RECOMMENDATION ITU-R M.1469-1*

Methodology for evaluating potential for interference from time division multiple access/frequency division multiple access (TDMA/FDMA) mobile-satellite service (MSS)(Earth-to-space) transmissions into line-of-sight fixed service receivers in the 2 GHz range**

(Question ITU-R 201/8)

(2000-2005)

Scope

This Recommendation provides a methodology that may be used to assess the potential for interference from deployments of mobile earth stations (MES) that use non-directive antennas into line-of-sight fixed service (FS) receivers in the 2 GHz range. This method provides predictions of the probability of interference into FS receivers in areas where there is co-frequency sharing between the two services.

The ITU Radiocommunication Assembly,

considering

a) that mobile earth stations (MES) may potentially interfere with line-of-sight FS receivers operating in the 1 980-2 010 MHz and 2 010-2 025 MHz MSS bands within the MES coordination area, as determined using the methods in Radio Regulations (RR) Appendix 7;

b) that the nature of such interference would be time-varying;

c) that there is a need for detailed analysis tools to facilitate coordination between administrations operating MES and affected administrations operating FS receivers,

recognizing

a) that the frequency bands 1 980-2 010 MHz in all Regions and 2 010-2 025 MHz in Region 2 are allocated to the MSS (Earth-to-space) and the FS on a co-primary basis;

b) that in § 4.3 of Resolution 716 (Rev.WRC-2000), administrations have been encouraged, where practicable, to draw up plans for the gradual transfer of the frequency assignments to their FS stations in the bands 1 980-2 010 MHz and 2 170-2 200 MHz in all three Regions and 2 010-2 025 MHz and 2 160-2 170 MHz in Region 2 to other frequency bands;

c) that consequently, technical guidelines have been developed for consideration by administrations to facilitate transition of the FS from these frequency bands in order to prevent harmful interference to MSS (Earth-to-space) systems (see Recommendation ITU-R F.1335),

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* This Recommendation should be brought to the attention of Radiocommunication Study Group 3.

** This Recommendation was developed jointly by Radiocommunication Study Groups 8 and 9 and any further revision will be undertaken jointly.

recommends

1 that when assessing the potential for interference from MES to FS systems, account should be taken of the time-varying nature of MES signals received by FS stations, including the effects of predicted diurnal and geographic distributions of transmitting MES, and the temporal variations of the power level of desired signals in FS systems;

2 that the methodology in Annex 1 may be used in bilateral coordination for detailed assessment of the potential for interference to FS receivers from a population of MES using non-directive antennas (see Notes 1 and 2).

NOTE 1 – The application of the methodology in this Recommendation will require the development of algorithms or calculation procedures to address the implementation of the considerations described. The use or adaptation of these algorithms or procedures in any bilateral coordination would be subject to agreement by the concerned parties.

NOTE 2 – That in territories where a large number of FS systems are in operation, it may suffice to apply the methodology of Annex 1 with respect to a representative set of FS systems using their actual parameters, taking care to include FS systems that are likely to be most susceptible to interference by virtue of their locations and characteristics.

Annex 1

Methodology for detailed assessment of the potential for interference to FS receivers from MES

(see Note 1)

NOTE 1 – The methodology presented herein is applicable to FS systems, which enables a somewhat simplified approach that addresses the interfering signal power and the associated performance levels in an individual hop of a multihop radio-relay system. A similar methodology addressing a single hop of a multihop analogue radio-relay system can be developed and applied with respect to appropriate performance criteria (i.e. end-to-end performance criteria for a multihop analogue system that has been appropriately pro-rated according to the number of hops).

1 Introduction

This Annex presents a detailed simulation method that may be used to assess the potential for interference from realistic deployments of MES using non-directive antennas into line-of-sight FS receivers. The method provides detailed predictions of the probability of interference into FS receivers in areas where there is co-frequency sharing between the two services.

2 General description

A simulation is executed over a large number of time steps. At each time step the following calculations are performed:

2.1 The level of the desired signal at the FS receive station within a 1 MHz reference bandwidth is calculated using the FS transmission characteristics in conjunction with the model of multipath fading given in Recommendation ITU-R P.530. (See § 3 for more details.)

2.2 The aggregate interfering signal power in the reference bandwidth from all active MES deployed within a defined area is calculated at the input to each FS receiver. Digital terrain data is used to derive terrain profiles for the interference paths from each MES to each FS receiver. The basic transmission loss for each interference path is calculated using the methods in Recommendation ITU-R P.452. (See § 4 for more details.)

2.3 The $C/(N + I)$ at each FS receiver is calculated. (See § 5 for more details.) In calculating the value of N, the effects of all FS system degradations should be included (for example, see Recommendation ITU-R M.1319).

By running the simulation for a sufficiently long time (i.e. a very large number of time increments), statistically significant results can be gathered. This process is applied to various realistic deployments of MES in order to eliminate the sensitivity of the results to the particular deployments considered, which can be particularly important in cases where the number of simultaneously-transmitting MES located within line-of-sight of an FS station may vary substantially over time. The cumulative probability distribution of $C/(N + I)$ can then be compared with the performance objectives of the FS system (expressed in terms of equivalent $C/(N + I)$ thresholds within the reference bandwidth).

