RECOMMENDATION ITU-R S.1524

Coordination identification between geostationary-satellite orbit fixed-satellite service networks

(2001)

The ITU Radiocommunication Assembly,

considering

a) that the Plenipotentiary Conference (Minneapolis, 1998) agreed, through Resolution 86, on the need for improved coordination and notification of satellite networks;

b) that there is a need to accelerate the identification of geostationary-satellite orbit fixed-satellite service (GSO FSS) networks with which coordination is required;

c) that simple methods are needed for identifying the necessary co-frequency GSO FSS networks with which coordination must take place and which can be used in fulfilment of the objectives of Resolution 86;

d) that typical network characteristics of 6/4 GHz, 13-14/11-12 GHz and 30/20 GHz GSO FSS networks are well known;

e) that in many parts of the GSO co-frequency FSS networks in bands identified in *considering* d) above are closely spaced with overlapping beams;

f) that the operators of such networks have extensive experience in coordinating satellite systems with other co-frequency satellite systems;

g) that where applicable, the off-axis equivalent isotropically radiated power (e.i.r.p.) density recommended maximum levels on GSO FSS earth stations toward an adjacent GSO FSS network and power flux-density limits on GSO FSS space stations at the surface of the Earth are among the most important technical parameters used in defining orbital separation;

h) that a coordination arc can be defined around a given network such that interference between that network and networks outside that arc may typically be considered negligible compared to the interference from networks within that arc;

j) that network parameters developed to accommodate networks within the coordination arc would likely help to accommodate networks at greater orbital spacing;

k) that the coordination arc, by itself, may not be sufficient in some cases to identify all networks which might cause interference to or receive interference from a new network;

l) that the World Radiocommunication Conference (Istanbul, 2000) adopted Resolution 55 (WRC-2000) to bring into effect temporary procedures for improving satellite network coordination, including modifications to Articles 9, 11 and Table 5-1 of Appendix 5 of the Radio Regulations (RR), *recommends*

1 that determination of the need for coordination between GSO FSS networks should be based on coordination arcs of ±10°, in the bands 3 400-4 200 MHz, 5 725-5 850 MHz (Region 1) and 5 850-6 725 MHz, ±9° in the bands 10.95-11.2 GHz, 11.45-11.7 GHz, 11.7-12.2 GHz (Region 2), 12.2-12.5 GHz (Region 3), 12.5-12.75 GHz (Regions 1 and 3), 12.7-12.75 GHz (Region 2), and 13.75-14.5 GHz, and ±8° in the bands 17.7-20.2 GHz and 27.5-30 GHz about the nominal orbital positions of those networks;

2 that, although the full RR Appendix 4 data must still be provided, the information in Annex 1 is sufficient, and should be used, for determining whether the threshold coordination arc conditions defined in *recommends* 1 are exceeded for a co-frequency GSO FSS network;

3 that an administration, on its own initiative or with the assistance of the Radiocommunication Bureau (BR) in application of No. 9.41 and other relevant provisions of the RR (e.q. No. 13.1), may request that a co-frequency GSO FSS satellite network outside the coordination arc be included in coordination when the administration can demonstrate by analysis that the increase in the system noise due to the proposed network exceeds 6%;

4 that the administration filing the request for coordination, on its own initiative or with the assistance of the BR in application of No. 9.41 and other relevant provisions of the RR (e.q. No. 13.1), may request that a co-frequency GSO FSS satellite network within the coordination arc be excluded from the coordination when the filing administration can demonstrate by analysis that the increase in system noise to the network, within the coordination arc due to the proposed network, is less than 6%. This is to be confirmed by the BR which will inform the concerned administrations.

NOTE 1 – In order to implement *recommends* 3 and 4, the relevant RR Appendix 4 data should be used.

NOTE 2 – The coordination arc should apply to coordination only between satellite networks in the FSS using the GSO and operating in the same direction of transmission.

NOTE 3 – The bases for the values in *recommends* 1 are given in Annex 2.

NOTE 4 – In other FSS bands than those listed in *recommends* 1 and those covered by RR Appendix 30B, $\Delta T / T$ of 6% would continue to apply.

