RECOMMENDATION ITU-R BO.1835

Sharing between broadcasting-satellite service (BSS) networks using the Region 2 17.3-17.8 GHz BSS allocation and feeder links of BSS networks using the worldwide 17.3-17.8 GHz fixed-satellite service (FSS) (Earth-to-space) allocation

(2007)

Scope

This Recommendation addresses the design and coordination of new Region 2 BSS networks that will use the 17.3-17.8 GHz BSS allocation that took effect on 1 April 2007. Annex 1 to the Recommendation provides detailed parametric analyses of the two cases where coordination might be required with BSS networks that use the worldwide 17.3-17.8 GHz FSS (Earth-to-space) allocation for feeder links. The substance of the Recommendation is that coordination may not be required if the results of these analyses are taken into account in the design of Region 2 BSS networks intended for use in this new BSS allocation.

The ITU Radiocommunication Assembly,

considering

a) that, in all three ITU Regions, the 17.3-17.8 GHz band is subject to the broadcasting-satellite service (BSS) feeder-link Plans of Appendix 30A of the Radio Regulations (RR);

b) that the 17.3-17.8 GHz band is also allocated to BSS in Region 2;

c) that there is the possibility of interference from the Region 2 BSS transmitting satellite to Regions 1, 2 and 3 BSS feeder-link receiving satellites operating under Appendix 30A of the RR;

d) that Annex 4 of Appendix 30A of the RR provides threshold values for determining when coordination is required between transmitting space stations in the broadcasting-satellite service and a receiving space station in the feeder-link Plans in the frequency band 17.3-17.8 GHz;

e) that the criterion for determining when coordination is required is that the power flux-density from the Region 2 BSS transmit satellite arriving at the receiving space station of a broadcasting-satellite feeder link of another administration would cause an increase in the noise temperature of the feeder-link space station which exceeds a threshold value of $\Delta T/T$ corresponding to 6%;

f) that there may be unacceptable interference in the case of closely spaced Region 2 BSS transmit satellites and BSS feeder-link receive satellites, or in the case of interference from a Region 2 BSS satellite to a receive BSS feeder-link satellite located across the limb of the Earth,

recognizing

1 that studies described in Annex 1 show that very close spacing is feasible between Region 2 BSS satellites and BSS feeder-link receive satellites without exceeding the criterion contained in Annex 4 of Appendix 30A of the RR;

2 that studies described in Annex 1 show that interference across the limb of the Earth is limited to very few geometric scenarios that may not occur in practice;

3 that the key parameters in determining the proximity with which Region 2 BSS satellites and BSS feeder-link receive satellites could be deployed are the off-axis gain discriminations of the transmitting and receiving satellite antennas, the peak transmitting satellite equivalent isotropically radiated power (e.i.r.p.) levels, and the receiving satellite system noise temperature,

recommends

1 that administrations in Region 2 should take into account the analyses and results contained in Annex 1 when designing and deploying BSS networks in the 17.3-17.8 GHz band.

Annex 1

Parametric analyses on sharing between BSS networks using the Region 2 17.3-17.8 GHz BSS allocation and feeder links of BSS networks using the worldwide 17.3-17.8 GHz FSS (Earth-to-space) allocation

1 Introduction

The Region 2 allocation for the broadcasting-satellite service (BSS) in the 17.3-17.8 GHz band came into effect on 1 April 2007. This BSS band is paired with the 24.75-25.25 GHz FSS (Earth-to-space) band for its feeder links. The 17.3-17.8 GHz band, in accordance with Appendix 30A of the RR, is also allocated in the Earth-to-space direction for feeder links to the Appendix 30 12 GHz BSS networks in all three Regions. The term “reverse-band” typically refers to the situation where a frequency band is used for both Earth-to-space and space-to-Earth transmissions. The BSS networks operating under Appendices 30 and 30A are referred to as “17/12 GHz” networks, while those operating in the 17 GHz Region 2 BSS allocation are referred to as “24/17 GHz” networks.

This 17.3-17.8 GHz reverse-band operation creates the potential for the two interference paths illustrated schematically in Fig. 1:

– between the transmitting space stations and the receiving space stations in the 17 GHz band (satellite-to-satellite), and

– between the transmitting feeder-link earth stations and the receiving earth stations in the 17 GHz band.

This text addresses only the satellite-to-satellite case.