3 FS modelling

3.1 FS parameters

The deployment, equipment and performance characteristics of the FS system should be modelled using the parameters listed in Table 1. The fade depth should be calculated from Recommendation ITU-R P.530, which together with the free-space-loss is used to determine the basic transmission loss on the desired signal path.

TABLE 1

List of required FS parameters

Parameter
Antenna gain, G (dBi)
Antenna pattern, $G(\theta)$[(1)] (dBi)
Antenna noise temperature, T (K)
Transmission frequency, f (MHz)
e.i.r.p.$_{FS}$ (dBW)
Feeder loss, L_S (dB)
Feeder noise temperature (K)
Receiver occupied bandwidth (MHz)
FS station position (° N, ° E)
Antenna height above mean sea level (m)
Geoclimatic factor, K
Receiver noise temperature (K)

(1) FS antenna gain in the direction of the interferer.

3.2 Calculation of the power level of the desired signal

The first step is to calculate the received power level of the desired signal at an instant in time, $C(t)$. This is done with a random number generator to predict the fade depth, A, consistent with the distribution given in § 2.3 of Recommendation ITU-R P.530. The received signal level at each time step is calculated at the input of the FS receiver in each receiving station under consideration using the following equation:

$$C(t) = e.i.r.p._{FS} - L_{bf} + G - A(t) - L_s \tag{1}$$

where L_{bf} is the free space basic transmission loss. It may be possible in some cases, (e.g. based on measured data), to take account of diurnal and/or seasonal variations in multipath fading propagation behaviour.

4 MES modelling

4.1 MES geographic distribution

The MES geographic distribution is defined inside an area of interest (AoI), which has to be sufficiently large so that all significant interference contributions are taken into account. The AoI is overlaid with a grid of latitude/longitude points, which represent possible MES locations. The MES traffic profile is defined by two basic parameters:

– the number of active MES carriers at the local busy hour;

– a time of day profile.

The AoI can be subdivided into smaller cells, to enable variation of the above parameters.

At each time step the number of MES that are transmitting within a cell is determined from the MES traffic profile and the time of day. An MES at each point in the AoI will then be selected as being either transmitting or idle. This is determined by first determining the probability that an MES is transmitting, p(active), at this moment of time. A random number is then generated, and if the random number is less than p(active) the MES is assumed to be transmitting; otherwise, the MES is assumed to be idle.

The MES geographic distribution is assumed to be independent from time step to time step. This assumption can be made since the purpose of the method is to derive long-term interference statistics, not the time evolution of interference.

4.2 MES signal propagation

A terrain database is required to accurately predict the basic transmission loss on the interfering signal paths between the MES and the FS receiver. A terrain profile is generated for the great circle path between each transmitting MES and each FS receiver under consideration, and the basic transmission loss at each time step is calculated using the clear-air interference prediction method in Recommendation ITU-R P.452. Because this propagation model predicts basic transmission losses exceeded for time percentages of 50% or less (rather than a complete cumulative distribution), it is necessary to appropriately extend the predicted cumulative time distribution of loss to higher time percentages in order to encompass the relatively high losses that may occur (rather than assume that the 50% value is the maximum level of basic transmission loss). Likewise it may be appropriate to extrapolate the basic transmission loss to very small percentages of time (e.g. less than 0.001%), by assuming a suitable small value for a minimum basic transmission loss. Even with an extrapolation, this propagation model may underestimate the basic transmission loss in some situations (e.g. as a result of local phenomena not addressed by the model, such signal blockage due to intervening buildings not included in the terrain data and user "head blockage"). This leads to overestimation of interfering signal power levels.

4.3 The interference calculation

The interference power at each time step at the input of the FS receiver is calculated as follows:

$$I(t) = e.i.r.p._{MES} - L_b(t) + G(\theta) - L_s \tag{2}$$

where:

$e.i.r.p._{MES}$: equivalent isotropically radiated power of the MES within the reference bandwidth (dBW)

L_b: basic propagation loss for the interfering signal (see § 4.2).

For deployments involving multiple transmitting MES, the aggregate interfering signal at each time step is taken as the sum of all single-entry levels of interfering signal power.

$$I_{agg}(t) = 10 \log \left(\sum_i 10_i^{I(t)/10} \right) \tag{3}$$

where:

$I_i(t)$: single-entry interfering signals (dB).

5 Outputs

Each time step of the simulation will produce $C/(N + I)$ values for each FS receiver considered in the simulation. These values are suitably quantized (e.g. 1 dB intervals) and stored (e.g. as the number of occurrences of a quantized value). At the end of the simulation, the cumulative distribution functions can then be computed and compared to relevant FS performance objectives, e.g. from Recommendations ITU-R F.634 or ITU-R F.697, converted to equivalent $C/(N + I)$ thresholds.