ANNEX 1

Information required for identification of administrations and satellite networks based on GSO coordination arcs

A.1.a: Identity of satellite network

A.1.f: Country symbol of the notifying administration

A.3: Operating administration or agency

A.4.a.1: Nominal geographic longitude of the space station on the GSO

C.2.a: Assigned frequency

C.3.a: Assigned frequency band.

NOTE 1 – All information required for identification of administrations and satellite networks based on GSO coordination arcs is also required in RR Appendix 4 for notification or coordination of a GSO network. Accordingly the RR Appendix 4 item numbers are provided.

ANNEX 2

Coordination identification between GSO FSS networks

1 Introduction

This Annex deals with the appropriate coordination arc which may be adopted for identifying the need for coordination between GSO FSS networks in the bands 6/4 GHz, 13-14/11-12 GHz, and 30/20 GHz. The objective of the calculation is to define an orbital separation angle, α, beyond which the increase in noise temperature of the network subject to interference will not exceed 6%. Coordination would be required when a GSO network is within $\pm\alpha°$ from the proposed network.

The approach used is to examine the excess interference in typical FSS systems caused by other typical FSS systems at varying angular separations, and assessing the resultant risk created by not coordinating the two networks at the separation value.

2 Results of studies

2.1 Methodology and assumptions

The methodology used to calculate the separation angle between two GSO FSS networks is described below:

– First, the total carrier to noise + interference ratio ($C/(N + I)$) is calculated for the interfered with system.

– The aggregate interference from other GSO networks into the wanted system is set at 20% of the total system noise.

– The single-entry interference from one GSO network is 6% of the total system noise and allocated equally between the uplink and the downlink direction. Generally, the interference in a link is dominated by the contribution of interference from one direction rather than the other. Thus, this assumption will give a larger separation angle than that in a case of treating each link direction separately with the full 6% allowable interference allocated for each direction.

– The antenna pattern of the receiving earth station is assumed to comply with 29-25 log φ.

– For the uplink direction, the interfering transmitting earth station is assumed to be located at the wanted satellite maximum gain direction and the path losses are assumed to be the same for both the wanted and the interfering direction. The required separation angle will then be determined from the off-axis e.i.r.p. density radiation pattern of the interfering transmitting earth station.

– For the downlink direction, the interfering receiving earth station is assumed to be collocated with the wanted earth station. The required separation angle will then be determined from the interfering satellite e.i.r.p. density and the receiving antenna pattern of the interfered earth station.

2.2 System parameters

The parameters of the GSO networks used in this study are taken from the transparent (bentpipe) GSO link budget databases for the 13-14/11-12 GHz and 30/20 GHz bands. The fact that these carriers were given for the most sensitive GSO FSS links has been noted, however this database represents a suitable reference of GSO carriers for this purpose. It is also noted that for a typical GSO link budget, the separation angles would be smaller due to the high power of the GSO carriers.

Table 1 shows the assumed off-axis e.i.r.p. density used in this study. The transmitting earth station off-axis e.i.r.p. density values are taken from Recommendation ITU-R S.524 for both the 13-14/11-12 GHz and 30/20 GHz bands (in the case of 30/20 GHz band, Recommendation ITU-R S.524 contains off-axis e.i.r.p. density values only for the frequency range 29.5-30 GHz).

TABLE 1

e.i.r.p. and antenna pattern of GSO FSS networks

Frequency band (GHz)	Interfering Tx earth station off-axis e.i.r.p. density (dB(W/40 kHz))	Interfering Tx satellite e.i.r.p. density (dB(W/Hz))	Wanted earth station antenna pattern
13-14/ 11-12	39-25 log φ for 2.5° ≤ φ ≤ 7°	–22	29-25 log φ
30/20	19-25 log φ for 2.0° ≤ φ ≤ 7°	–18	29-25 log φ

2.3 Determination of single-entry carrier to interference (C/I) due to interference from another GSO network

This section describes the calculation required to determine the allowable interference from other GSO networks into an interfered-with GSO network from the parameters provided in these databases.

