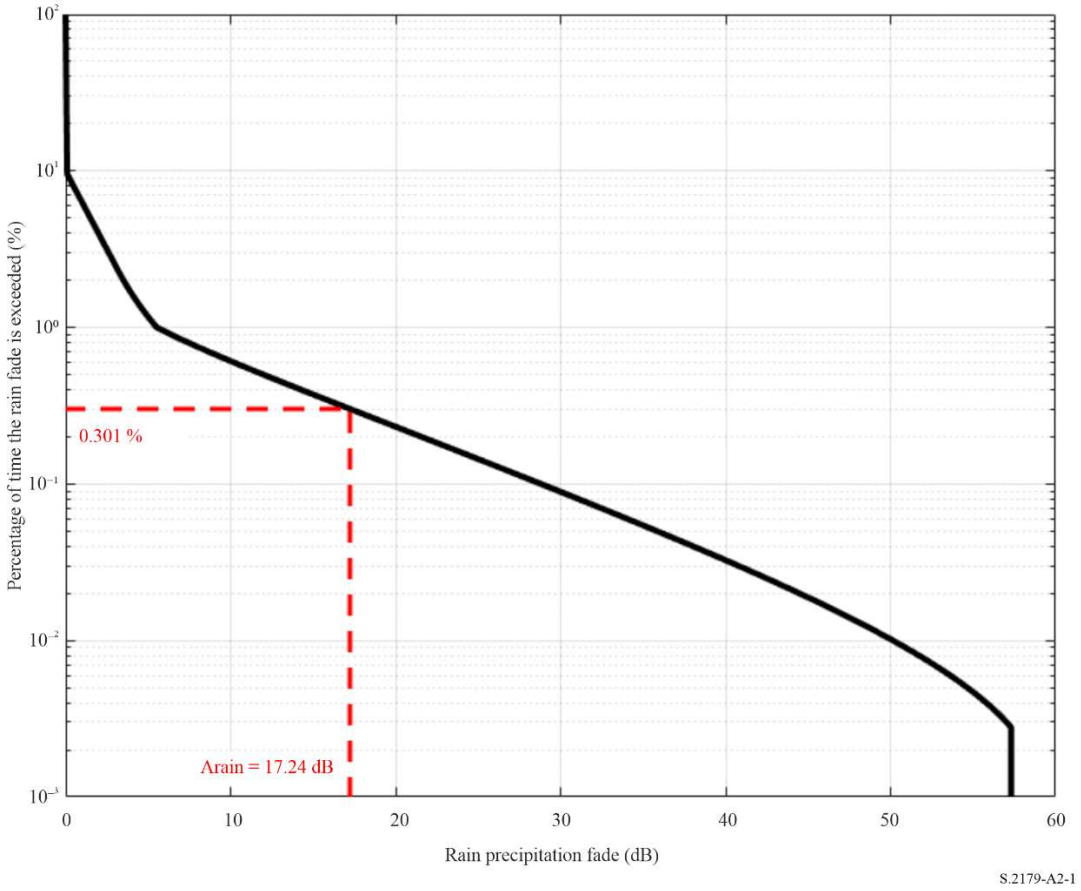
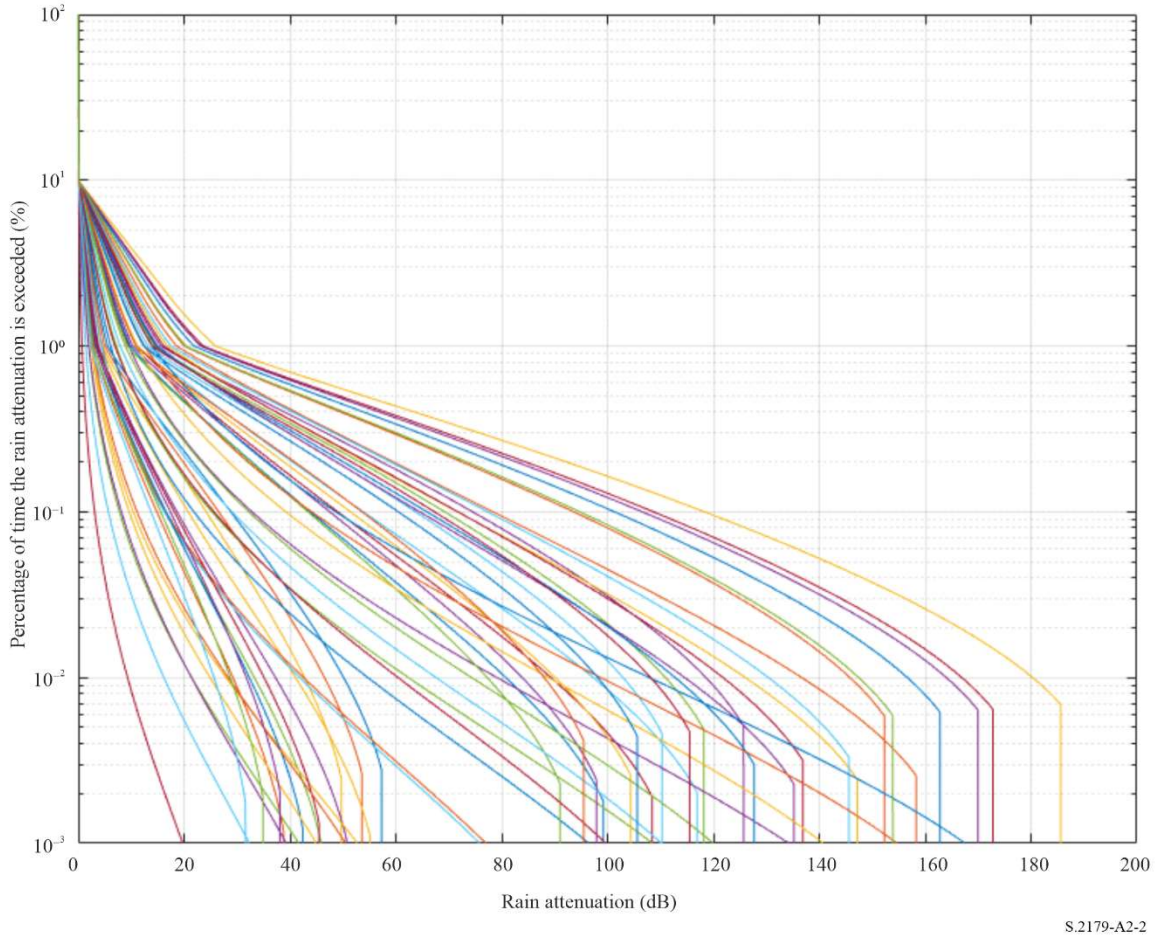


