

RECOMMENDATION ITU-R S.1781

Possible methodology for frequency sharing between bidirectional geostationary fixed-satellite service networks comprising ubiquitously deployed earth stations

(Question ITU-R 209/4)

(2007)

Scope

This Recommendation provides a methodology to establish frequency compatibility, based on area coordination, between two fixed-satellite service (FSS) systems when one or both systems involve large numbers of ubiquitously deployed ground terminals and the terminals of one system are transmitting while the terminals of the other system are receiving in the same frequency bands allocated bidirectionally to the FSS.

The ITU Radiocommunication Assembly,

considering

- a) that there is a growing interest in the ubiquitous deployment of very small aperture terminal (VSAT)-type fixed-satellite service (FSS) earth stations, i.e. in the installation and operation of earth stations without individual licences but under the overall licence for the system in which they operate;
- b) that in such cases the precise locations of particular earth stations would not be known at the time that frequency coordination is carried out for the system;
- c) that the need to deploy the earth stations in large numbers would make their coordination on a site-by-site basis difficult;
- d) that some frequency bands in which such deployment would be desirable are allocated to the FSS on a bidirectional basis;
- e) that some of the bands allocated to the FSS on a bidirectional basis are also subject to specific regulatory provisions, for example, provisions of the FSS Allotment Plan or of the Radio Regulations (RR) Appendix 30A Plan;
- f) that some administrations may opt for some form of area coordination within which VSAT-type FSS earth stations may operate in a single direction of transmission;
- g) that in such cases as described in *considering* f) it may be helpful for administrations to have methodologies for determination of the overall coordination area based on technical criteria of their choice,

noting

- a) that the coordination contour around the region within which an administration wishes to implement area coordination may border other areas of coordination contained in the territory of the same administration or international borders;

b) that administrations would need to take necessary steps to identify the frequency bands and associated geographical areas where any coordination method involving a large number of terminals operating in the same band would be implemented,

recognizing

- a) that administrations are free to pursue bilateral agreements outside of the scope of the RR;
- b) that administrations are free to choose the level of protection to be afforded to the VSAT-type FSS earth stations deployed in their territory;
- c) that, in the case of international coordination, administrations would have to agree on earth station and protection characteristics to be considered;
- d) that factors such as the protection of receiving earth stations with respect to higher-powered transmitting earth stations located in the territory of administrations not included in a bilateral agreement may indicate the desirability of recording receiving earth stations with the Radiocommunication Bureau, whether or not they are covered by a bilateral agreement;
- e) that for the case of earth stations planned to operate in bands allocated to the FSS on a bidirectional basis subject to specific regulatory provisions, these provisions must also be taken into account by administrations when planning their deployment,

recommends

1 that administrations intending to license within their territory, based on area coordination, ubiquitously deployed VSAT-type FSS earth stations operating in bands allocated bidirectionally to the FSS, should consider the use of the guidelines contained in Annex 1 to this Recommendation.

Annex 1

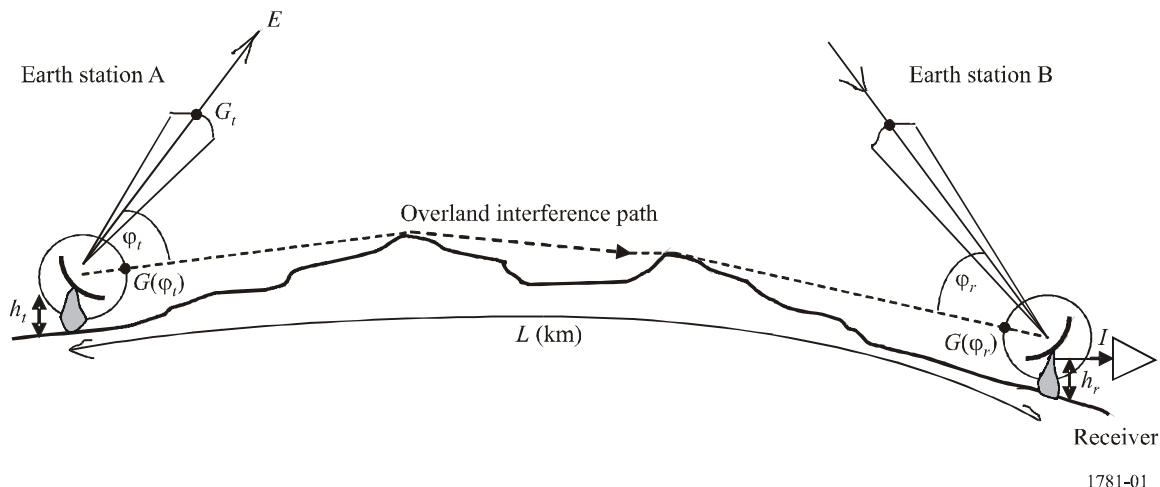
1 Introduction

This Annex contains the elements of a methodology to establish frequency compatibility between two FSS systems when one or both systems involve large numbers of ubiquitously deployed ground terminals, and the terminals of one system are transmitting while the terminals of the other system are receiving.