Throughout this Annex, ratios expressed in lower case letters are used to denote power ratios and upper case letters are used when the power ratios are expressed in dB. The uplink is designated by the subscript ↑ and the downlink by the subscript ↓. The total power from both uplink and downlink is designated by the subscript t.

The total carrier-to-system noise ratio of the wanted network which is comprised of thermal noise, internal noise and interference due to other GSO networks and terrestrial systems is determined as follows:

$$\left\{\frac{c}{i+n}\right\}_t^{-1} = \left(\frac{c}{n}\right)_t^{-1} + \left(\frac{c}{i_{internal}}\right)_t^{-1} + \left(\frac{c}{i_{terrestrial}}\right)_t^{-1} + \left(\frac{c}{i_{GSO}}\right)_t^{-1} \tag{1}$$

where:

$c/(i+n)_t$: total carrier-to-system noise ratio (uplink and downlink direction)

$(c/n)_t$: carrier-to-thermal noise ratio from both uplink and downlink direction

$(c/i_{internal})_t$: carrier-to-internal interference ratio from both uplink and downlink direction

$(c/i_{terrestrial})_t$: carrier-to-terrestrial interference ratio from both uplink and downlink direction

$(c/i_{GSO})_t$: carrier-to interference ratio due to all other GSO networks from both uplink and downlink direction.

Assuming that the aggregate interference due to all other GSO networks and the single-entry interference from one GSO network (both uplink and downlink) are 20% and 6% of the total system noise, respectively, we have:

$$\left\{\frac{c}{i_{\text{SEI\_GSO}}}\right\}_t^{-1} = \left\{\left(\frac{c}{n}\right)_t^{-1} + \left(\frac{c}{i_{internal}}\right)_t^{-1} + \left(\frac{c}{i_{terrestrial}}\right)_t^{-1}\right\} \times \frac{0.06}{0.8} \tag{2}$$

where:

$(c/i_{\text{SEI\_GSO}})_t$: carrier-to-interference ratio due to one interfering GSO network.

The total interference due to another GSO network is assumed to be allocated equally to both uplink and downlink direction. Thus, the $C/I_{\text{SEI\_GSO}}$ in the uplink and downlink will be 3 dB higher than the total $C/I_{\text{SEI\_GSO}}$ which is determined from equation (2).

$$\left(\frac{C}{I_{\text{SEI\_GSO}}}\right)_\uparrow = \left(\frac{C}{I_{\text{SEI\_GSO}}}\right)_\downarrow = \left(\frac{C}{I_{\text{SEI\_GSO}}}\right)_t + 3 \qquad \text{dB} \tag{3}$$

2.4 Determination of the required uplink separation angle

The separation angles for both uplink and downlink are then calculated from the $C/I_{\text{SEI-GSO}}$ taking into account the bandwidth difference between the wanted and interfering network.

3 Results of studies using maximum and minimum e.i.r.p. data

The excess interference margins were calculated using INTELSAT IICM parameters. The values used for the maximum interfering parameters are given in Table 2 and for the minimum receive parameters are given in Table 3, respectively. These parameters are considered typical of many systems in the FSS.

In order to simplify the different combinations and types of carriers used in the INTELSAT system, all carriers were categorized into one of four distinct types, namely:

– narrow-band digital carriers,

– wideband digital carriers,

– analogue frequency division multiplex/frequency modulation (FDM/FM) or companded frequency division multiplex (CFDM)/FM carriers,

– FM/TV (slowly swept) carriers.

The summary of the carrier parameters used in this study is given in Table 3.

TABLE 2

Uplink and downlink limits for use in calculating interference margins in Tables 4 and 5

Frequency band (GHz)	Non-FM/TV uplink power density (dB(W/Hz))	FM/TV uplink power (dBW)	Non-FM/TV downlink e.i.r.p. density (dB(W/Hz))	FM/TV downlink e.i.r.p. (dBW)
6/4	–30	33	–25	38
13-14/11-12	–36	27	–13	50

Using the limits defined in § 2, Table 4 gives the excess interference margin for the different types of carriers at various orbital separations for the 6/4 GHz band, and Table 5 gives the excess interference margin for the different types of carriers at various orbital separations for the 13-14/11-12 GHz band. It should be noted that the interference margin computed from FM/TV into narrow-band carriers assumes that the FM/TV carriers are modulated at all times with live video or test patterns in addition to the energy dispersal signal so that they can be treated as noise-like interference with a maximum spectral density of –63 dBc/Hz. It is assumed that the interfering beam is copolarized and operates co-frequency with the wanted network beam. A 1 dB of topocentric advantage is used.