Figure A2-1 also indicates the percentage of time for which the rain attenuation is greater than 17.24 dB.

Figure A2-2 provides the precipitation fade CCDFs for all 54 combinations of rain.

FIGURE A2-2

GSO reference links precipitation fade CCDFs with modified attenuation values for small percentages (54 GSO rain conditions)



When computing the PDFs from the CCDFs, two impulse functions have been implemented, to have a complete PDF. The first impulse function is added at the maximum precipitation fade and the second impulse function is added at the precipitation fade of 0 dB in order to obtain 100% when doing the summation of the probabilities of the PDF. This is in line with the methodology explained in Annex 2 to Recommendation ITU-R S.2157.

A2.3 Generation of epfd complementary cumulative distribution function and probability distribution function

As indicated in Recommendation ITU-R S.2157, Recommendation ITU-R S.1503 should be used to determine the epfd CCDF from the non-GSO FSS parameters and the frequency, dish size and Earth station antenna gain pattern. The epfd CCDF will be calculated at the worst-case geometry from Recommendation ITU-R S.1503. The epfd CCDF will be composed of *N* bins spaced by 0.01 dB.

The epfd CCDF should then be converted into a PDF as follows:

1) Ensure that the percentage of time of the first bin of the epfd CCDF is 100% and the last bin is 0%.

2) For each of the bin, convert this CCDF into a PDF of epfd:

$$PDF_n = \frac{CCDF_n - CCDF_{n+1}}{100} \quad \text{for } n < N$$
$$PDF_n = 0 \quad \text{for } n = N$$

with: $\sum_{n=1}^{N} PDF_n = 1$.

Each bin of the epfd CCDF contains the probability that the epfd is at least X dB W/m^2 in the reference bandwidth. Each bin of the PDF contains the probability that the epfd is between X and X + 0.01 dB.

