

RECOMMENDATION ITU-R P.1412

**PROPAGATION DATA FOR THE EVALUATION OF COORDINATION
BETWEEN EARTH STATIONS WORKING IN THE BIDIRECTIONALLY
ALLOCATED FREQUENCY BANDS**

(1999)

The ITU Radiocommunication Assembly,

considering

- a) that the Radio Regulations allocate some frequency bands for the bidirectional use of Earth-space systems;
- b) that different propagation paths should be taken into account for the assessment of the need for coordination for two earth stations being operated bidirectionally;
- c) that studies have been undertaken by Radiocommunication Study Group 1 on the determination of the coordination area around an earth station in frequency bands between 0.1 GHz and 105 GHz;

recommends

- 1 that the information and illustrative examples contained in Annex 1 should be taken into account when considering the need for coordination between earth stations operated bidirectionally.

ANNEX 1

1 Introduction

The possible requirements for operating earth stations in bidirectional frequency allocations raises a number of considerations which need to be consolidated in order to demonstrate that sharing is feasible in many cases. This Annex demonstrates this feasibility and then extends the assessment to particular areas where such operations require more careful scrutiny. By facilitating the evaluation of interference potential within the coordination area determined by Recommendation ITU-R IS.848, the feasibility of such operations is emphasized.

The purpose here is to provide a simplified procedure, applicable to representative geometrical configurations, concentrating on the evaluation of the effect of rain scatter in bidirectional coordination.

2 Interference scenarios

Three interference configurations are considered:

- between two (large) earth stations, with both transmitter and receiver operating to two separate geostationary satellites;
- between a geostationary-satellite orbit (GSO) terminal and a feeder link for a non-GSO satellite of the mobile-satellite service (i.e. earth station with a large antenna);
- between a GSO terminal and a large number of non-GSO fixed-satellite service (FSS) terminals (small antennas).

For the first two of these configurations, which employ medium/high gain antennas, the narrow-beam approximation of the bistatic radar equation may be used.

For the third configuration, with one medium/high gain antenna and many small earth stations with widebeam antennas, the narrow-beam approximation can be used for the main lobe of the high gain antenna to the side lobe of the widebeam antenna. In this case, it is assumed that the small earth stations may be limited to elevation angles above 40°; other cases with elevation angles down to 15° may need a different approach, e.g. using the auxiliary contour method.

3 Basis of the method

3.1 Mode (1), clear air propagation

For mode (1), the interference along the great circle plane containing the boresight will be reduced by at least 22 dB when the elevation angle of the earth station antenna is increased from 5° to at least 40°. At other azimuths, not along the boresight azimuth, the reduction will be smaller but it will be from a lower initial value of antenna gain in that direction.

3.2 Mode (2), hydrometeor scatter

For mode (2), the computation is more complex but a reduction in coupling can be inferred qualitatively from the reduced common volume within the atmosphere which will result from raising the earth station elevation angles from 5° to at least 40°.

The geometry assumed for the method is shown in Fig. 1, where T is the transmitter and R is the receiver. It is assumed initially, that the beam from T is in, or near, the vertical direction with an isolated rain cell located so as to fill the beam, i.e. a "worst case" situation. Applying the general equation for bistatic scatter to an element δV in the beam as shown in Fig. 1:

$$P_r / P_t = (G_t / 4\pi y^2) (\eta \cdot \delta V / 4\pi x^2) (G_r \lambda^2 / 4\pi) \quad (1)$$

where:

- x : distance from δV to R
- y : distance from δV to T
- G_t : transmitter antenna gain
- G_r : receiver antenna gain
- η : average cross section per unit volume
- λ : wavelength

and no attenuation is assumed outside the beam from T.