In the derivation of the worst-case interference margin given in Tables 4 and 5, the following assumptions were made. Based on these assumptions, improvement factors are also identified:

– For determining the uplink interference margin, it is assumed that the interfering earth station is located at the beam peak of the wanted network receive beam. For determining the downlink interference margin, it is assumed that the wanted receive earth station is located at the beam peak of the interfering transmit beam. This represents a worst-case condition and, on average, the interference margin could be improved by 2 dB.

– The carriers transmitted or received at the earth stations as assumed in this study are worst-case carriers. In general, such worst-case situations do not arise due to the compatibility requirements with the closer adjacent satellite networks, and the fact that the worst-case carriers of the interfering network are not co-frequency with the most sensitive carriers of the wanted networks. Based on these assumptions, the interference margin could be improved by up to 3 dB.

– The earth stations side-lobe performance assumed in this study follow exactly the 29-25 log φ pattern of some ITU-R Recommendations. On average, the interference margin could be improved by 1 dB due to improved performance in actual side lobe.

Taking into consideration the factors described above, the negative interference margins of up to 6 dB with respect to the $\Delta T / T$ criteria could be considered acceptable. Furthermore, due to the fact that the measures to be adopted by the proposed satellite system in order to protect intervening adjacent satellites will considerably reduce the potential to cause interference into satellites located farther away, some prior safety factor may be assumed.

4 Summary of results

From the results, it follows that an angular separation of ±9° for the 13-14/11-12 GHz band and ±8° for the 30/20 GHz band will ensure that the $\Delta T / T$ of 80% of the GSO FSS networks studied will not exceed the value of 6%. These values can be used as a trigger for the coordination of GSO networks sharing the same frequency band.

The choice of an appropriate value to select depends upon the perceived likelihood that the presence of intervening successfully coordinated networks would assure that interference is not likely. In the three bands in question, the nominal separations in most countries range from 2-4° in the 6/4 GHz band, and 2° in the 13-14/11-12 GHz and the 30/20 GHz bands. Thus, it is to be expected that the number of intervening networks would be higher at 6/4 GHz band than in the other two bands. Thus, coordination arcs of ±10°, ±9° and ±8° are indicated.

The maximum permissible uplink power density and uplink power level assumes a transmit earth station antenna side-lobe envelope of 29-25 log φ.

TABLE 3

Summary of INTELSAT minimum parameters used in the calculation of interference margins in Tables 4 and 5

Space station	Carrier type	Uplink frequency (GHz)	Downlink frequency (GHz)	Uplink e.i.r.p. (dBW)	Downlink e.i.r.p. (dBW)	C/N (dB)	Occupied bandwidth (MHz)	Rx earth station gain (dBi)
VII/VIIA	Analogue	6	4	56.7	9.8	15.0	1.100	59.3
VIII	Narrow-band digital	6	4	32.9	–9.4	9.7	0.013	53.5
VII/VIIA	Narrow-band digital	6	4	49.4	–2.0	9.7	0.013	41.8
IX	Wideband digital	6	4	60.1	31.4	5.9	8.590	42.3
VII	Wideband digital	6	4	84.7	31.6	5.9	8.590	33.0
VII	Wideband digital	6	4	64.4	27.5	8.9	5.727	44.3
VII/VIIA	FM/TV	6	4	75.6	29.7	17.4	30.000	53.5
VII/VIIA	FM/TV	6	4	77.1	25.0	14.3	18.000	50.3
VIII	Analogue	14	11	53.3	17.6	15.0	1.100	63.0
VIII	Analogue	14	11	54.4	17.4	15.0	1.100	63.0
805	Narrow-band digital	14	11	40.7	5.1	14.0	0.051	63.0
VIII	Narrow-band digital	14	11	45.5	14.7	10.5	0.077	44.1
IX	Wideband digital	14	11	61.6	47.0	7.9	29.935	47.7
VII	Wideband digital	14	11	82.3	46.5	7.9	29.935	39.4
IX	FM/TV	14	11	62.6	47.0	12.0	15.750	47.3
VII	FM/TV	14	11	71.9	41.4	12.0	15.750	43.9

