Radiocommunication Bureau (BR)

Circular Letter
CCRR/53

26 October 2015

To Administrations of Member States of ITU

Subject: **Draft modification to the Rules of Procedure on the calculation methodology for calculation of probability of harmful interference between space networks (*C/I* ratios)**

Please find enclosed draft modified Rules of Procedure (Edition of 2012) related to calculation methodology for calculation of probability of harmful interference between space networks (*C/I* ratios) contained in Part B, Section B3 of the Rules of Procedures.

In accordance with No. **13.17** of the Radio Regulations, these draft Rules of Procedure are made available to administrations for comment before being submitted to the RRB pursuant to No. **13.14**. Pursuant to No. **13.12A** *d)* of the Radio Regulations, any comments that you may wish to submit should reach the Bureau not later than **4 January 2016**, in order to be considered at the 71st meeting of the RRB, scheduled for 1-5 February 2016. Comments should be sent either by telefax to +41 22 730 5785 or by email to brmail@itu.int.

François Rancy
Director

Annex: 1
Distribution:
- Administrations of Member States of ITU
- Members of the Radio Regulations Board

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ANNEX 1

Modification of the Rule of Procedure concerning calculation methodology for calculation of probability of harmful interference between space networks (*C/I* ratios) contained in Part B, Section B3 of the Rules of Procedures

Working Party 4A (WP4A) at its June 2015 meeting considered the issue of the implementation of the methodology for the calculation of the probability of harmful interference between space networks contained in Section B3, Part B of the Rules of Procedure (RoP) and concluded that "it would be beneficial for administrations if additional clarity is added to the text of some elements of the RoP, i.e.:

i) Clarification on which C/N ratio (calculated C/N or C/N objective provided by an administration) is used in the examination under No. **11.32A** of the Radio Regulations. In particular, WP 4A would like for the text to clearly highlight the differences in the methodologies used for examining the interference vis-à-vis the incoming network and the incumbent ones;

ii) Clarification on what power levels (maximum or minimum) are used in the computation of the C/I ratios in the same examination;

iii) Clarification on how the test point(s) for which the various C/I ratios are calculated within the relevant service area(s) are determined for both uplink and downlink respectively."

WP4A considered also some possible examples of modified text for Part B, Section B3 of the Rules of Procedure clarifying these issues.

In response to a request for clarification addressed to the Director of the Radiocommunication Bureau (Annex 15 to Doc. 4A/669), the Bureau has prepared draft modifications to the Part B, Section B3 Rules of Procedure including WP4A clarifications and also additional elements further improving the clarity of the Rules:

- More information regarding additional margins establishing relation between carrier to total noise power level and carrier to internal noise power; and,
- Update of calculation method to remove the reference to overall link calculations.

PART B

SECTION B3

MOD

Rules concerning ~~calculation~~ methodology for calculation of probability of harmful interference between ~~space~~ satellite networks (*C*/*I* ratios)

Reasons: *Editorial improvement.*

MOD

3 Methodology

To perform the above-mentioned compatibility analysis the following methodology will be used.

The methodology is based on Recommendation ITU-R S.741-2. A set of carrier-to-interference (*C*/*I*) calculations, using power values submitted by notifying administrations in items C.8.a.1/C.8.b.1 (i.e. the maximum value of the peak envelope power/the total peak envelope power) of Appendix **4** for both wanted and interference carrier levels, are performed following the geometrical considerations of Recommendation ITU-R S.740 and an interference adjustment factor is calculated as shown below to take into consideration the frequency offset situations as well as the difference in the bandwidths between the wanted and the interfering carriers. These *C*/*I* values are then compared with the required *C*/*I* values derived from the criteria appearing in Table 2 of § 3.2 below which contains a set of single entry interference criteria to protect different types of carriers. In the case of required *C*/*I* values agreed by administrations and communicated to the Bureau, the calculated *C*/*I* values will be compared with these mutually agreed *C*/*I* values.