The satellite-to-satellite interference path will occur when the signals from the transmitting 24/17 GHz satellite impinge on the receiving antenna of the 17/12 GHz satellite in 17.3-17.8 GHz. The amount of interference is determined by the physical separation between the satellites, the e.i.r.p. level of the transmitting 24/17 GHz BSS satellite, the off-axis gains of the 17 GHz transmitting and receiving satellite antennas towards each other, and the noise temperature of the receiving satellite.

The criterion for determining if coordination is required between a transmitting space station of a 24/17 GHz network and a receiving space station of a 17/12 GHz network is provided in § 1 of Annex 4 of Appendix 30A of the RR, and is defined as a $\Delta T/T$ of 6%.

There are two cases for this potential interference:

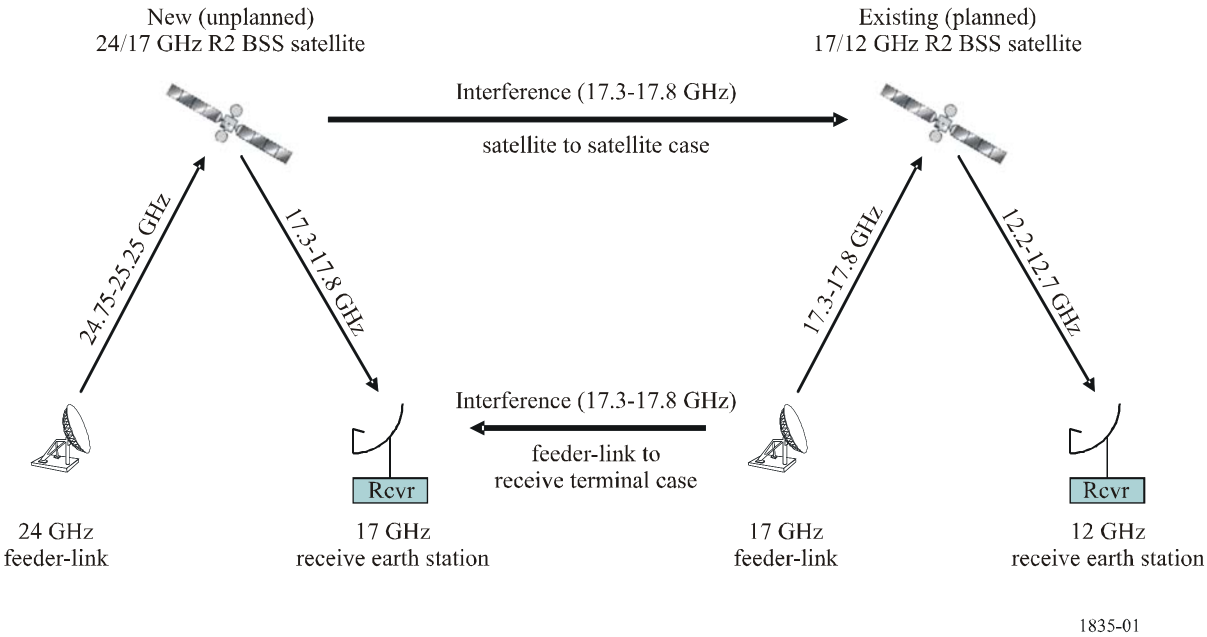
Case 1: the adjacent-satellite case, where the 17/12 GHz and 24/17 GHz satellites are closely spaced along the orbital arc, and

Case 2: the equatorial-limb case, where the 17/12 GHz and 24/17 GHz satellites are separated by approximately 162.6° along the orbital arc, i.e. across the equatorial limb of the Earth.

Analyses for these two cases are presented below in § 2 and 3, respectively.

FIGURE 1

Reverse-band operation and interference paths for Region 2 BSS and feeder links



2 Adjacent-satellite case

This section addresses closely-spaced satellites. A parametric analysis was conducted to determine the required orbital separation between a 24/17 GHz transmitting BSS space station and a 17/12 GHz receiving BSS space station that are located very close to each other along the geostationary arc. The key operational parameters in determining the required separation in order to meet the $\Delta T/T$ of 6% condition are the transmit e.i.r.p. of the 24/17 GHz satellite, the off-axis discriminations of the transmit and receive satellite antennas, and the receive satellite noise temperature of the 17/12 GHz satellite.

The off-axis angle relative to boresight for both transmit and receive antennas is approximately 90 degrees. These large off-boresight angles lead to antenna off-axis gains that are substantially below the peak of the boresight gain. Examination of published diagrams for receive gain toward the GSO arc for Region 2 assignments and modifications shows typical values between 0 and –5 dBi. These diagrams envelope the actual receive antenna patterns.

