

RECOMMENDATION ITU-R RS.1280*,**

**SELECTION OF ACTIVE SPACEBORNE SENSOR EMISSION CHARACTERISTICS
TO MITIGATE THE POTENTIAL FOR INTERFERENCE
TO TERRESTRIAL RADARS OPERATING
IN FREQUENCY BANDS 1-10 GHz**

(Question ITU-R 213/7)

(1997)

The ITU Radiocommunication Assembly,

considering,

- a) that active spaceborne sensors may be operated in common frequency bands with systems in the radiolocation and radionavigation services;
- b) that active spaceborne sensors may have technical characteristics which would cause unacceptable interference to terrestrial radars operating in frequency bands 1-10 GHz;
- c) that the last 20 years of experience in sharing the bands have shown no record of harmful interference occurrences;
- d) that some terrestrial radars are designed to provide an amount of processing gain with respect to certain types of pulsed interference;
- e) that the exact value of the processing gain of a terrestrial radar with respect to a particular type of pulsed interference may not be known;
- f) that some of the technical characteristics of spaceborne sensors can be adapted to enhance the compatibility with terrestrial radars, but this flexibility is limited by the sensor performance requirements,

recommends

- 1 that the methodology given in the Annex 1 may be used to improve the emission characteristics of active spaceborne sensors in order to enhance the compatibility with terrestrial radars operating in common frequency bands;
- 2 that when specific interference or sharing criteria have been established for a frequency band, these should be used rather than the generic criteria in the Annex 1.

* This Recommendation was developed jointly by Radiocommunication Study Groups 7 and 8, and future revisions should be undertaken jointly.

** Radiocommunication Study Group 7 made editorial amendments to this Recommendation.

1 Introduction

A methodology is presented that allows an estimate to be made as to whether or not the unwanted signal received by a terrestrial radar from an active spaceborne sensor may cause difficulties if operated in common frequency bands. The calculations highlight a number of parameters of the sensor that can be chosen such that the sharing situation is improved.

The frequency bands below 10 GHz being considered by this methodology are 1 215-1 300 MHz, 3 100-3 300 MHz, 5 250-5 350 MHz, 8 550-8 650 MHz and 9 500-9 800 MHz. These are commonly called L-, S-, C-, and X-band (the latter two) by radar operators. The characteristics of these various bands are such that L- and S-bands are quite often used for search and surveillance radars, while C- and X-bands are often used for tracking radars.

2 Calculation of interference to terrestrial radars

The average interfering signal power level, I (dBW), received by a terrestrial radar from spaceborne is calculated from

$$I = 10 \log P_t + 10 \log (\tau PRF) + G_t + G_r - (32.44 + 20 \log (fR)) + OTR - PG \quad (1)$$

where:

- P_t : peak spaceborne sensor transmitter power (W)
- τ : spaceborne sensor pulse width (s)
- PRF : spaceborne sensor pulse repetition frequency (Hz)
- G_t : spaceborne sensor antenna gain towards terrestrial radar (dBi)
- G_r : terrestrial radar antenna gain towards spaceborne sensor (dBi)
- f : frequency (MHz)
- R : slant range between sensor and radar (km)
- OTR : radar receiver on-tune rejection (dB)
- PG : processing gain (dB), rejection of unwanted signals due to radar receiver signal processing (assumed to be zero if not known).

Equation (1) gives the average interference signal power level. The average interference power level is used when it can be determined that such use is appropriate: For example, a radar that performs a fast Fourier transform on the received signal will “smear” the dissimilar pulsed signal across a number of bins, resulting in an averaged interfering signal level. The on-tune rejection term is calculated from:

$$OTR = 10 \log (B_r/B_t) \quad \text{for } B_r \leq B_t \quad (2a)$$

$$= 0 \quad \text{for } B_r > B_t \quad (2b)$$

where:

- B_r : receiver bandwidth
- B_t : bandwidth of the transmitted interfering signal.

If the peak interfering signal is of interest, then the second term of equation (1) should be left out, and on-tune rejection is calculated from the following:

Input pulse with no frequency modulation:

$$OTR = 20 \log (B_r \tau) \quad \text{for } B_r \tau < 1 \quad (3a)$$

$$= 0 \quad \text{for } B_r \tau > 1 \quad (3b)$$

Input pulse with frequency modulation:

$$OTR = 10 \log \left(\frac{B_r^2 \tau}{B_c} \right) \quad \text{for } \frac{B_r^2 \tau}{B_c} < 1 \quad (4a)$$

$$= 0 \quad \text{for } \frac{B_r^2 \tau}{B_c} > 1 \quad (4b)$$

where:

B_r : terrestrial radar IF bandwidth

B_c : chirp bandwidth of spaceborne sensor

τ : sensor pulse width.

3 Interference criteria for terrestrial radars

General interference criteria for the terrestrial radars have been postulated based upon preliminary work of JRG 7-8R; if specific criteria exist for specific systems or frequency bands, these should be used.

3.1 Surveillance radars

It will be assumed that the received signal-to-noise of the surveillance radars may not be degraded by more than 0.5 dB longer than a single scan time, taken to be 10 s. This equates to an interference-to-noise power ratio of –9 dB at the receiver IF stage. The average interfering signal power level is considered to be of interest in the case of the surveillance radars.

3.2 Tracking radars

Tracking radars often use “range gates” to exclude all returns other than those at specific ranges of interest. An important consideration in determining the susceptibility of a tracking radar to an interfering pulse train is the fraction of interfering pulses that are coincident with the range gate. The coincidence of interfering pulses with the range gate will depend upon whether the desired and undesired pulse repetition frequencies are related by integer multiples (Case I) or not (Case II). The fraction of coinciding pulses, f_c , is found from

$$f_c = \frac{GCF(PR F_i, PR F_g)}{PR F_g} \quad \text{for Case I} \quad (5a)$$

$$f_c = PR F_i (\tau_g + \tau_i) \quad \text{for Case II} \quad (5b)$$

where:

$PR F_i$: interfering pulse frequency

$PR F_g$: gate repetition frequency

$GCF(PR F_i, PR F_g)$: greatest common factor of $PR F_i$ and $PR F_g$

τ_i : interfering pulse width

τ_g : gate width.

Note that when $\tau_i > \tau_g$ and the desired and undesired PRFs are not related by integer multiples (Case II), f_c is approximately the duty cycle of the interfering pulses. This situation is considered to be the typical case, and is used in the following determination of degradation threshold for a tracking radar.