Thereafter, a set of margins *M* (*C*/*I* calculated – *C*/*I* required) are derived. It should be noted that to evaluate the *C*/*I* required, a set of carrier-to-noise ratio (*C*/*N*) objectives are used (performance) and a *K* value, generally of either 12.2 or 14.0 dB, is added in accordance with the above-mentioned Table 2 of § 3.2 below. It should also be noted that these values correspond to a maximum permissible interference of 6% or 4% of the total noise power *N* of the protected assignments (performance). ~~The *C/N* objectives, submitted to the Bureau in accordance with Appendix **4** (Annex 2 item C.8.e.1) by the administration responsible for the satellite network under examination, will be used to assess the probability of harmful interference received by this satellite network. To assess the probability of harmful interference generated by this satellite network into other satellite networks, *C/N* objectives submitted by responsible administrations for those other networks will be used only if they are lower than the corresponding calculated *C/N* values for those networks. Otherwise, those calculated *C/N* values will be used. If no *C/N* objectives were submitted by responsible administrations (this was not required in the past) those calculated *C/N* values will be used.~~

In order to identify *C/I* required to be used for calculations, two scenarios are analyzed:

I. The assessment of interference caused by incumbent networks into the network submitted for the examination under No. **11.32A**:

In this case, to calculate the required C/I of the examined network, the *C/N* objective of the network (see item C.8.e.1 of Annex 2 of Appendix **4**) submitted by the notifying administration for examination under No. **11.32A** is used.

II. The assessment of interference caused by the network submitted for examination under No. **11.32A** into incumbent networks:

In this case, to calculate the required C/I of each of the incumbent networks, the lower value between the submitted *C/N* objective (see item C.8.e.1 of Annex 2 of Appendix **4**) and the calculated C/N (using power values submitted by the notifying administration in items C.8.a.1/C.8.b.1 of Appendix **4**) of the incumbent network is used.

If no *C/N* objectives are submitted by notifying administrations (since this was not required in the past), the calculated *C/N* values are used.

In respect of *C/N* ratio calculations used to define single entry protection criteria (*C/I* required), Table 2 of Recommendation ITU-R S.741-2 (see below) defines "*C/N* " as a "ratio (dB) of carrier to total noise power which includes all internal system noise and interference from other systems". Therefore, and to comply with this definition, an additional margin of 0.46 dB for cases involving wanted analogue TV emissions and 1.87 dB for other wanted emissions will be added to the margins calculated on the basis of the internal system noise values provided by the concerned administrations. Attachment 2 contains the calculation methodology used for deriving the above-mentioned additional margin.

Reasons: *To clarify:*

- *the values of peak power used in calculations:*
  *Since emissions contain both maximum and minimum values of peak power/power densities there were no clarity regarding power levels used for C/I calculation. For the computation of the so-called "calculated C/N ratios", the Bureau is using power values submitted by the notifying administration in items C.8.a.1/C.8.b.1 (i.e. the maximum value of the peak envelope power/the total peak envelope power) of RR Appendix **4**.*

- *the C/N ratio (calculated C/N or C/N objective provided by an administration) used in the examination under No. **11.32A** of the Radio Regulations:*
  The proposed modification highlights the differences in the methodologies used for examining the interference vis-à-vis the incoming network and the incumbent ones. This modification provide both additional emphasis and further clarity on this important aspect of the examination, e.g. the choice of C/N to be used further in calculations.

Effective date of application of the Rules: immediately after approval.