The 17/12 GHz assignments that may be affected are the current Region 2 Plan feeder-link assignments whose technical parameters are specified in Appendix 30A of the RR and its subsequent modifications. For the satellite receive antenna, the characteristics, e.g. noise temperature and off-axis satellite gain, of the original Region 2 Plan are used in the analysis. The Region 2 Plan specifies a receive noise temperature of 1 500 K. Additionally, § 3.7.3 of Annex 3 of Appendix 30A of the RR assumes that, for off-axis angles greater than approximately 20°, the receive off-axis satellite antenna discrimination is equal in magnitude, but of opposite sign, to the peak gain of the antenna. Therefore, this analysis assumed an off-axis receive gain of 0 dBi towards the adjacent satellite, although in reality there is likely to be more discrimination.

Given that the 24/17 GHz satellite transmit power could be relatively high due to the use of spot beams to cover small geographic areas, the parametric analysis considered peak e.i.r.p. values from 55 dBW to 65 dBW. In addition, for the 24/17 GHz transmit antenna, values of off-axis discrimination in the range 40 to 60 dB were assumed. Finally, three values of receive system noise temperature were taken into account. The results are presented in the following three tables.

TABLE 1

Varying interfering satellite peak e.i.r.p.

Line No.	Parameter	Units	Case 1	Case 2	Case 3
1	R2 assignment system temp.	dBK	31.8	31.8	31.8
2	Boltzmann's Constant	dB(W/K/Hz)	–228.6	–228.6	–228.6
3	Noise power density (N_0)	dB(W/Hz)	–196.8	–196.8	–196.8
4	Frequency	GHz	17.5	17.5	17.5
5	Isotropic area	dB(m^2)	–46.3	–46.3	–46.3
6	17 GHz transponder bandwidth	MHz	24.0	24.0	24.0
7	Victim satellite receive gain toward interferer	dBi	0.0	0.0	0.0
8	Interfering satellite peak e.i.r.p.	dBW	55.0	60.0	65.0
9	TX off-axis discrimination of interfering satellite	dB	50.0	50.0	50.0
10	Resultant orbital separation between satellites	degrees	**0.02**	**0.03**	**0.06**
11	Orbital separation in km	km	14.1	25.0	44.4
12	Spreading loss	dB	93.9	98.9	103.9
13	Interfering receive power	dBW	–135.3	–135.3	–135.3
14	I_0/N_0	dB	–12.2	–12.2	–12.2
15	Delta *T*/*T*	%	6.0	6.0	6.0

Table 1 shows the required orbital separations to meet a Δ*T*/*T* of 6% for varying 24/17 GHz satellite transmit e.i.r.p. levels. The peak e.i.r.p.s range from 55 to 65 dBW (Line 8). The corresponding required orbital separations are shown both in degrees (Line 10) and in km (Line 11). Using the highest e.i.r.p. of 65 dBW, a reasonable off-axis discrimination of 50 dB, and a receive system noise temperature of 31.8 dBK (1 500 K), the required separation distance is 0.06°. If a station-keeping tolerance of ±0.1° is added for each satellite, the minimum orbital separation between nominal locations to meet a 6% Δ*T*/*T* would be 0.26°.

TABLE 2

Varying interfering satellite off-axis discrimination

Line No.	Parameter	Units	Case 4	Case 5	Case 6
1	R2 assignment system temp.	dBK	31.8	31.8	31.8
2	Boltzmann's Constant	dB(W/K/Hz)	–228.6	–228.6	–228.6
3	Noise power density (N_0)	dB(W/Hz)	–196.8	–196.8	–196.8
4	Frequency	GHz	17.5	17.5	17.5
5	Isotropic area	dB(m^2)	–46.3	–46.3	–46.3
6	17 GHz transponder bandwidth	MHz	24.0	24.0	24.0
7	Victim satellite receive gain toward interferer	dBi	0.0	0.0	0.0
8	Interfering satellite peak e.i.r.p.	dBW	65.0	65.0	65.0
9	TX off-axis discrimination of interfering satellite	dB	40.0	50.0	60.0
10	Orbital separation between satellites	degrees	0.19	0.06	0.02
11	Orbital separation in km	km	140.5	44.4	14.1
12	Spreading loss	dB	113.9	103.9	93.9
13	Interfering receive power	dBW	–135.3	–135.3	–135.3
14	I_0/N_0	dB	–12.2	–12.2	–12.2
15	Delta T/T	%	6.0	6.0	6.0

Table 2 shows the variation in required separation distance (Lines 10 and 11) in order to maintain a $\Delta T/T$ of 6% while the transmit antenna discrimination was varied from 40 to 60 dB (Line 9). In this case, the 24/17 GHz satellite peak transmit e.i.r.p. was held constant at 65 dBW. For the worst case of only 40 dB of transmit antenna discrimination, the required orbital separation is 0.19°. Again, adding the maximum ±0.1° station-keeping error for each satellite yields 0.39° separation between satellite centers.