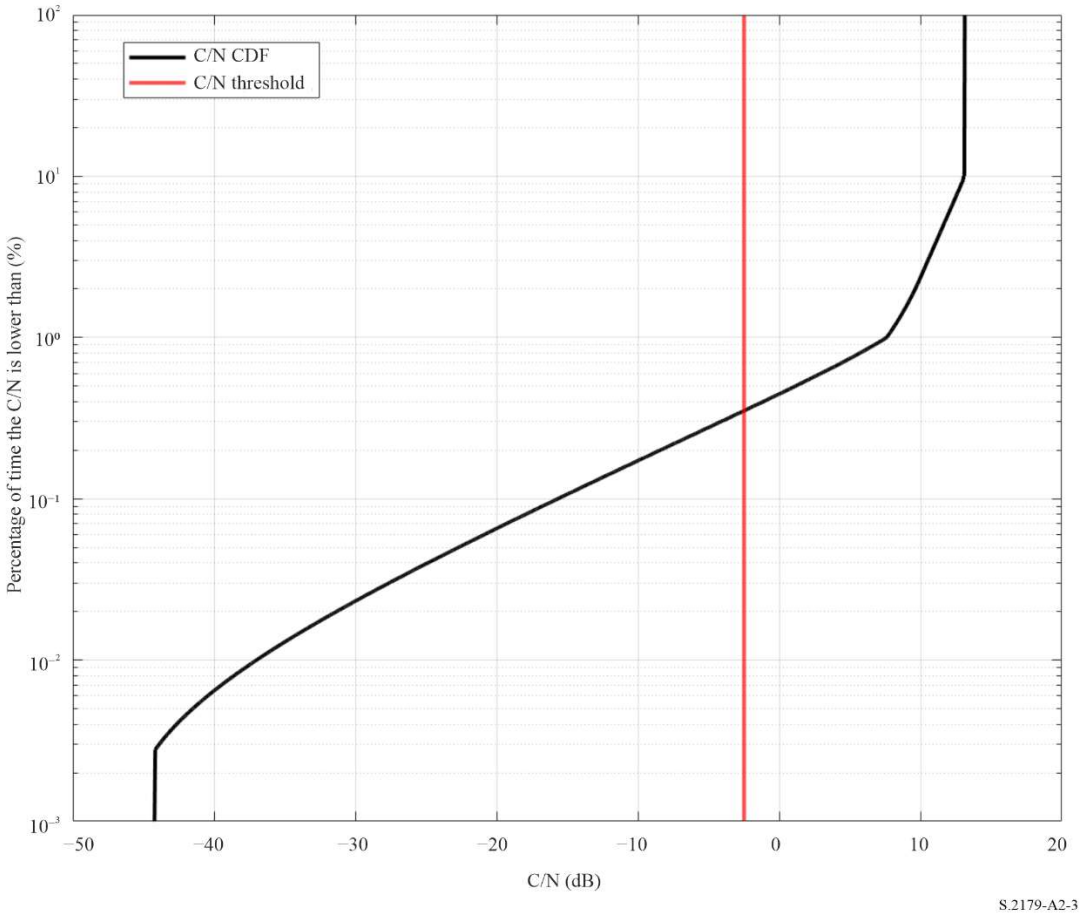
A2.4 *C/N* cumulative distribution function and probability distribution function

The *C/N* cumulative distribution function (described in Step 3[4]), under rain conditions without interference, is generated from the precipitation fade CCDFs transformed into PDFs in § A2.2 for all GSO valid links.

Figure A2-3 provides the result for link #73 under rain condition #1.

FIGURE A2-3

GSO reference link #73 under rain condition #1 *C/N* CDF assuming precipitation without interference (*C/N* = 13.13 dB with no precipitation and *C/N* threshold is equal to −2.5 dB)



A2.5 Spectral efficiency (SE) cumulative distribution function and probability distribution function

The spectral efficiency PDF is needed to perform Step 4B.

---

[4] The *C/N* cumulative distribution function described in Step 3 does not consider *Mointer,* the maximum *C/N* value is shifted by *Mointer* dB compared to the *C/N* value indicated in column Q of the "*C/N* and Arain" tab of the Excel file in § A2.8.

The spectral efficiency PDFs are computed for all valid links based on the *C*/*N* PDFs in § A2.4 with precipitation and without interference.

