

## RECOMMENDATION ITU-R M.1584

**Methodology for computation of separation distances between earth stations of the radionavigation-satellite service (Earth-to-space) and radars of the radiolocation service and the aeronautical radionavigation service in the frequency band 1 300-1 350 MHz**

(Resolution 607 (WRC-2000))

(2002)

The ITU Radiocommunication Assembly,

*considering*

- a) that the band 1 300-1 350 MHz is allocated on a primary basis to the aeronautical radionavigation service (ARNS) for use by ground-based radar systems;
- b) that the World Radiocommunication Conference (Istanbul, 2000) (WRC-2000) has added a primary allocation to the radionavigation-satellite service (RNSS) (Earth-to-space) in the 1 300-1 350 MHz band;
- c) that WRC-2000 has raised the status of the radiolocation service from secondary to primary in the 1 300-1 350 MHz band;
- d) that the allocation to the radiolocation service is used by terrestrial as well as airborne radar systems;
- e) that there is a potential for interference between uplink stations in the RNSS and radar systems of the ARNS and radiolocation service;
- f) that radar systems of the ARNS and radiolocation service can be protected with the implementation of adequate separation distances;
- g) that Appendix 7 of the Radio Regulations (RR) shall be used to determine the affected administrations for the coordination of specific RNSS earth stations in the Earth-to-space direction under RR No. 9.17,

*recognizing*

- a) that WRC-2000 added RR No. 5.337A stating the use of the band 1 300-1 350 MHz by earth stations in the RNSS and by stations in the radiolocation service shall not cause harmful interference to, nor constrain the operation and development of, the ARNS;
- b) that operational and practical difficulties exist in complying with and maintaining the separation distance between RNSS uplink stations and airborne radars, thus possibly adversely affecting the mission capabilities of the airborne radars;
- c) that, for the examples used in Annexes 1 and 2, in order for RNSS earth stations to properly protect ground and airborne radiodetermination stations, it is necessary to provide an attenuation of 50 dB for elevation angles of 10° or less,

*noting*

- a) that the application of the methodology for the example in Annex 1 results in computed separation distances ranging from 50-325 km between RNSS earth stations and radars in the radionavigation service;

b) that the application of the methodology for the example in Annex 2 without a choke ring results in computed separation distances up to the radio horizon of the airborne radars,

*recommends*

1 that the methodologies in Annexes 1 and 2 be taken into account, when selecting the location of RNSS uplink earth stations in the range 1 300-1 350 MHz, in order to compute separation distance between RNSS uplink stations and radiolocation and aeronautical radionavigation radar systems;

2 that administrations continue to study the compatibility issues between RNSS earth station transmitters and airborne radiolocation radars and provide these studies to ITU-R.

NOTE 1 – Administrations should continue to study the compatibility issues between RNSS satellite receivers and radars in the radionavigation and radiolocation services and provide these studies to ITU-R.

## ANNEX 1

### **Methodology for computation of separation distances between earth stations of the RNSS (Earth-to-space) and terrestrial radars of the radiolocation service and the ARNS in the frequency band 1 300-1 350 MHz**

#### **1 Introduction**

New radionavigation-satellite systems will use the band 1 300-1 350 MHz for the transmission by uplink stations of information such as navigation, synchronization or integrity data, to a constellation of medium Earth orbiting (MEO) satellites.

This study provides an analysis of the interference created by uplink stations into receiving terrestrial radar.

It results from the study that a separation distance permits to avoid excess interference into terrestrial radar.

#### **2 Systems characteristics**

##### **2.1 Radiolocation and aeronautical radionavigation radars**

The radar parameters used in this Recommendation are those given in Recommendation ITU-R M.1463 – Characteristics of and protection criteria for radars operating in the radiodetermination service in the frequency band 1 215-1 400 MHz, covering radars of the radiolocation service and ARNS.

In order to calculate radar perturbation thresholds, the following formula and a –6 dB protection criteria ( $I/N$ ) as given in Recommendation ITU-R M.1463 have been used:

$$P_{threshold} \text{ (dBm)} = 10 \log (K T_0 FB) + 24$$

TABLE 1  
Radar-receiving parameters

|                     | Bandwidth<br>(MHz) | Reception antenna<br>gain<br>(dBi) | Perturbation threshold<br>(dBm) |
|---------------------|--------------------|------------------------------------|---------------------------------|
| System 1            | 0.780              | 33.5                               | −119.1                          |
| System 2            | 0.690              | 38.9                               | −119.6                          |
| System 3            | 4.4 and 6.4        | 38.2                               | −108.8 and −107.2               |
| System 4            | 1.2                | 32.5                               | −115.7                          |
| Wind profile radars | 2.5                | 33.5                               | −114.5                          |

## 2.2 Typical RNSS radio uplink stations

- Transmitted power:  $\leq 57.1$  dBm
- Antenna type: omnidirectional with a physical isolation for low elevation (typically 50 dB attenuation with a choke-ring (see Appendix 2 to Annex 1 for the description of a choke ring))
- Orientation: zenith
- Maximum gain:  $\leq 3$  dBi
- Gain:  $\leq 1$  dBi for elevation angles less than  $10^\circ$
- Modulation: spread spectrum (1.023 and 10.23 Mchip/s)
- Polarization: left-hand circular polarization
- Height: 2 m
- Network: less than 20 uplink stations regularly spaced around the world. Each uplink station transmits on the same frequency to a constellation of MEO satellites.