TABLE 3

Varying receive 12/17 GHz satellite noise temperature

Line No.	Parameter	Units	Case 7	Case 8	Case 9
1	R2 assignment system temp.	dBK	31.8	29.5	27.8
2	Boltzmann's Constant	dB(W/K/Hz)	–228.6	–228.6	–228.6
3	Noise power density (N_0)	dB(W/Hz)	–196.8	–199.1	–200.8
4	Frequency	GHz	17.5	17.5	17.5
5	Isotropic area	dB(m^2)	–46.3	–46.3	–46.3
6	17 GHz transponder bandwidth	MHz	24.0	24.0	24.0
7	Victim satellite receive gain toward interferer	dBi	0.0	0.0	0.0
8	Interfering satellite peak e.i.r.p.	dBW	65.0	65.0	65.0
9	TX off-axis discrimination of interfering satellite	dB	40.0	40.0	40.0
10	Orbital separation between satellites	degrees	0.19	0.25	0.30
11	Orbital separation in km	km	140.5	181.5	222.2
12	Spreading loss	dB	113.9	116.2	117.9
13	Interfering receive power	dBW	–135.3	–137.5	–139.2
14	I_0/N_0	dB	–12.2	–12.2	–12.2
15	Delta T/T	%	6.0	6.0	6.0

Table 3 shows the required orbital separations for receive system noise temperatures of 1 500 K, 900 K and 600 K. The peak interfering e.i.r.p. was held constant at 65 dBW and the off-axis discrimination was held constant at 40 dB. The worst-case orbital separation is 0.30°, or 0.50° with maximum station-keeping tolerances.

These results show that only a very closely spaced 24/17 GHz satellite will likely cause an exceedance of the allowed ΔT/T level of 6% toward receiving 17/12 GHz satellites. The design of 24/17 GHz satellite networks should strive to take the results of these analyses into account in order to avoid unnecessary coordinations with 17/12 GHz assignments and modifications in the Region 2 Plan. It is noted that many satellites in Region 2 operate with station keeping of ±0.05°, rather than 0.1°. This would reduce all of the above total orbital separations by either 0.05 or 0.1 degree, depending on whether one or both satellites had the tighter station-keeping.

3 Equatorial-limb case

The equatorial-limb case is the case in which the interference path from a Region 2 transmitting 24/17 GHz satellite to a Region 1 or 3 receiving 17/12 GHz satellite grazes the limb of the Earth. Figure 2 depicts this configuration. The angle between the transmitting and receiving satellites is approximately 162.6°, and the straight-line distance between the transmitting and receiving satellites for this case is 83 362 km or less. Figures 2 and 3 show the geometry for this case.