C/*N* is converted to a spectral efficiency via equation (3) of Recommendation ITU-R S.2131:

$$SE(C/N) = 0, \text{ for } C/N < -8.9$$

$$SE(C/N) = 0.030337\ C/N + 0.376643, \text{ for } -8.9 \leq C/N < -2.5$$

$$SE(C/N) = 0.5933 + 0.1415\ C/N + 0.0096\ C/N^2, \text{ for } -2.5 \leq C/N < 0$$

$$SE(C/N) = 0.5933 + 0.1388\ C/N + 0.003\ C/N^2, \text{ for } 0 \leq C/N < 25.02$$

$$SE(C/N) = 5.944, \text{ for } C/N \geq 25.02$$

The SE versus *C*/*N* is represented in Fig. A2-4.

FIGURE A2-4

Spectral efficiency versus *C*/*N*

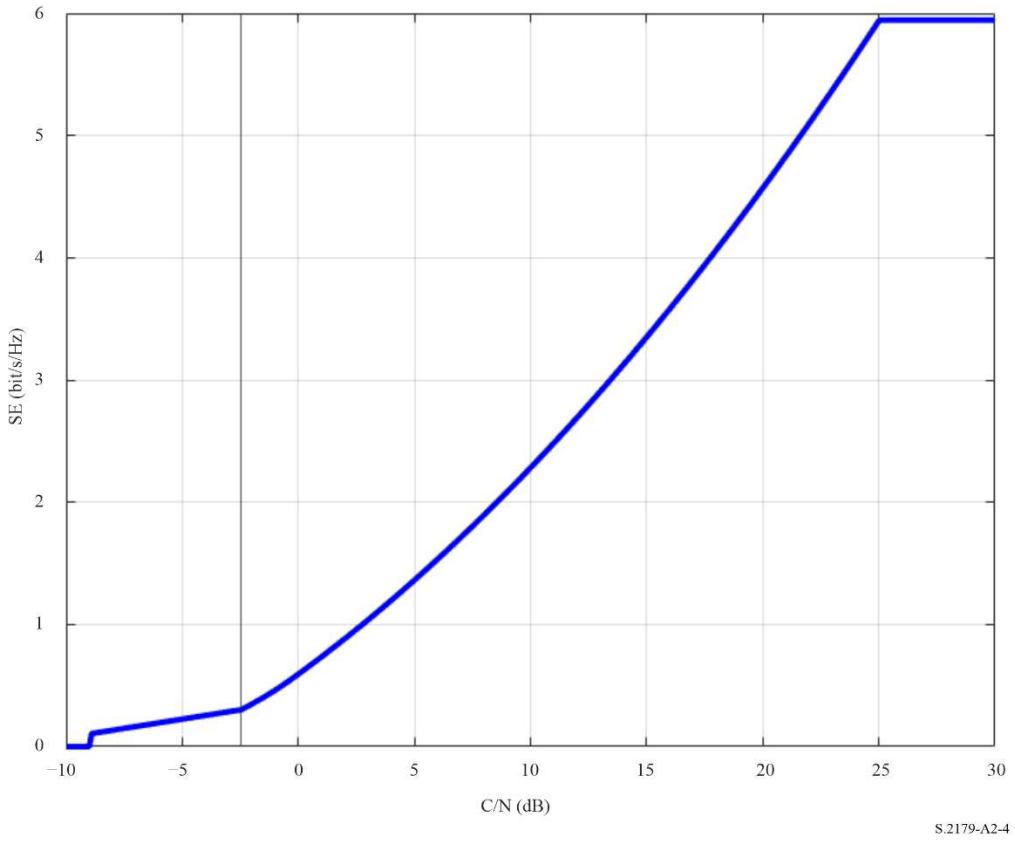
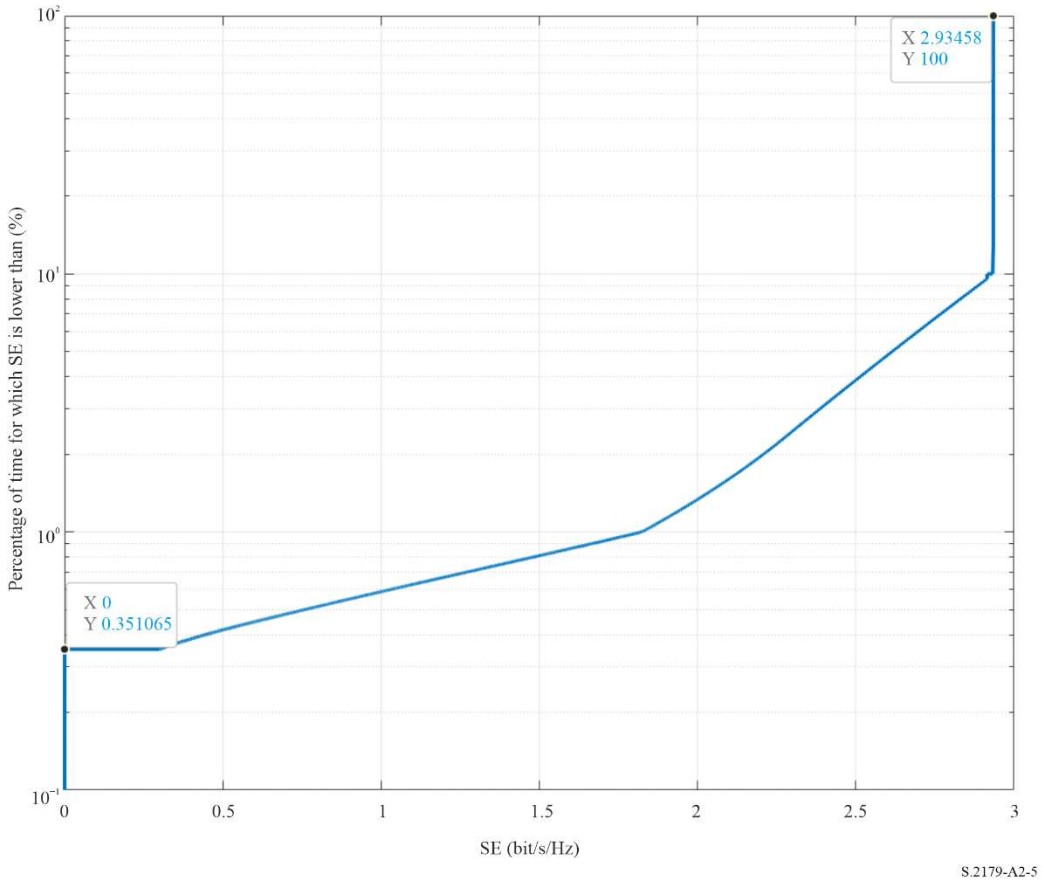