MOD

3.2 Margin *M*, *C/I*, *C/N* algorithms

TABLE 2

Single entry interference (SEI) protection criteria

Interfering carrier type / Desired carrier type	Analogue (TV-FM) or other	Digital	Analogue (other than TV-FM)
Analogue (TV-FM)	C/N_{tot} + 14 (dB)		
Digital	If DeNeBd ≤ InEqBd then C/N_{tot} + 9.4 + 3.5 log (δ) – 6 log (*i*/10) (dB) (i.e., C/N_{tot} + 5.5 + 3.5 log (DeNeBd (MHz))) Otherwise if DeNeBd > InEqBd then C/N_{tot} + 12.2 (dB)	C/N_{tot} + 12.2 (dB)	
Analogue (other than TV-FM)	13.5 + 2 log (δ) – 3 log (*i*/10) (dB) (i.e., 11.4 + 2 log (DeNeBd (MHz)))	C/N_{tot} + 12.2 (dB)	
Other	13.5 + 2 log (δ) – 3 log (*i*/10) (dB) (i.e., 11.4 + 2 log (DeNeBd (MHz)))	C/N_{tot} + 14 (dB)	

where:

C/N_{tot}: ratio (dB) of carrier to total noise power which includes all internal system noise and interference from other systems, related to C/N_i internal as follows:

$$\left(\frac{C}{N_{tot}}\right) = \left(\frac{C}{N_i}\right) - X$$

Where *X* is the value of additional margin defined in Attachment 2, Sections 3 to 5 and C/N_i is based on internal system noise power and defined in Attachment 1, Section 3.

DeNeBd: necessary bandwidth of desired carrier (Appendix **4**, Annex 2, item C.7.a)

InEqBd: equivalent bandwidth of interfering carrier (equal to total power to power density ratio (see Appendix **4**, Annex 2, items C.8.a.1 and C.8.a.2 respectively))

δ: ratio of desired signal bandwidth to peak-to-peak deviation of the TV carrier caused by the energy dispersal signal (a peak-to-peak deviation of 4 MHz is used in all cases)

i: pre-demodulation interference power in the desired signal bandwidth expressed as a percentage of the total pre-demodulation noise power (a value of 20 is used in all cases).

Reasons: *to provide a relation between carrier to total noise power, which includes all internal system noise and interference from other systems and carrier to internal noise power. The inclusion of other interference sources into noise power through the additional margin allows identification of single entry interference protection criteria without actually calculating interference from other systems.*

ATTACHMENT 1

Calculation algorithms (*M*, *C*/*I*, *C*/*N*)

MOD

1 Margin algorithm

To compute the margins, it is necessary first to determine the required $\left(\frac{C}{I}\right)_m$ value, which is a function of the *C*/*N* and the *K* factor:

~~$$\left(\frac{C}{I}\right)_m = \left(\frac{C}{N}\right) + K$$~~

$$\left(\frac{C}{I}\right)_m = \left(\frac{C}{N_i}\right) + K - X$$

where:

$\left(\frac{C}{I}\right)_m$: required *C*/*I* value (dB)

$\left(\frac{C}{N_i}\right)$: *C*/*N*$_i$ objective or calculated value of *C*/*N*$_i$ (dB) (see ~~the 3rd paragraph of~~ § 3 above~~)~~ and section 3 below).

K : factor used in computing the required *C*/*I* (dB). Generally, this will be either 14.0 or 12.2, depending on the modulation characteristics of the desired signals (see Recommendations ITU-R S.483 and ITU-R S.523).

X Additional margin to comply with the definition of carrier to total noise power which includes all internal system noise and interference from other systems. Attachment 2 contains methodology used for deriving the additional margin.

Since $\left(\frac{C}{I}\right)_m$ and $\left(\frac{C}{I}\right)_a$ will vary depending on the geographical location within the service, area both values are computed:

– At the geographical locations of the associated specific earth stations, if any, or,

– In case of associated typical Earth Stations, at the test point located within the service area where the $\left(\frac{C}{I}\right)_a$ value is minimum in accordance with the method given in Attachment 3.

Reasons: *These modifications provide clarification on the use of additional margin and provide the reference to new Attachment 3, which contains a description of test-point selection procedure.*

Effective date of application of the Rules: immediately after approval.