FIGURE 2

Overlapping transmit and receive beams for equatorial-limb case

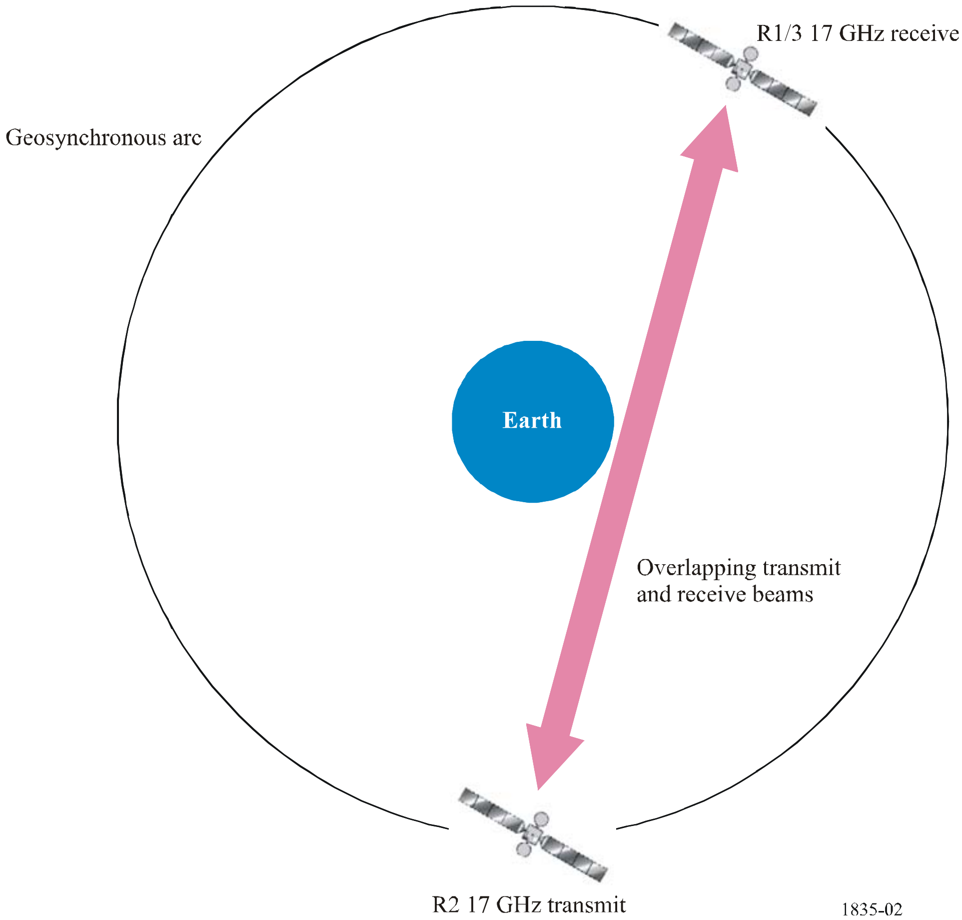
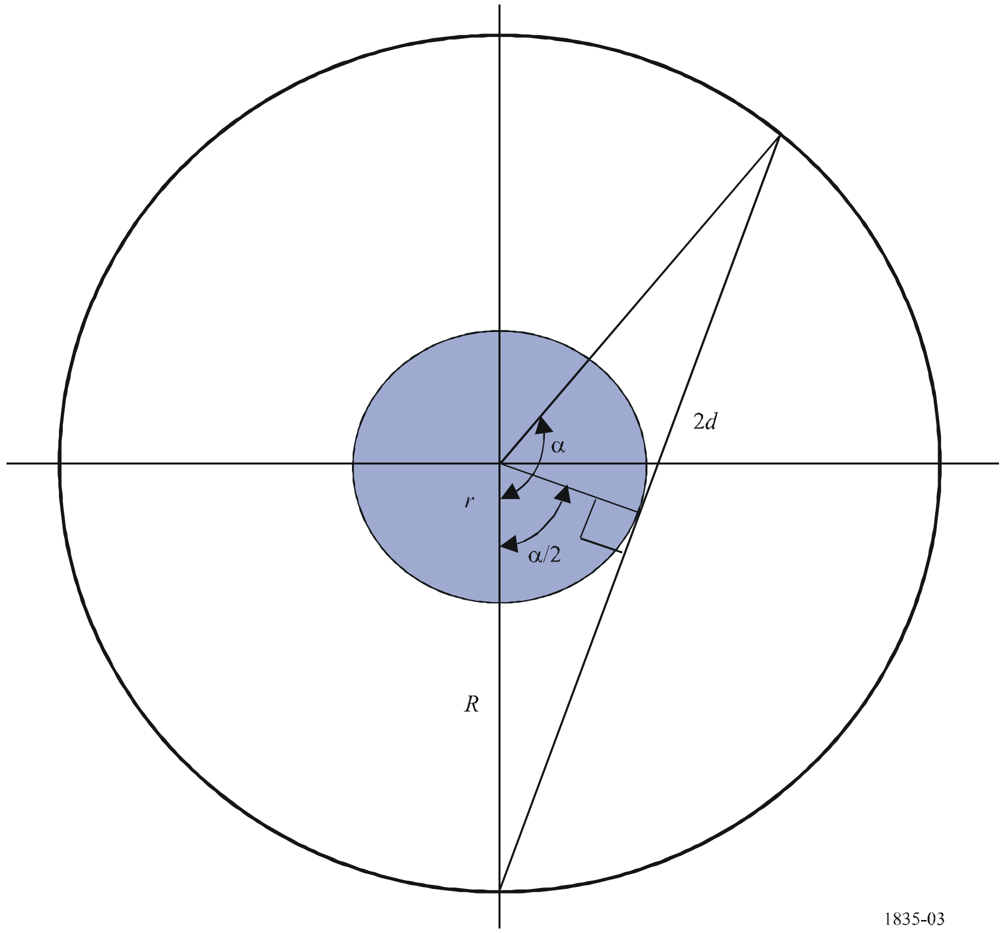