Figure A2-5 provides the result for link #73 and the rain condition number #1.

FIGURE A2-5

GSO reference link #73 under rain condition #1 *SE* CDF assuming precipitation and no interference (*SE* max is equal to 2.93 bits/s/Hz without precipitation)



It should be noted that the spectral efficiency is set to 0 when C/N is lower than the $(C/N)_{threshold}$ as indicated in Step 4B. This corresponds to time percentage lower than 0.3510% in the case of link #73 and rain condition number #1.

A2.6 Spectral efficiency average (SE_R)

The average spectral efficiency (SE_R) is computed from the spectral efficiency PDFs in § A2.5 using the following equation under rain conditions and with no interference:

$$SE_R = \frac{\sum_{n=1}^{N}(SE_n \times P_n)}{\sum_{n=1}^{N} P_n}$$

where:

N : number of bins in the SE PDF

P_n : time percentage corresponding to a specific SE_n using the SE PDF from § A2.5. This is done for all SEs for which the associated C/N value is higher than the C/N threshold, as per Recommendation ITU-R S.2157.

The result is presented in the "SER_prain" tab in the Excel file in § A2.8.

A2.7 GSO link unavailability and average spectral efficiency limits

Step 4 indicates that the C/N and $C/(N+I)$ distributions should be used to check the compliance with unavailability and the average spectral efficiency criteria in RR No. **22.5L**.

RR No. **22.5L** mentions that:

A non-GSO in FSS in Q/V bands shall not exceed:

– a single-entry increase of 3% of the time allowance for the *C*/*N* associated with the shortest percentage of time specified in the short-term performance objective of the generic GSO reference link;

and

– a single-entry permissible allowance of at most 3% reduction in the time weighted average spectral efficiency calculated on an annual basis for the generic GSO reference links using ACM.

In view of RR No. **22.5L**, the methodology to determine the maximum level of interferer that will not cause interference to a GSO system will be studied considering two parameters:

– increase of link unavailability and its limit "UR_{I_Limit}" (see § A2.7.1);

– reduction of the average spectral efficiency and its limit "SE_{RI_limit}" (see § A2.7.2).

A2.7.1 GSO link unavailability limit

The maximum unavailability (U_{RI_Limit}) assuming the precipitation and the interference is computed in accordance with Step 4A:

$$U_{RI_Limit} = 1.03 \times U_R$$

For the case of GSO link #73 under rain condition #1 for which U_R is 0.3510%, an unavailability increase of 3% would lead to a U_{RI_Limit} equal to 0.3616% in the presence of a non-GSO system interferer.

