

RECOMMENDATION ITU-R M.1459*

**PROTECTION CRITERIA FOR TELEMETRY SYSTEMS IN THE AERONAUTICAL MOBILE
SERVICE AND MITIGATION TECHNIQUES TO FACILITATE SHARING WITH GEOSTATIONARY
BROADCASTING-SATELLITE AND MOBILE-SATELLITE SERVICES IN THE
FREQUENCY BANDS 1 452-1 525 MHz AND 2 310-2 360 MHz**

(Question ITU-R 62/8)

(2000)

The ITU Radiocommunication Assembly,

considering

- a) that in Region 2, frequency allocations to the aeronautical mobile service for telemetry have a primary status in the band 1 435-1 525 MHz and have priority over other mobile services under RR No. S5.343;
- b) that WARC-92 adopted an additional allocation in the band 1 429-1 535 MHz, on a primary basis to the aeronautical mobile service for Belarus, the Russian Federation and Ukraine to be used exclusively for aeronautical telemetry subject to RR No. S5.342;
- c) that in accordance with the decision by WRC-95, in the United States of America, telemetry stations in the aeronautical mobile service have a primary status in the 2 300-2 390 MHz band and have priority over other mobile services under RR No. S5.394;
- d) that in Canada, telemetry stations in the aeronautical mobile service have a primary status in the 2 300-2 483.5 MHz band and have priority over other mobile services under RR No. S5.394;
- e) that in France, frequency assignments to telemetry stations in the aeronautical mobile service have a primary status in the 2 310-2 360 MHz band and have priority over other mobile services under RR No. S5.395;
- f) that in Europe future airborne telemetry equipment should tune primarily to the frequency range 2 300-2 400 MHz;
- g) that the band 1 492-1 525 MHz has been allocated to the MSS (space-to-Earth) in Region 2 taking account of the provisions of RR Nos. S5.348 and S5.348A;
- h) that WARC-92 allocated the band 1 452-1 492 MHz on a primary basis to the BSS (digital sound broadcasting (DSB)) (see Note 1) and the broadcasting service (DSB) subject to the provisions of RR Nos. S5.345 and S5.347;
- j) that at WARC-92, an additional allocation in the United States of America, India and Mexico of the 2 310-2 360 MHz band to BSS (DSB) and the broadcasting service (DSB) was made on a primary basis under RR No. S5.393;
- k) that in the band 1 452-1 525 MHz, WARC-92 adopted an alternative allocation on a primary basis for the fixed and mobile services in the United States of America in accordance with RR No. S5.344;
- l) that in Japan in the band 1 492-1 525 MHz, a coordination threshold of $-150 \text{ dB(W/m}^2\text{)}$ in any 4 kHz band for all angles of arrival was adopted at WRC-95 for the protection of specialized land mobile services in accordance with RR No. S5.348A;
- m) that coordination is required under RR No. S9.11A and Resolution 528 (WARC-92);
- n) that Resolutions 528 (WARC-92) and 213 (Rev.WRC-95) invited the ITU-R to conduct the necessary studies prior to the next competent WRC;
- o) that additional studies have been introduced in the ITU-R for determining the probability of interference to telemetry stations in the aeronautical mobile service which could lead to less stringent protection values, and that these studies are expected to continue;

* This Recommendation should be brought to the attention of Radiocommunication Study Group 6.

p) that telemetry stations in the aeronautical mobile service have a wide range of characteristics and some may have less stringent protection criteria values than those contained in the *recommends*,

recommends

1 that the values needed for protection of the aeronautical mobile service for telemetry systems in the 1 452-1 525 MHz band shared with geostationary satellites in the BSS (DSB) or the MSS, should be determined by the following (see Note 4):

– for geostationary satellites visible to any aeronautical telemetry receiving station, the protection value corresponds to a pfd at the telemetry receiving station in any 4 kHz band for all methods of modulation:

–181.0	dB(W/m ²)	for	$0^\circ \leq \alpha \leq 4^\circ$
–193.0 + 20 log α	dB(W/m ²)	for	$4^\circ < \alpha \leq 20^\circ$
–213.3 + 35.6 log α	dB(W/m ²)	for	$20^\circ < \alpha \leq 60^\circ$
–150.0	dB(W/m ²)	for	$60^\circ < \alpha \leq 90^\circ$

where α is the angle of arrival (degrees above the horizontal plane);