MOD

2 The $\left(\frac{C}{I}\right)_a$ algorithm for interfering situations

The basic *C*/*I* is adjusted as follows:

$$\left(\frac{C}{I}\right)_a = \left(\frac{C}{I}\right)_b - I_a$$

where:

$\left(\frac{C}{I}\right)_a$: adjusted value of *C*/*I*, taking into account the interference adjustment factor (dB)

$\left(\frac{C}{I}\right)_b$: basic calculated value of *C*/*I*, before taking into account the interference adjustment factor (dB)

I_a : interference adjustment factor (dB).

~~The adjusted *C/I* values will be determined separately for the uplink and downlink, keeping in mind that the interference adjustment factor may be different for the uplink and for the downlink.~~

~~The overall *C/I* will also be computed. If there are uplink calculations only (i.e., no downlink for the desired or interfering signal, or both, or no downlink frequency overlap between the desired and interfering signals), the values of the overall *C/I* are simply the uplink values of *C/I*. Similarly, if there are downlink calculations only (i.e., no uplink for the desired or interfering signal, or both, or no uplink frequency overlap between the desired and interfering signals), the values of the overall *C/I* are simply the downlink values of *C/I*. However, if the desired and interfering signals have both an uplink and a downlink, the overall *C/I* will be computed for each downlink test point using the *worst case* uplink *C/I* and the individual downlink *C/I* values:~~

$$\left(\frac{C}{I}\right)_T = 10 \log_{10}\left[10^{-\frac{\left(\frac{C}{I}\right)_u}{10}} + 10^{-\frac{\left(\frac{C}{I}\right)_d}{10}}\right]$$

—

~~where:~~

~~$\left(\frac{C}{I}\right)_T$: overall value of *C/I* for a particular downlink test point (dB)~~

~~$\left(\frac{C}{I}\right)_u$: worst-case uplink *C/I* at any uplink test point (dB)~~

$\left(\frac{C}{I}\right)_d$: downlink *C/I* for a particular downlink test point (dB).

Reasons: *Before WRC-2000 there was a need to provide strapping tables to cover all of the possible combinations of the uplink and downlink frequencies in order to identify coordination requirements based on overall link comprising uplink and downlink. However, WRC-2000 took a decision to simplify provisions of Radio Regulations, by separating coordination requirements for the two directions of transmissions. This resulted in making strapping data (Appendix **4**, Section D) optional. For the case when strapping information is provided for both examined and existing networks, the Bureau for simplicity is also providing only separate link calculation under No. 11.32A.*

Effective date of application of the Rules: immediately after approval.

MOD

3 The *C/N* algorithm

The algorithm for *C/N* requires the computation of the value of *N*, as follows:

~~$N = -228.6 + 10\left[\log_{10}(T_R) + 6 + \log_{10}(BW)\right]$~~

$$N_i = -228.6 + 10\left[\log_{10}(T_R) + 6 + \log_{10}(BW)\right]$$

where:

Ni ~~*N*~~ : value of internal system noise (dBW)

T_R : receiving system noise temperature (K)

BW : bandwidth (MHz).

The value of *Ni* ~~*N*~~ is determined once for the uplink (if there is an uplink) and once for the downlink (if there is a downlink) for the desired system.

Once *Ni* ~~*N*~~ is determined, *C/Ni* will be computed at each uplink test point (if there is an uplink) and each downlink test point (if there is a downlink):

~~$\left(\frac{C}{N}\right) = C - N$~~

$$\left(\frac{C}{N_i}\right) = C - N_i$$

where:

C : carrier (dBW)

Ni ~~*N*~~ : internal system noise (dBW) computed above.