The result of U_{RI_limit} for all valid links is presented in the "URI_limit" tab in the Excel file in § A2.8.

A2.7.2 GSO link average spectral efficiency limit

The minimum average spectral efficiency (SERI) assuming the precipitation and the interference is computed in accordance with Step 4B:

$$SE_{RI_Limit} = (1 - 0.03) \times SE_R$$

For the case of GSO link #73 under rain condition #1 the average spectrum efficiency SE_R is 2.8819 bits/s/Hz and SE_{RI_Limit} is 2.7955 bits/s/Hz.

The result of SE_{RI_Limit} for all valid links is presented in the "SERI_limit" tab in the Excel file in § A2.8.

A2.8 Excel file provided all specific values of input parameter to be used

Specific values of the detailed input parameters needed by the BR in support of calculating the impact of a single non-GSO system into reference GSO valid Earth to space links following the methodology in Attachment 2 to Annex 1 to Recommendation ITU-R S.2157 and Resolution **770 (Rev.WRC-23)** are provided in the attached Excel file at 48 GHz (Excel file Part 2).

Part 2.xlsx

A2.9 Examples of interference calculation from a non-GSO system to generic GSO reference links

This example is based on a pre-existing filing example available within the ITU tool Gibc. It can be found in the folder epfd/Test of the Gibc installation folder. The files have been adapted to include the Q/V bands but the characteristics and masks of the system have not been modified.

A2.9.1 Non-GSO system parameters

TABLE A2-1

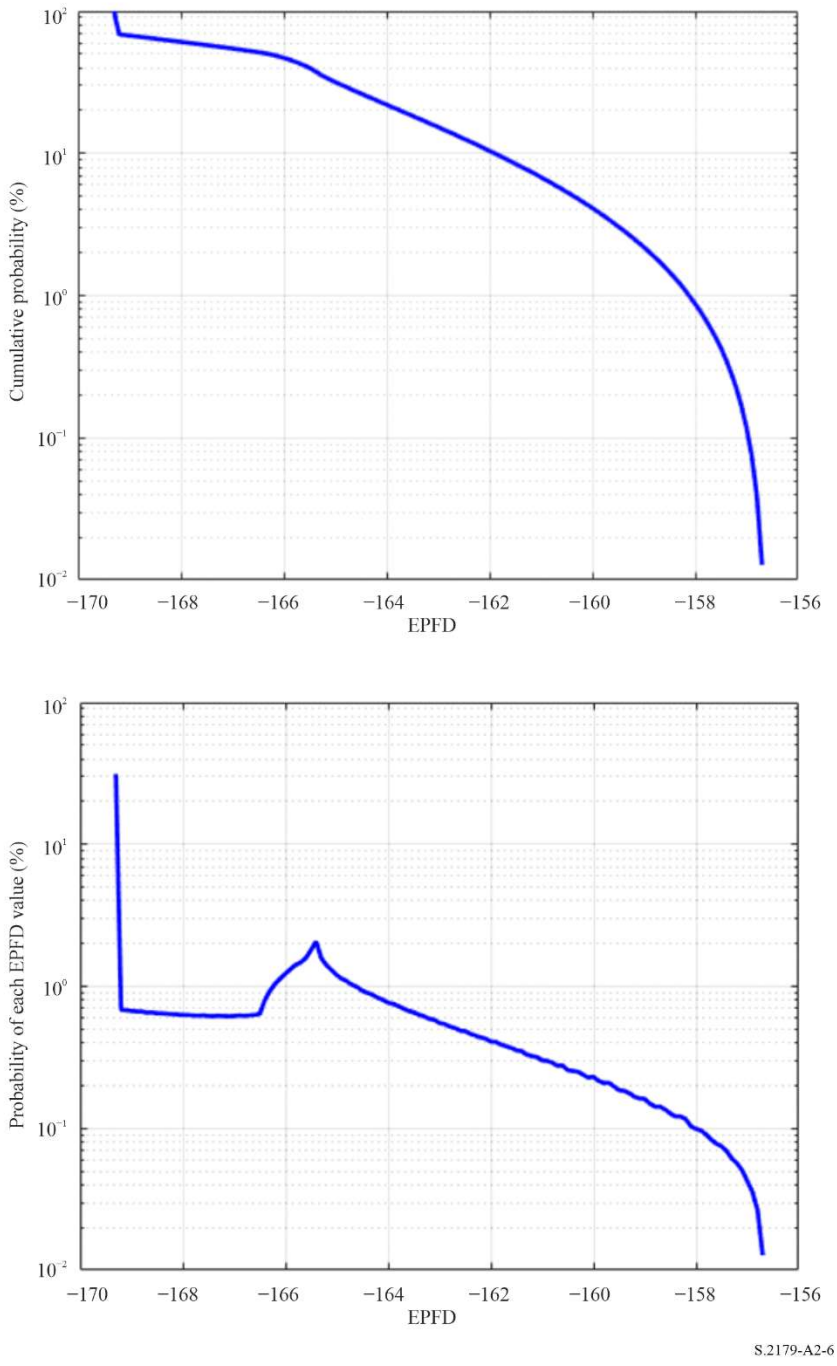
Number of planes	20
Satellites per plane	4
Inclination (degrees)	53
Altitude (km)	1 469.155
Minimum elevation angle (degree)	10