The total power is used to transmit two signals, one spread with a 1.023 Mchip/s code and the other spread with a 10.23 Mchip/s code. While the 10.23 Mchip/s code signal has a power of 53 dBm, the 1.023 Mchip/s has a power of 55 dBm. As a worst-case illustration and for the purpose of this study, frequency of the uplink stations is taken as the same as the radar. However, the impact of a frequency shift is studied.

## 3 Interference of RNSS uplink stations into radar

### 3.1 Compatibility study

In order to assess the separation distance necessary to protect radar reception, the propagation loss,  $L$  (dB), is calculated as:

$$\begin{aligned}
 L &= P_t + G_t - A_t - FL_t + G_r - FL_r + R_b - D_{pol} - P_{threshold} \\
 &= P_{interfering} - P_{threshold}
 \end{aligned}$$

where:

- $P_t$ : transmitting interfering power (dBm)
- $G_t$ : transmitting interfering gain (dBi) in the radar direction
- $A_t$ : physical isolation at low elevation (due to choke ring) (dB)
- $FL_t$ : transmitting feeder losses (dB)
- $P_{threshold}$ : perturbation threshold (dBm)
- $G_r$ : reception gain (dBi)
- $FL_r$ : reception feeder losses (dB)
- $R_b$ : rejection factor (dB)
- $D_{pol}$ : polarization coupling factor (dB).

The rejection factor  $R_b$  represents the amount of the RNSS emission total power which is filtered by the radar receiver. Thus, it takes into account the radar receiver bandwidth, the frequency offset between the radar and the RNSS uplink emission central frequencies and the RNSS signal normalized power spectral density (NPSD). For a square binary phase-shift keying modulation (expected for RNSS):

$$\begin{aligned}
 R_b &= \int_{(B_r)} NPSD(f) df \\
 &= \int_{f_{0R}-B_r/2}^{f_{0R}+B_r/2} \frac{1}{f_c} \cdot \sin^2 \left( \frac{(f-f_{0T})}{f_c} \right) \cdot df \\
 &= \int_{f_{0R}-f_{0T}-B_r/2}^{f_{0R}-f_{0T}+B_r/2} \frac{1}{f_c} \cdot \sin^2 \left( \frac{f}{f_c} \right) \cdot df
 \end{aligned} \tag{2}$$

where:

- $B_r$ : reception bandwidth.

It is to be noticed that the slow code (code rate = 1.023 Mchip/s) is also a short code (1 023 chips). Consequently, the spectrum of the corresponding signal has 1 kHz line components. Some of these line components have a power level greater than the  $(\text{sinc } x)^2$  values, but the average of lines keeps approximately a  $(\text{sinc } x)^2$  shape. Taking into account that the reception bandwidth is large with respect to the 1 kHz intervals, a great number of line components are averaged and equation (2) is adequate to compute  $R_b$ .

Following the determination of  $L$ , one can evaluate the corresponding separation distance. This is done through Recommendation ITU-R P.452 – Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above about 0.7 GHz, as well as Recommendation ITU-R P.526 – Propagation by diffraction. The method proposed in Recommendation ITU-R P.452, Table 5, has been used in order to derive the overall prediction taking into account the path type (line-of-sight, line-of-sight with sub-path diffraction or trans-horizon).

In Table 2 are given the main hypotheses that have been taken into account in the application of the above Recommendations:

TABLE 2

### Main hypotheses for protection distances calculations

| Model                     | Parameter                                                                                                               | Value  | Comment                                                                                                                    |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------|--------|----------------------------------------------------------------------------------------------------------------------------|
| Tropospheric scatter      | Path centre sea-level refractivity: $N_0$                                                                               | 360    | Compromise among all the continents' worst values                                                                          |
| Ducting/layer reflection  | Over-sea surface duct coupling corrections for the interfering and the interfered-with stations ( $A_{ct}$ , $A_{cr}$ ) | 0 dB   | It is assumed that the distance from each terminal to the coast along the great-circle interference-path is more than 5 km |
|                           | Terrain roughness parameter, that is the maximum height of the terrain above the smooth Earth surface ( $h_m$ )         | < 10 m | We assume that the Earth's surface is smooth                                                                               |
| Additional clutter losses | Additional losses due to local ground clutters such as buildings, vegetation, ... ( $A_{ht}$ , $A_{hr}$ )               | 0 dB   | We assume the worst case that there are no local ground obstacles between the interfering and the interfered-with stations |
| All                       | Refractive index lapse rate over the first 1 km of the atmosphere ( $\Delta N$ )                                        | 80     | Worst-case value                                                                                                           |
| All                       | Required time percentage for which the calculated basic transmission loss is not exceeded: $p$                          | 1%     |                                                                                                                            |
| All                       | Median effective Earth radius factor ( $K_{50}$ )                                                                       | 2.0389 | Obtained with $\Delta N = 80$                                                                                              |

### 3.2 Calculation of separation distance beyond which protection is assured (protection distance)

Equation (1) is applied for all radars given in Recommendation ITU-R M.1463, for both worst-case co-frequency operations and for 3 MHz frequency off-set operation between the centre frequency of the radar and the RNSS emission. In Appendix 1 of this Annex are given the tables with the required loss calculations in order to protect each type of radar.