2 that the values needed for protection of the aeronautical mobile service for telemetry systems in the 2 310-2 360 MHz band shared with the BSS (DSB) should be determined by the following (see Note 4):

– for geostationary satellites visible to any aeronautical telemetry receiving station, the protection value corresponds to a pfd at the telemetry receiving station in any 4 kHz band for all methods of modulation:

–180.0	dB(W/m ²)	for	$0^\circ \leq \alpha \leq 2^\circ$
–187.1 + 23.66 log α	dB(W/m ²)	for	$2^\circ < \alpha \leq 11,5^\circ$
–162	dB(W/m ²)	for	$11,5^\circ < \alpha \leq 90^\circ$

where α is the angle of arrival (degrees above the horizontal plane);

3 that the calculation methods and mitigation techniques given in Annexes 1 and 2 may be used, as applicable, for determining the probability of interference to telemetry systems in the aeronautical mobile service.

NOTE 1 – DSB refers to digital audio broadcasting as per RR Nos. S5.345 and S5.393.

NOTE 2 – The example calculation used to derive the protection values as set out in Annex 1 represent a worst-case scenario. Mitigation techniques given in Annex 2 may enhance sharing.

NOTE 3 – As safety of life aspects are to be considered with mobile aeronautical telemetry systems and efficient use of the spectrum allocated by WARC-92 to the BSS (sound) appears not to be possible, attention is drawn to studies being conducted under Question ITU-R 204/10 (see Recommendation ITU-R BO.1383).

NOTE 4 – Administrations are encouraged to submit information to ITU-R concerning performance and availability targets for the mobile aeronautical telemetry service with a view to developing an appropriate ITU-R Recommendation.

ANNEX 1

Calculation of pfd interference levels to aeronautical mobile telemetry systems from geostationary satellite emissions

1 Introduction

The analyses and results given in the following sections of this Annex are for the purpose of calculating interference to aeronautical mobile telemetry systems.

2 Development of values

The following development can be used in general, but the numerical values are for the 1 452-1 525 MHz band.

2.1 Telemetry system characteristics

General system characteristics are given in the CPM Report to WARC-92 and are as follows. Aeronautical telemetry and telecommand operations are used for flight testing of manned and unmanned aerospace vehicles. Vehicles are tested to their design limits, thus making safety of flight dependent on the reliability of information received on a real-time basis. When being tested to design limits, signal strength loss can exceed 30 dB due to nulls in the aircraft antenna pattern caused by aircraft attitude changes.

Required C/N :	9-15 dB
Transmitter power:	2-25 W
Modulation type:	PCM/FM
Transmission path length:	up to 320 km
Receiving system noise temperature:	200-500 K
Receiving antenna gain:	20-41 dB

Receive antenna first side-lobe levels for two antennas:

10 m (diameter):	20 dBi (antenna gain)
	2.4° (from centre)
2.44 m (diameter):	7-14 dBi (antenna gain)
	10° (from centre)

A number of antenna diameters are employed between the 20-41 dB limits. Left-hand and right-hand circular, as well as linear polarizations, are used.

Channel assignments are made in 1 MHz increments. Typical emissions are 1, 3 and 5 MHz in bandwidth with wider assignments made for video and other complex measurements.

The maximum air space for a telemetry receiving site is defined as a cylinder with a horizontal radius of 320 km around the site, with the lower bound determined by visibility and the upper bound determined by an altitude of 20 km. The minimum air space for a particular mission is defined as a vertical cylinder with a radius of 20 km within the maximum air space with the same lower and upper bounds as for the maximum air space.

Continuous RF tracking is employed using both monopulse and conical scan techniques.

Two antenna diameters are given a 2.44 m and a 10 m diameter. Figure 1 shows measured gain values for three 2.44 m antennas. Since these antennas track a moving vehicle so that the antenna gain toward a geostationary satellite is variable, there is a side lobe and backlobe gain which is exceeded or not exceeded 50% of the time. The following composite pattern is developed on this basis for antenna gains from 29 dB to 41.2 dB.

