

RECOMMENDATION ITU-R M.1315

**METHODOLOGY FOR EVALUATING INTERFERENCE FROM NARROW-BAND
MOBILE-SATELLITE NETWORKS TO SPREAD-SPECTRUM DIRECT-SEQUENCE
MOBILE-SATELLITE NETWORKS OPERATING WITH SPACE STATIONS IN
LOW-EARTH ORBIT AT FREQUENCIES BELOW 1 GHz**

(Question ITU-R 83/8)

(1997)

Summary

Simplified and detailed methodologies are presented for evaluating the effect of narrow-band interfering signals on spread-spectrum communication channels. The methodologies allow a rapid comparison of the relative effects of changes to parameters of the desired and interfering signals, such as power level, bandwidth, and frequency offset, which may be investigated to facilitate sharing between narrow-band and spread-spectrum mobile-satellite networks.

The ITU Radiocommunication Assembly,

considering

- a) that permissible levels of interference to spread-spectrum, direct-sequence networks operating in the low-Earth orbit mobile-satellite service (LEO MSS) should be based on performance objectives for that service;
- b) that LEO MSS networks proposed for operation in shared frequency bands should be designed to accommodate limited interference from systems operating in the same bands, including other LEO MSS networks (both spread-spectrum and narrow-band),

recommends

- 1 that the detailed analysis methodology in Annex 1 be used for fully evaluating the degradation in performance of direct-sequence, spread-spectrum LEO MSS networks caused by narrow-band LEO MSS transmissions;
- 2 that the simplified methodology of Annex 2 be used to determine whether a potential interference condition exists between transmitters in a narrow-band LEO MSS network and receivers in a direct-sequence, spread-spectrum LEO MSS network.

ANNEX 1**Detailed methodology for assessing interference****1 Introduction**

The performance of a spread-spectrum LEO MSS network can be degraded by the simultaneous operation of narrow-band transmitters in the same frequency band. Whilst it is of general interest to compute the bit-energy-to-noise density ratio, E_b/N_0 , to estimate interference to a particular communication link, it is often sufficient to compute the carrier-to-noise density (CND) at the input to the receiver. In fact, without detailed knowledge of a particular receiving

system, E_b/N_0 may be difficult or impossible to compute, whereas CND is relatively easy to compute. The effect of noise sources outside the network is easily expressed as a change to the CND, allowing easier comparison between alternative designs and frequency sharing arrangements.

Interference effects expressed as changes to CND are computed both for the worst case of an interfering transmitter being within the main lobe of a tracking antenna and for the more prevalent case of the interfering transmitter being in a side lobe of the tracking antenna.

2 Outline of the calculation procedure

Step A: Collection of network parameters:

- orbital parameters (altitude, constellation description),
- spacecraft radio parameters (power, bandwidth, antenna gain pattern, polarization),
- Earth station radio parameters (antenna, G/T).

Step B: Computation of the spread-spectrum CND network without external interference.

Step C: Computation of CND due to external interference in both main beam and side lobes for each simultaneously received interfering signal, including the effect of frequency offset.

Step D: Computation of overall CND ($C/(N_0 + I_0)$) for each interfering signal and of degradation to CND.

Step E: Computation of the overall CND degradation due to multiple-channel simultaneous interference entries.

3 Calculation steps (as defined in the above outline)

Step A: Collection of network parameters

To illustrate the calculation steps, two LEO MSS networks using the same downlink frequencies are assumed to have the parameters given in Table 1. It is assumed that the space station antennas are designed to compensate for the changing Earth-space basic transmission loss as the spacecraft rises, transits the sky, and sets. By assuming coupling into the main beam of the earth station, the computation can be made independent of receiver antenna gain. In the case of interference coming from a direction other than that of the main beam, the gain difference (or discrimination) between main and side lobes must be obtained (or a typical value must be assumed).

For this example, the spread-spectrum mobile earth station (user terminal) has a minimum elevation angle of 10° and an average elevation angle of 25° to its space station, and the feeder link (gateway) earth station operates with a 5° minimum elevation angle.

For the interfering transmitters in the narrow-band network, path loss values are required at the minimum elevation angle and the elevation angle which produces the maximum interfering signal.

Step B: Computation of spread-spectrum CND network without external interference

The overall CND of a communication network with a simple, frequency-translating transponder, is the reciprocal of the sum of the reciprocals of the CND values for the uplink and downlink. In the case of a multi-user spread-spectrum network of n users, additional noise in a particular user's link comes in the form of the carrier signals of the $(n - 1)$ other users. The CND for both of the inbound links (user terminal-to-satellite and satellite-to-gateway earth station) are computed and the carrier to self-interference ratio (CND_s) is computed. These will be combined to form a CND value that can be used as a basis for comparison with values determined when out-of-network interference is present.

TABLE 1

Typical parameters of example non-GSO MSS networks operating below 1 GHz

Network	Spread-spectrum (SS) network	Narrow-band (NB) network
<i>Orbital parameters</i>		
– Altitude (km)	1 000	775
– Number of satellites	24	32
– Number of orbits (satellites/orbit)	6 (4 satellites)	4 (8 satellites)
– Satellite separation, degree	90	45
<i>Operational parameters</i>		
Inbound Link (user–satellite):		
– Emission designation	905KG1D	Not applicable (the two example networks use different uplink frequencies)
– Frequency (MHz)	148.4245	
– Chip rate (kHz)	614.4	
– Maximum e.i.r.p. (dBW)	3.5	
– Number of users	12	
– Receiver G/T (dB(K ⁻¹))	–30	
– Path loss for minimum link (dB)	144.7 (10° minimum elevation angle)	
– Path loss for average link (dB)	141.1 (25° average elevation angle)	
Inbound Link (satellite–gateway):		
– Emission designation	905KG1D	5K00G1D
– Frequency (MHz)	137.5	137-138
– Maximum e.i.r.p. (dBW)	–14	7
– Path loss for minimum link (dB)	145.3 (5° elevation angle)	143.9 (5° elevation angle)
– Path loss for average link (dB)	140.7 (25° elevation angle)	140.4 (19° elevation angle)
– Path loss for maximum pfd (dB)	139.5 (32° elevation angle)	136 (42° elevation angle)
– Channel spacing (kHz)	–	10
– Antenna gain (dB)	16	–
– Side lobe gain (dB)	1	–
– Polarization	Left hand circular	Right hand circular
– Receiver G/T (dB(K ⁻¹))	–19.2	–

GSO: geostationary-satellite orbit.

In the equations below, the variables are defined as follows:

- n : number of simultaneous users
 C : carrier power (dBW)
 N : noise power (dBW)
 N_0 : noise density (dB(W/Hz))
 I : interference power (dBW)
 I_0 : interference density (dB(W/Hz))
 BW : bandwidth
 X : polarization isolation (dB)
 $e.i.r.p.$: effective isotropic radiated power (dBW)
 G : gain (dB)
 G_{diff} : gain difference between the desired and interfering antennas (dB)
 T : noise temperature (dBK)