A2.9.2 NGO satellite system epfd CCDF

The CCDF of epfd has been calculated.

FIGURE A2-6

Non-GSO system epfd CCDF and PFD



A2.9.3 Calculation of U_{RI} and SE_{RI} including interference

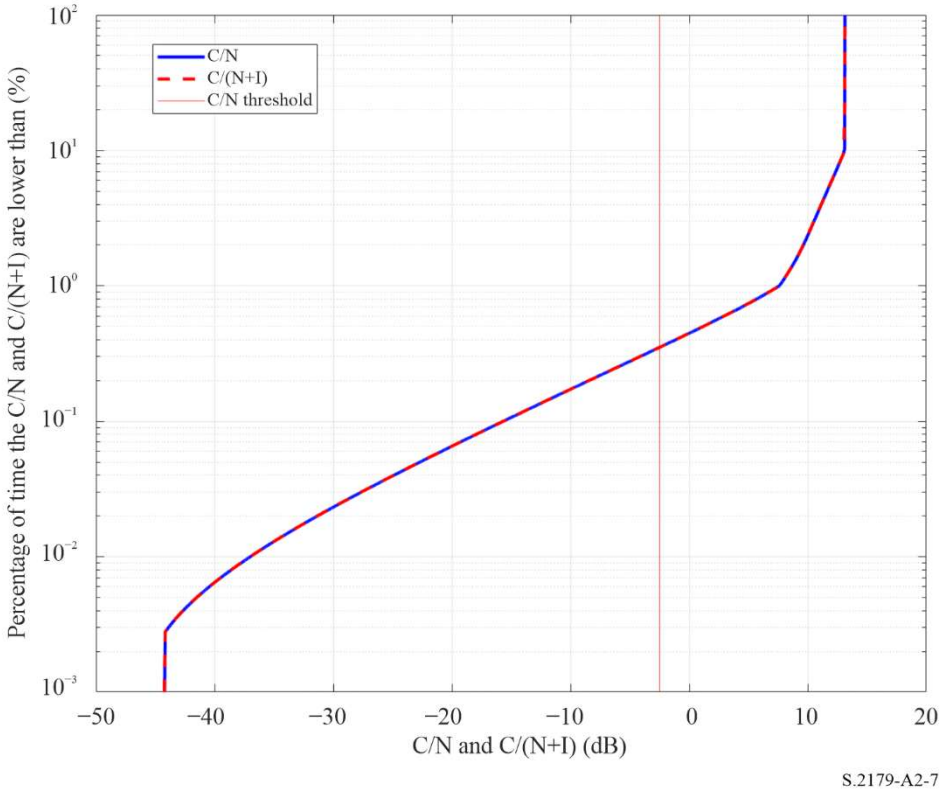
A2.9.3.1 Computation of C/N, $C/(N+I)$ CDF and U_{RI}

Following the procedure explained in Step 4 of Recommendation ITU-R S.2157, and as explained for the C/N in § A2.4, the $C/(N+I)$ PDFs are calculated using the bins methodology and the modified discrete convolution for all the valid links. The resulting U_{RI} are presented in the "URI" tab of the Excel file.

Figure A2-7 provides the result for link #73 under rain condition #1.