$$G(\theta) = 41.2 + 20 \log \left(\frac{\sin 1.952 \theta}{1.952 \theta} \right) \quad \text{dBi} \quad \text{for} \quad 0^\circ \leq \theta \leq 0.94^\circ \quad (1a)$$

$$G(\theta) = 35.1 - 20 \log \theta \quad \text{dBi} \quad \text{for} \quad 0.94^\circ < \theta \leq 3.82^\circ \quad (1b)$$

$$G(\theta) = 29 + 20 \log \left(\frac{\sin 0.479 \theta}{0.479 \theta} \right) \quad \text{dBi} \quad \text{for} \quad 3.82^\circ < \theta \leq 5.61^\circ \quad (1c)$$

$$G(\theta) = 27.27 - 18.75 \log \theta \quad \text{dBi} \quad \text{for} \quad 5.61^\circ < \theta \leq 12.16^\circ \quad (1d)$$

$$G(\theta) = 34.05 - 25 \log \theta \quad \text{dBi} \quad \text{for} \quad 12.16^\circ < \theta \leq 48^\circ \quad (1e)$$

$$G(\theta) = -8 \quad \text{dBi} \quad \text{for} \quad 48^\circ < \theta \leq 180^\circ \quad (1f)$$

The values of 1.952 and 0.479 associated with angle θ are in radians.

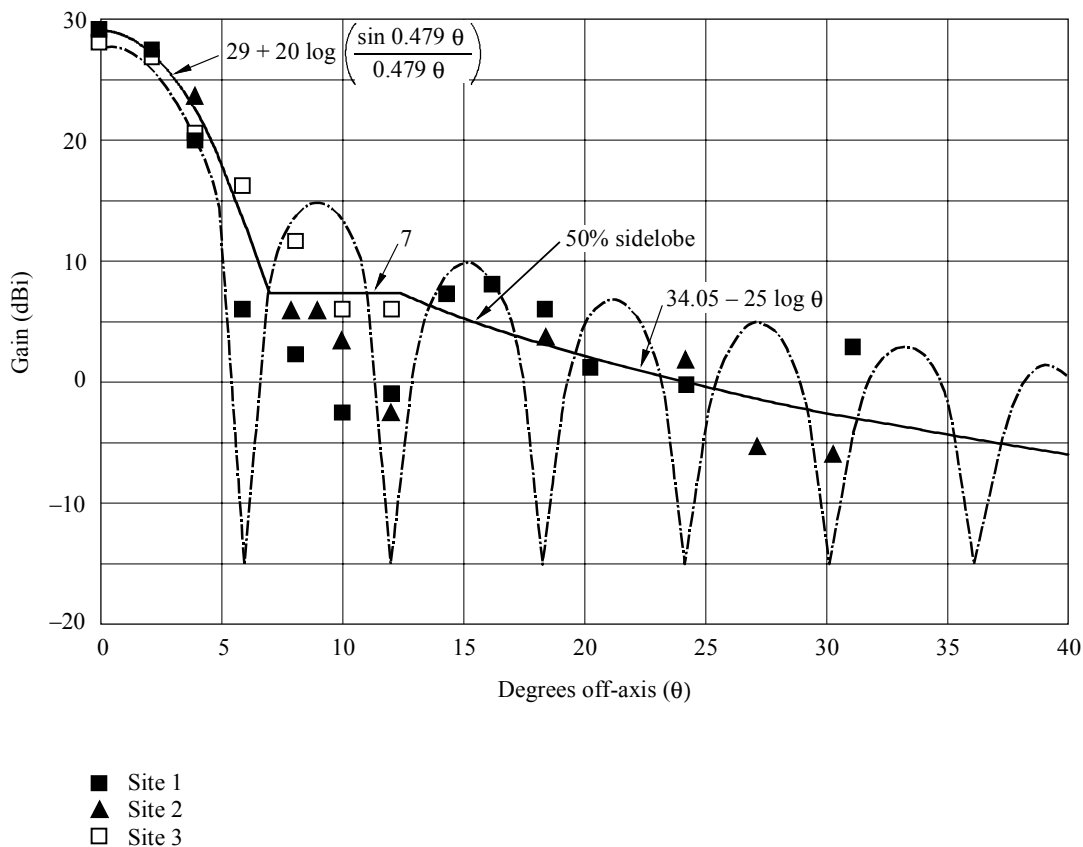
The telemetry transmitting antennas are mounted on airborne vehicles and, ideally, would be isotropic radiators to cover all possible radiation angles toward the telemetry receiving station. However, in practice, multiple reflections and blockage from the airborne vehicles cause large variations in the gain pattern. Multiple reflections generally result in a Raleigh fading distribution, and measured gain functions have shown that this is approximately the case as shown in Fig. 2. Using Fig. 2 for a near-worst case, including propagation effects, the probability (portion of time), P_1 , that a given gain, G_1 , is not exceeded can be expressed as:

$$P_1 (G \leq G_1) = (1 - e^{-3.46 G_1})^{1.25} \text{ (numerical)} \quad (2)$$

Distributions corresponding to an exponent of $(-5G_1)$ are observed.