~~The overall *C/N* is also computed. If there is an uplink only, the values of the overall *C/N* are simply the uplink values of *C/N*. Similarly, if there is a downlink only, the values of the overall *C/N* are simply the downlink values of *C/N*. However, if there is both an uplink and a downlink, the overall *C/N* is computed for each downlink test point using the *worst case* uplink *C/N* and the individual downlink *C/N* values:~~

$$\left(\frac{C}{N}\right)_T = 10\log_{10}\left[10^{-\frac{\left(\frac{C}{N}\right)_u}{10}} + 10^{-\frac{\left(\frac{C}{N}\right)_d}{10}}\right]$$

~~where:~~

~~$\left(\frac{C}{N}\right)_T$: overall value of *C/N* for a particular downlink test point (dB)~~

~~$\left(\frac{C}{N}\right)_u$: worst-case uplink *C/N* at any uplink test point (dB)~~

~~$\left(\frac{C}{N}\right)_d$: downlink *C/N* for a particular downlink test point (dB).~~

Reasons: *Similar to above.*

Effective date of application of the Rules: immediately after approval.

ATTACHMENT 2

Additional margins to be taken into consideration

MOD

2 Calculations performed according to No. 1.174

No. **1.174** defines the equivalent satellite link noise temperature as follows:

"The noise temperature referred to the output of the receiving antenna of the *earth station* corresponding to the radio frequency noise power which produces the total observed noise at the output of the *satellite link* excluding the noise due to *interference* coming from *satellite links* using other *satellites* and from terrestrial systems."

The internal system noise temperature values provided by the administrations to derive the internal system noise, *N*, i.e., T_s and T_e are defined in Appendix **8** as follows:

"T_s : the receiving system noise temperature of the space station, referred to the output of the receiving antenna of the space station (K)"

"T_e : the receiving system noise temperature of the earth station, referred to the output of the receiving antenna of the earth station (K)."

The above-mentioned values are combined in accordance with Recommendation ITU-R S.738 to derive T_{min}, lowest *equivalent satellite link noise temperature,* as follows:

$$T_{min} = T_e + \gamma_{min}\, T_s + T_a$$

where:

T_a : other internal noise

γ_{min} : minimum transmission gain of a specific satellite link subject to interference.

Calculation of equivalent satellite link was mandatory before WRC-2000. After the decisions of WRC-2000 RR, Appendix **4** strapping information in Appendix **4**, which is required to conduct overall link calculations became optional.

Therefore, and for simplicity T_s and T_e are used separately to conduct uplink and downlink *C/I* calculations respectively for all the cases.

Reasons: *Before WRC-2000 there was a need to provide strapping tables to cover all of the possible combinations of the uplink and downlink frequencies in order to identify coordination requirements based on overall link comprising uplink and downlink. However, WRC-2000 took a decision to simplify provisions of Radio Regulations, by separating coordination requirements for the two directions of transmissions. This resulted in making strapping data (Appendix **4**, Section D) optional. For the case when strapping information is provided for both examined and existing networks, the Bureau for simplicity is also providing only separate link calculation under No**. 11.32A**.*

Effective date of application of the Rules: immediately after approval.

MOD

3 Noise to be calculated in accordance with Recommendation ITU-R S.741-2

To be in accordance with Recommendation ITU-R S.741-2 it seems necessary to add to the values of *N* calculated by the program on the basis of T_e and T_s mentioned above, the maximum permissible level of aggregate interference caused by other ~~space~~ satellite systems ~~networks~~ as appears in Recommendations ITU-R S.466 (for FDM-FM telephony), ITU-R S.483 (for TV analogue) and ITU-R S.523 (for digital emissions) as well as the contribution of terrestrial emissions sharing the same frequency bands as defined in Recommendation ITU-R SF.356 (into telephone channels employing frequency modulation), and ITU-R SF.558 (into systems employing 8-bit PCM encoded telephony).

Reasons: *Editorial improvement.*

MOD

4.1.1 Aggregate interference produced by other ~~space~~ satellite systems~~networks~~ sharing the same frequency band (Recommendation ITU-R S.466)

Reasons: *Editorial improvement.*

MOD

4.1.3 Calculation of the additional margin

N_{tot} : total link noise including all internal noise and interference from other systems

N_i : link internal noise

X : noise due to interference from other systems

then:

$$N_{tot} = N_i + X$$

where:

$$X = (0.25 + 0.1)\, N_{tot}$$

Therefore:

$$N_{tot} = N_i + 0.35\, N_{tot}$$

$$N_{tot}\,(1 - 0.35) = N_i$$

$$N_{tot} = 1.53\, N_i$$

Additional margin: $10 * \log(1.53) = 1.87$ dB.