The analysis developed in this Annex is based on system parameters used in the band 12.5-12.75 GHz. Since the bidirectional FSS allocations apply only in Region 1 in that band, it is necessary to use Region 1 countries as a basis for the examples. The methodology, however, is general and can be applied to any bands where there is bidirectional FSS sharing.

2 Methodology

FIGURE 1



1781-01

In the example illustrated in Fig. 1, earth station A operates to a geostationary satellite equipped to use the 12.5-12.75 GHz FSS (Earth-to-space) allocation, while earth station B operates to another geostationary satellite using the 12.5-12.75 GHz FSS (space-to-Earth) allocation. Earth station A transmits a PSK carrier centred on 12.625 GHz, with an e.i.r.p. spectral density of E dB(W/MHz), and interferes via an overland path with the reception by earth station B of another phase shift keying (PSK) carrier centred on 12.625 GHz. The interference spectral density, I , at the input to the receiver in earth station B is then given by:

$$I = E - G_t + G(\phi_t) - pl + G(\phi_r) \quad \text{dB(W/MHz)} \quad (1)$$

where:

- G_t : on-axis gain of the antenna at earth station A (dBi)
- $G(\phi_t)$: earth station A antenna gain toward the horizon in the direction of earth station B (dBi)
- pl : path loss between the two stations (dB)
- $G(\phi_r)$: earth station B antenna gain toward the horizon in the direction of earth station A (dBi)
- ϕ_t : off-axis angle at earth station A toward the horizon in the direction of earth station B (degrees), and
- ϕ_r : off-axis angle at earth station B toward the horizon in the direction of earth station A (degrees).

Instead of using absolute case assumptions, it is possible to generate contours within which deployment of FSS stations operating in opposite directions of transmission in the same bands would be compatible for any given percentage of cases by appropriate selection of the parameters to be used with equation (1).

For example, during 2002, an ITU-R survey of existing and planned FSS earth stations produced statistics of diameters of antennas, their e.i.r.p. and the bandwidth of the carriers transmitted. The survey included almost 127 000 terminals with antennas in the diameter range 1.5 to 2.1 m. Although the survey concentrated mainly on earth stations designed to transmit in the band

14-14.5 GHz, it may be assumed that a survey concentrating on the band 12.5-12.75 GHz would yield similar statistics, albeit from a smaller database. These results could be used to make reasonable assumptions for the parameters E and G_t in equation (1).

The values of φ_t or φ_r depend on the latitude and longitude of the earth station, the longitude of the satellite to which it is operating, and the azimuth bearing of the other earth station. The variation in φ with these parameters is calculated in Appendix 1, which also shows how cumulative distribution functions of off-axis angles for interference between earth stations operating in opposite directions of transmissions can be developed so that adequate values of φ_t and φ_r may be chosen for use with equation (1).

2.1 Methodology applied to an international example

The ITU-R survey of existing and planned FSS earth stations in 2002 revealed that the most popular diameter of antennas installed up to then and operating in the band 14-14.5 GHz was around 1.8 m, and that 98% of such antennas transmitted carriers whose e.i.r.p.s did not exceed 52 dBW and whose bandwidths do not exceed 1 MHz. The values of $E = 52 \text{ dB(W/MHz)}$ and $G_t = 10 \log ((0.65) \{ \pi \cdot (1.8) / \lambda \}^2) = 45.7 \text{ dBi}$ were therefore selected for the present example.

As shown in Appendix 1, for about 96% of the earth stations φ_t and φ_r will not be less than 25° , and therefore $G(\varphi_t)$ and $G(\varphi_r)$ will not be greater than -3 dBi . Appendix 1 also shows that, if $G(\varphi_t) \cong -3 \text{ dBi}$, then it is sufficiently conservative to assume that $G(\varphi_r) \cong -10 \text{ dBi}$, and vice versa.