FIGURE 3

Equatorial limb geometry



In the above Figs 2 and 3 the following applies:

R = GSO altitude = 35 796 km

r = radius of the Earth = 6 370 km

$r/(r + R) = \cos(\alpha/2)$

$\alpha/2 = 81.3°; \alpha = 162.6°$

$2d = 2(r + R)\sin(\alpha/2) = 83\ 362$ km

When the geometry of the equatorial-limb interference case is examined, it is clear that there exists only a small number of combinations of transmit/receive coverage areas and orbit locations that have the potential for interference. Limb-of-the-Earth interference is only possible when a Region 2 24/17 GHz transmitting satellite and a Region 1 or 3 17/12 receiving satellite serve countries close to the equator, and have appreciable amounts of off-axis antenna gains in the equatorial plane. In Regions 1 and 3, there are only a comparatively few broadcasting-satellite service areas that are near the equator. These include those for Indonesia, Australia, Papua New Guinea, India and countries in Central Africa.

In order to have any appreciable interference across the limb of the Earth from a Region 2 24/17 GHz transmitting satellite into a Region 1 or 3 17/12 GHz receiving satellite, all of the following conditions would have to occur:

– transmitting satellite beam covers Central America or equatorial South America;

– appreciable transmit power in the equatorial plane, i.e. low arrival angle of the transmit beam;

– receiving satellite beam covers equatorial or sub-tropical countries;

– appreciable receive gain in the equatorial plane, i.e. low arrival angle of the receive beam.

The spreadsheet below calculates the $\Delta T/T$ interference into a Region 3 Plan assignment from a fictional Region 2 24/17 GHz transmitting satellite. The Region 3 INDA_101 assignment was used in this analysis. The off-axis receive gain (Line 7) was obtained using GIMS. Even with a high interfering e.i.r.p. value of 65 dBW and no off-axis gain discrimination at the edge of the Earth, the $\Delta T/T$ is less than 1%. This highly conservative example demonstrates that the chance for any appreciable limb-of-the-Earth interferenceis extremely small.

TABLE 4

Calculation of $\Delta T/T$ for equatorial-limb case

Line No.	Parameter	Units	
1	R1/3 assignment system temp.	dBK	27.8
2	Boltzmann's Constant	dB(W/K/Hz)	228.6
3	Noise power density (N_0)	dB(W/Hz)	–200.8
4	Frequency	GHz	17.5
5	Isotropic area	dB(m^2)	–46.3
6	17 GHz transponder bandwidth	MHz	24.0
7	Region 1/3 satellite receive gain toward interferer	dBi	0.7
8	Interfering satellite peak e.i.r.p.	dBW	65.0
9	TX off-axis discrimination of interfering satellite	dB	0.0
10	Orbital separation between satellites	degrees	162.6
11	Orbital separation in km	km	83 361.7
12	Spreading loss	dB	169.4
13	Interfering receive power	dBW	–150.1
14	I_0/N_0	dB	–23.0
15	Delta T/T	%	**0.5**

4 Conclusions

The parametric analyses presented in this Annex show that the potential for interference from a transmitting 24/17 GHz BSS satellite in Region 2 into 17/12 GHz satellites operating under Appendices 30 and 30A of the RR in any Region is only possible in two scenarios. One (the adjacent-satellite case) is when the transmitting and receiving satellites are very closely spaced, and the other (the equatorial-limb case) is when the transmitting and receiving satellites are in "opposition" across the geostationary orbital arc.

In the case of the adjacent satellites, care must be taken in the design of the 24/17 GHz satellites such that the transmit power in the direction of the orbital arc (i.e. roughly 90°) is sufficiently low to avoid interfering with nearby 17/12 GHz receiving satellites, as shown in parametric Tables 1 through 3. For this case, it was shown that with reasonable operating characteristics, transmitting and receiving satellites can be spaced 0.02 to about 0.3° apart, not including station-keeping.

For the equatorial-limb case, the likelihood of any significant interference can be avoided with only modest precautions, such as keeping arrival angles to service areas above 20°, and reducing the amount of spillover power transmitted towards the orbital arc.