TABLE 4

Worst-case interference margin at 6/4 GHz band

Trigger angle (degrees)	Interfering carrier	Non-FM/TV	FM/TV(1)
	Wanted carriers	Interference margin (dB)	Interference margin (dB)
6	Analogue	–10.2	–10.2
	Narrow-band digital	–9.6	–9.6
	Wideband digital	–6.4	–
	FM/TV	–11.0	–
7	Analogue	–8.5	–8.5
	Narrow-band digital	–7.9	–7.9
	Wideband digital	–4.8	–
	FM/TV	–9.3	–
8	Analogue	–7.1	–7.1
	Narrow-band digital	–6.5	–6.5
	Wideband digital	–3.3	–
	FM/TV	–7.9	–
9	Analogue	–5.8	–5.8
	Narrow-band digital	–5.2	–5.2
	Wideband digital	–2.0	–
	FM/TV	–6.6	–
10	Analogue	–4.6	–4.6
	Narrow-band digital	–4.0	–4.0
	Wideband digital	–0.9	–
	FM/TV	–5.5	–
11	Analogue	–3.6	–3.6
	Narrow-band digital	–3.0	–3.0
	Wideband digital	–	–
	FM/TV	–4.4	–
12	Analogue	–2.7	–2.7
	Narrow-band digital	–2.1	–2.1
	Wideband digital	–	–
	FM/TV	–3.5	–
13	Analogue	–1.8	–1.8
	Narrow-band digital	–1.2	–1.2
	Wideband digital	–	–
	FM/TV	–2.6	–
14	Analogue	–1.0	–1.0
	Narrow-band digital	–0.4	–0.4
	Wideband digital	–	–
	FM/TV	–1.8	–
15	Analogue	–0.2	–0.2
	Narrow-band digital	–	–
	Wideband digital	–	–
	FM/TV	–1.1	–

(1) FM/TV modulated by video (noise-like with –63 dBc/Hz).

TABLE 5

Worst-case interference margin at 13-14/11-12 GHz band

Trigger angle (degrees)	Interfering carrier / Wanted carriers	Non-FM/TV Interference margin (dB)	FM/TV(1) Interference margin (dB)
6	Analogue Narrow-band digital Wideband digital FM/TV	–8.2 –8.7 –6.2 –8.7	–8.2 –8.7 – –
7	Analogue Narrow-band digital Wideband digital FM/TV	–6.5 –7.0 –4.5 –7.0	–6.5 –7.0 – –
8	Analogue Narrow-band digital Wideband digital FM/TV	–5.1 –5.6 –3.1 –5.6	–5.1 –5.6 – –
9	Analogue Narrow-band digital Wideband digital FM/TV	–3.8 –4.3 –1.8 –4.3	–3.8 –4.3 – –
10	Analogue Narrow-band digital Wideband digital FM/TV	–2.7 –3.2 –0.7 –3.2	–2.7 –3.2 – –
11	Analogue Narrow-band digital Wideband digital FM/TV	–1.6 –2.1 – –2.1	–1.6 –2.1 – –
12	Analogue Narrow-band digital Wideband digital FM/TV	–0.7 –1.2 – –1.2	–0.7 –1.2 – –
13	Analogue Narrow-band digital Wideband digital FM/TV	– –0.3 – –0.3	– –0.3 – –
14	Analogue Narrow-band digital Wideband digital FM/TV	– – – –	– – – –
15	Analogue Narrow-band digital Wideband digital FM/TV	– – – –	– – – –

(1) FM/TV modulated by video (noise-like with –63 dBc/Hz).