~~In the absence of sufficient information to calculate an additional margin for cases in which uplink and downlink are treated independently e.g. telemetry and telecommand signals the initial margins will be used i.e. no additional margin will be considered for these cases.~~

Reasons: *The current implementation of the Rules of Procedure is considering additional margin for independent links irrespective of the type of the signals.*

Effective date of application of the Rules: immediately after approval.

MOD

4.2.1 Aggregate interference produced by other ~~space~~ satellite systems ~~networks~~ sharing the same frequency band (Recommendation ITU-R S.523)

Reasons: *Editorial improvement.*

MOD

4.3.1 Aggregate interference produced by other ~~space~~ satellite systems ~~networks~~ sharing the same frequency band (Recommendation ITU-R S.483)

Reasons: *Editorial improvement.*

ADD

ATTACHMENT 3

Finding test-points for C/I calculation

1 Introduction

The assessment of probability of harmful interference shall be based on:

- one test-point in downlink within the service area of wanted satellite where the $\left(\frac{C}{I}\right)_a$ value is minimum.
- two test-points in uplink wanted and interfering links producing minimum value of $\left(\frac{C}{I}\right)_a$.

$\left(\frac{C}{I}\right)_a$ has minimum value when wanted signal is at minimum and interference signal is at maximum.

2 Test-point for the downlink C/I calculation

The position of wanted receiving earth station for which C/I is calculated is selected using the following criteria:

- Earth station is located within service area of wanted satellite;
- Earth station is visible from interfering satellite;
- The difference between satellite gain of wanted satellite and satellite gain of interfering satellite towards wanted earth station is at minimum.

The minimum gain difference is identified following the procedure below:

- Generating grid-points within wanted satellite service area A_W;
- Finding wanted satellite gain G_W towards each of the grid-point $a \in A_W$;
- Finding interfering satellite gain G_I towards each of the grid-point $a \in A_W$;
- Finding the grid-point $a_{\min}$ where the difference between satellite gains towards each satellite is at minimum, i.e. $Min\left[G_W(a_{\min}) - G_I(a_{\min})\right]$

The Bureau developed GIMS gain interpolation library to find the satellite gain for all the grid-points.

Figure A3-1 below gives graphical example of the identified test-point.

3 Test-points for the uplink C/I calculation

For the uplink calculation, it is necessary to identify locations of two earth stations – one transmitting earth station in the wanted link and another transmitting station in the interfering link.

The position of these earth stations are selected using the following criteria:

- Wanted earth station is located within service area of wanted satellite;
- Interfering earth station is located within service area of interfering satellite;
- Interfering earth station is visible from wanted satellite;
- The difference between wanted satellite gain towards wanted earth station and interfering earth station is at minimum.

The minimum gain difference is identified following the procedure below:

- Generating grid-points within wanted satellite service area A_W ;
- Generating grid-points within interfering satellite service area A_I ;
- Finding wanted satellite gain G_W towards each of the grid-point in A_I
- Selecting test-point $a_W \in A_W$ where wanted satellite gain is at minimum $G_{W_{Max}}$;
- Finding interfering satellite gain G_I towards each of the grid-point in A_W ;
- Selecting test-point $a_I \in A_I$ where interfering satellite gain is at maximum $G_{I_{Max}}$.

Figure A3-2 below gives graphical example of the procedure used.

Reasons: *to provide clarification on how the test point(s) for which the various C/I ratios are calculated within the relevant service area(s) are determined for both uplink and downlink, in particular highlighting the fact that the test-point is selected if C/I ratio in the given point is minimum.*

Effective date of application of the Rules: immediately after approval.