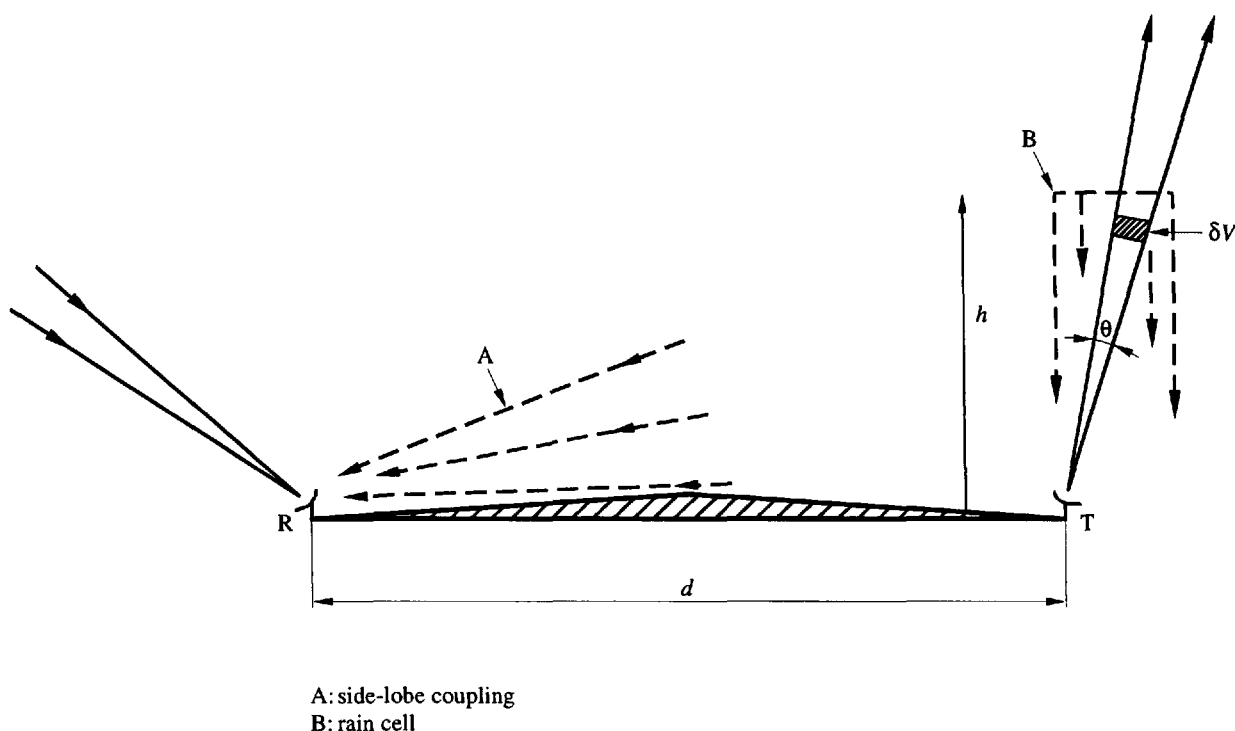
Suppose d , the separation between T and R, is appreciably greater than the rain height, h . Then if the beam from R is directed in azimuth and elevation so that it is at least 45° from any portion of the rain in the beam from T, there is a simple expression for the side-lobe gain of R in the rain direction. Also, most of the rain in the beam from T will contribute to the scatter (assuming no significant site shielding) until d becomes much larger than, say, 100 km. Even for $d = 200$ km, 80% of the rain volume in the beam will still be effective, assuming $h = 4$ km and a "4/3 Earth" model.

Substituting for δV , in terms of G_t and integrating for the whole volume, it can easily be shown that the ratio of received to transmitted power is given by:

$$P_r / P_t \approx (G_r \eta \lambda^2 h) / 256 d^2 \quad (2)$$

for the conditions assumed, where G_r is the side-lobe gain (assumed uniform) as shown in Fig. 1, and the beam T is in, or near, the vertical direction.

FIGURE 1
Bidirectional scatter geometry



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The estimation of the additional loss due to attenuation outside the common volume is a complex problem of statistical variability in both rainfall rate, and rain cell size. However, recognizing that a "conservative" estimate is necessary in coordination, an isolated rain cell may be assumed. The additional loss will depend, at a given frequency, on the size of the cell and its location. If it is located so that an appreciable portion of the cell is between T and R, the extra loss may be significant. If its centre lies on the other side of T from R (but still filling the T beam), the extra loss will be small. It has been shown that, due to the compensating effects of decreasing cell diameter and increasing rate of attenuation (dB/km) as rainfall rate increases, the additional loss is not strongly dependent on rainfall rate, being approximately 4 dB, for rainfall rates in the range 10-60 mm/h, at 18 GHz; about 2 dB at 12 GHz; and negligible at 4 GHz. Although the geometry would be somewhat different, the same values could be assumed for attenuation outside the rain-scatter volume. With this addition, plus a small correction for gaseous absorption where necessary, the transmission loss can be calculated as a function of distance, frequency, and of reflectivity (i.e. rainfall rate). It is appropriate to assume a value of 4 km for the rain height, h , a value which is representative of a time percentage of about 0.01% for latitudes of 0° to 55° .

For the third configuration, listed in § 2, use Recommendation ITU-R P.620 as a basis for the computations if the elevation of the widebeam antenna goes below 30° .

4 Illustrative examples of the application of the method to the three configurations

4.1 Bistatic scatter calculations for GSO/FSS

Numerical integrations using the bistatic radar equation have been performed for main lobe – side-lobe coupling between two stations working in the bidirectional mode. Calculations were made assuming the transmitter and receiver have similar gains of 57.5 dB, with a side-lobe pattern given by:

$$G(\varphi) = 32 - 25 \log_{10}(\varphi) \quad (3)$$

The transmitter elevation angle was fixed at 30° . The receiver was assumed to be pointing away from the transmitter direction, i.e. with an elevation angle greater than 90° . The geometry is shown in Fig. 2.