Taking these values for E , G_t , $G(\varphi_t)$ and $G(\varphi_r)$ as representing a quasi-worst-case, equation (1) becomes:

$$I = -6.7 - pl \quad \text{dB(W/MHz)} \quad (2)$$

According to Recommendation ITU-R S.1323, a GSO FSS link should be designed on the basis that “the aggregate interfering power from the earth and space station emissions from all other GSO FSS networks ... does not exceed, at the input to the demodulator, ... 20% of the total system noise power under clear-sky conditions...”. For the present example it is assumed that the aggregate interference comprises equal contributions from the uplink and downlink emissions of all co-directional and bidirectional GSO FSS systems in a 1 MHz band centred on 12.625 MHz. Hence the aggregate interference received at earth station B from all earth stations using this 1 MHz band in the Earth-to-space direction is limited here to a maximum of 5% of the link noise budget.

With the exception of CDMA networks, only one earth station can transmit to a given satellite at a given carrier frequency and sense of polarization, at the same time, within the coverage of a given receive beam, since the uplinks of multiple co-frequency carriers to the same beam would interfere grossly with each other. (Although CDMA allows n such carriers to coexist under these circumstances, the carrier e.i.r.p. of each earth station in that case is only about $1/n$ -th of the e.i.r.p. of a single earth station employing FDMA.) At latitudes near 50° the GSO is above 10° elevation at any single point on the Earth's surface over a longitude range of about 120° (i.e. $\pm 60^\circ$). The minimum spacing between co-frequency, co-coverage satellites in ITU Regions 1 and 3 is about 3° , and in Region 2 it is about 2° . It follows that, in the limit, 40 to 60 earth stations in a given coverage area could transmit on the same carrier frequency and polarization to different satellites in the GSO, the interference between their uplinks being within acceptable limits owing to the discrimination provided by their antenna transmit patterns.

However, even if in the carrier band considered the GSO spectrum resource was fully utilized in this manner, it is highly unlikely that all the earth stations transmitting in the common coverage area would be located sufficiently near to a given earth station receiving a co-frequency carrier to cause

significant interference to that earth station. For one thing, it is likely that the resource would be divided among several countries because a typical satellite beam operating in the band 14-14.5 GHz is dimensioned for continental, rather than national, coverage. Hence an allowance for ten earth stations transmitting in the 1 MHz band at 12.625 GHz and interfering with the same earth station receiving at this frequency is deemed to be sufficiently conservative for present purposes. In this study the maximum interference from a single earth station A to earth station B in clear air is therefore limited to 0.5% of the system noise budget.

Since interference via overland paths is affected by propagation conditions, it is necessary to know the percentage of time for which “clear air” conditions apply. In Recommendation ITU-R S.1062 the long-term BER requirements are permitted to be exceeded for no more than 10% of the worst month, which corresponds to 4% of the average year. Hence the interference from earth station A to earth station B should not exceed 0.5% of system B noise for more than 4% of the time, i.e.:

$$I \leq 10 \log ((0.05)(k T B)) \quad \text{dBW} \quad (3)$$

where:

$10 \log (k)$: -228.6 dB(W/Hz) per Kelvin (Boltzmann’s constant)

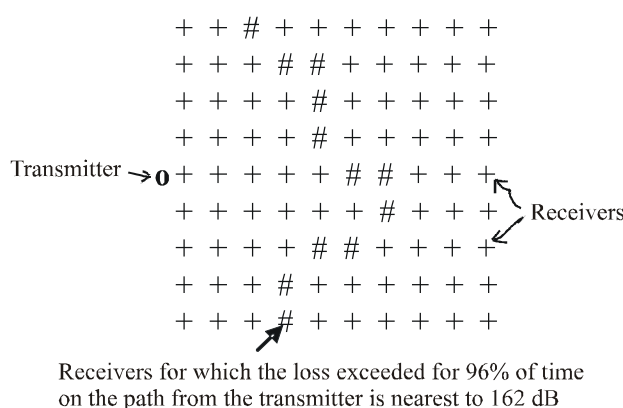
T : system noise temperature (> 200 K for most 14-14.5 GHz uplinks)

B : 1 MHz as defined above.

By combining equations (2) and (3) it may be deduced that, for the band to be shared by bidirectional FSS networks, the loss on the interference path between earth stations A and B should be 162 dB or greater for at least 96% of the time.

If a terrain database is available, i.e. a database containing the heights above sea level of the land at evenly distributed points over a given area, the information and algorithms in Recommendations ITU-R P.452 and ITU-R P.526 may be used to calculate the propagation loss exceeded for any given percentage of time over the Great Circle path between any two data points within that area. These Recommendations cover both line-of-sight and transhorizon paths, including atmospheric absorption and the diffraction, ducting and tropospheric scatter modes of propagation as appropriate. Thus if a software model comprising a single transmitter and a large number of evenly-spaced receivers is constructed, it is possible to compute the losses exceeded for a given percentage of time on the paths between the transmitter and each and every receiver, and thus to identify all the paths where the loss is close to a given value – see Fig. 2.

FIGURE 2



1781-02