FIGURE A2-7

GSO reference link #73 under rain condition #1 *C*/(*N*+*I*) CDF assuming precipitation and interference (*C*/(*N*+*I*) = 13.13 dB with no precipitation and no interference *C*/*N* threshold is equal to −2.5 dB)



U_{RI} is then calculated for each valid link as the sum of probabilities from all bins for which the $C/(N+I)$ is lower than the C/N threshold. For link #73 under rain condition #1, U_{RI} is 0.35146%.

A2.9.3.2 Calculation of SE_{RI}

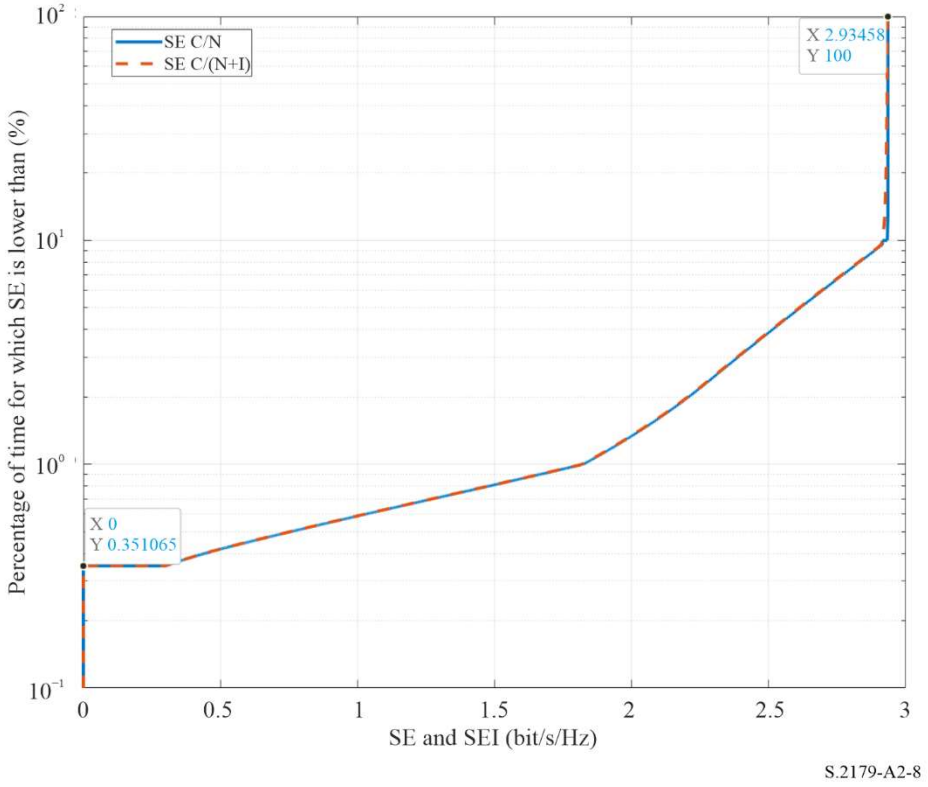
The spectral efficiency PDFs, as explained in § A2.5, is calculated for all valid links based on the $C/(N+I)$ PDFs with precipitation and interference. The resulting SE_{RI} are presented in the "SERI" tab of the Excel file in § A2.8.

$C/(N+I)$ is converted to a spectral efficiency via equations presented in § A2.5.

Figure A2-8 provides the result for link #73 and the rain condition number #1.

FIGURE A2-8

GSO reference link #73 under rain condition #1 SE and SEI CDF assuming precipitation and interference (SE = 2.93 bits/s/Hz without precipitation and interference)



The spectral efficiency is set to 0 when $C/(N+I)$ is lower than the $(C/N)_{threshold}$ as indicated in Step 4B.

For the case of GSO link #73 where the sum of $C/(N+I) > C/N_{th}$ (−2.5 dB), under the rain conditions specified in 1 and considering interferences, the average spectrum efficiency SE_{RI} is 2.8786 bits/s/Hz.

A2.9.4 Non-GSO system compliance

For each link both conditions related to UR and SER have to be fulfilled:

$$U_{RI} \leq U_{R,Limit}$$

$$SE_{RI} \geq SE_{R,Limit}$$

In the tabs “URI” and “SERI”, all valid links are in green and in red when the above conditions are not met.

For link #73 under rain condition #1, the interferences are acceptable:

– U_{RI} was 0.35146%, which is lower than the limit, which was set to 0.3616%.

– SE_{RI} was 2.8786 bits/s/Hz which is higher than the limit, which was set to 2.7955 bits/s/Hz.