FIGURE A3-1

Finding worst-test point on the downlink

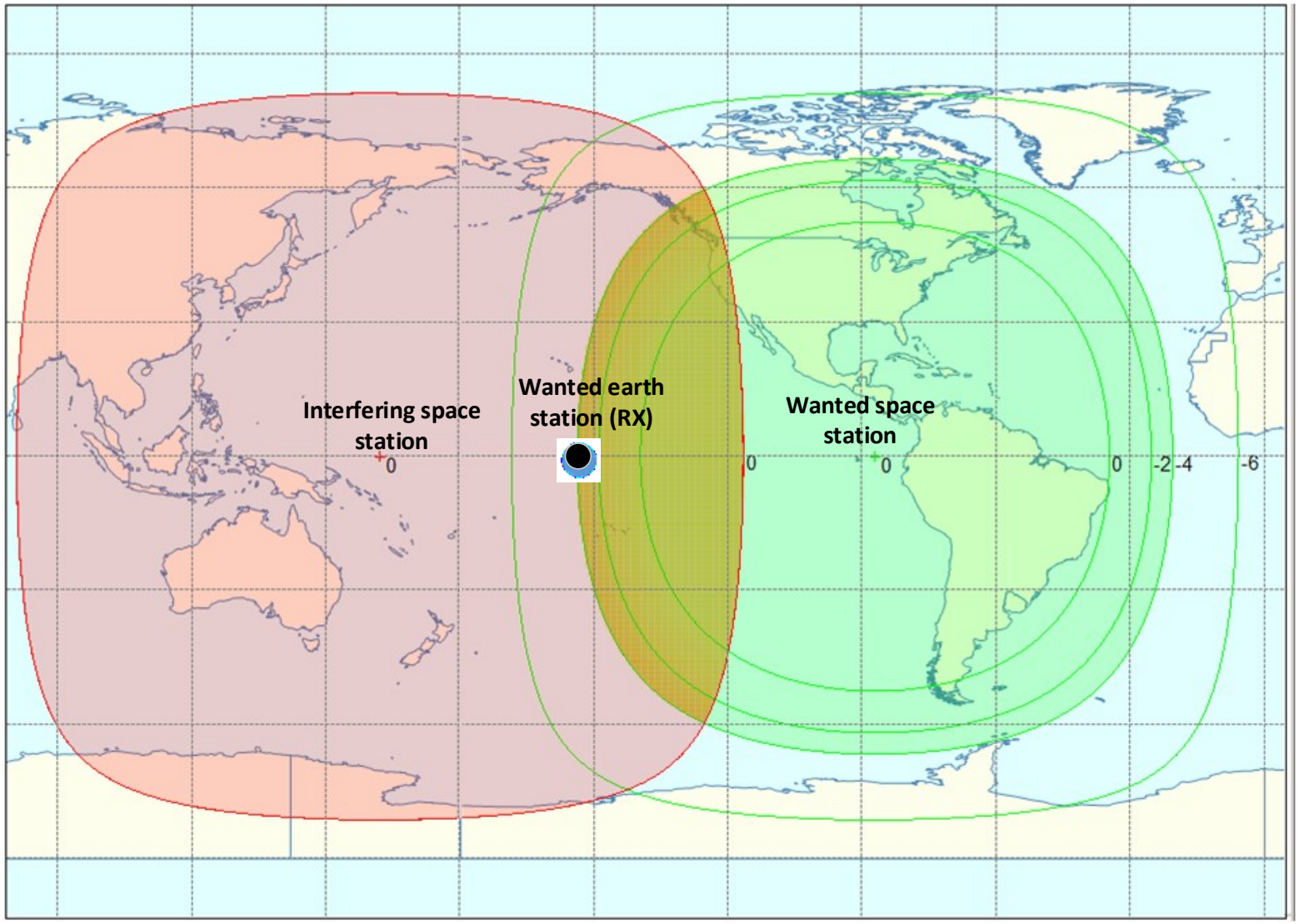

FIGURE A3-2

Finding worst-test points on the uplink