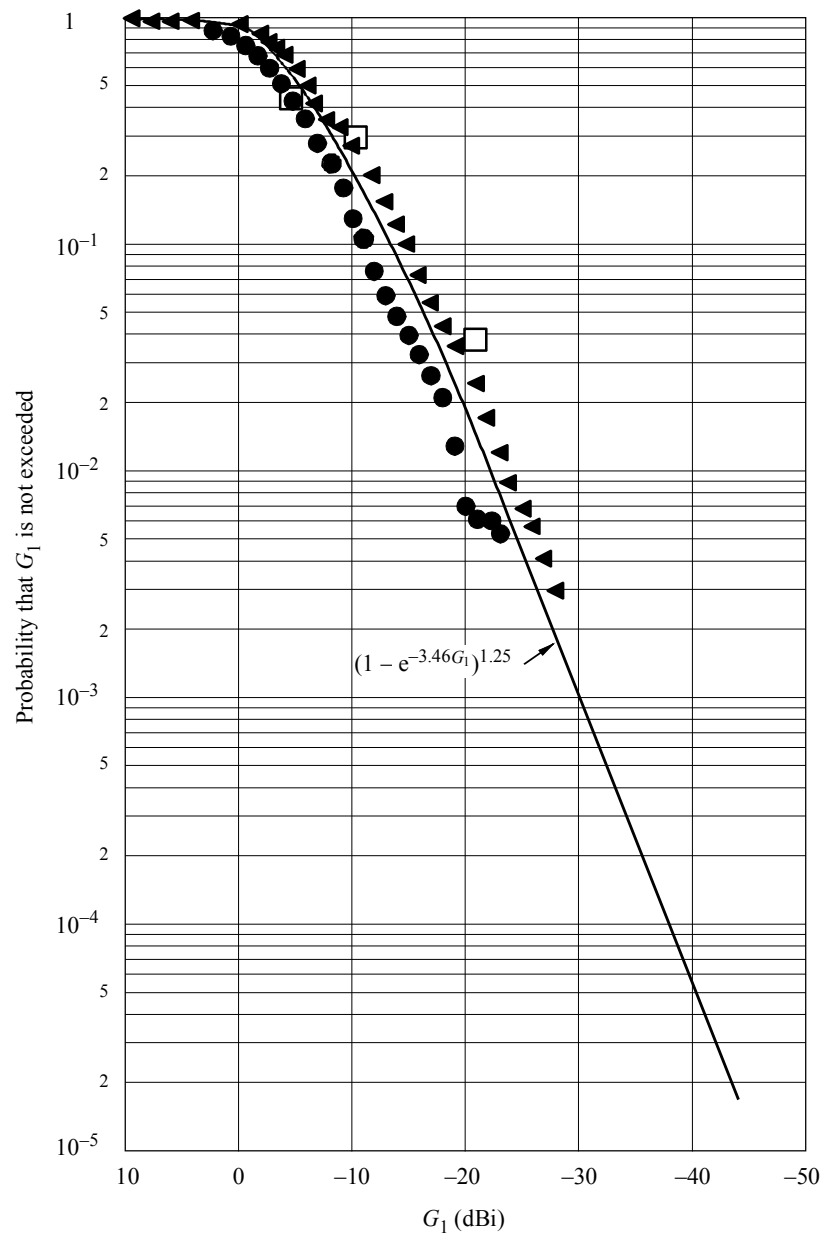
The received C/N and carrier power, C , at output of the telemetry receiving antenna are proportional to this function.

FIGURE 1
Measured data on 2.44 m diameter antennas



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FIGURE 2
Airborne telemetry transmitting antenna gains, G_1



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2.2 Interference from geostationary satellites

2.2.1 Time-gain function of interference

If it is assumed that the telemetry antenna may be pointed at any point on its hemisphere of visibility, the cumulative probability, P_2 , that a satellite at geostationary altitude is within a radius of θ , as viewed from the telemetry receiving station, is:

$$P_2 = (1 - \cos \theta) \quad \text{for } 0 \leq \theta \leq \pi/2 \quad (3)$$

