International Telecommunication Union

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Radiocommunication Sector of ITU

Recommendation ITU-R M.2007
(03/2012)

Characteristics of and protection criteria for radars operating in the aeronautical radionavigation service in the frequency band 5 150-5 250 MHz

M Series

Mobile, radiodetermination, amateur and related satellite services

International Telecommunication Union

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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SM	Spectrum management
SNG	Satellite news gathering
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Note*: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R M.2007

Characteristics of and protection criteria for radars operating in the aeronautical radionavigation service in the frequency band 5 150-5 250 MHz

(2012)

Scope

This Recommendation specifies the characteristics of and protection criteria for radar operating in the aeronautical radionavigation service (ARNS) in the frequency band 5 150-5 250 MHz. The technical and operational characteristics should be used when analysing compatibility between radars operating in the aeronautical radionavigation service with systems in other services.

The ITU Radiocommunication Assembly,

considering

a) that the antenna, signal propagation, target detection, and large necessary bandwidth of radar required to achieve their functions are optimum in certain frequency bands;

b) that the technical characteristics of radar operating in the radionavigation service are determined by the mission of the system and vary widely even within a frequency band;

c) that representative technical and operational characteristics of systems operating in frequency bands allocated to the aeronautical radionavigation service (ARNS) are required to determine the feasibility of introducing new types of systems;

d) that procedures and methodologies are needed to analyse compatibility between radars operating in the ARNS and systems in other services.

recognizing

a) that the frequency band 5 150-5 250 MHz is allocated on a primary basis to aeronautical radionavigation, fixed-satellite (earth-to-space), and mobile except aeronautical mobile in accordance with RR No.5.446A;

recommends

1 that the technical and operational characteristics of the radars operating in the ARNS described in Annex 1 should be considered representative of those operating in the frequency band 5 150-5 250 MHz and used in studies of compatibility with systems in other services;

2 that Recommendation ITU-R M.1461 should be used in analysing compatibility between radars operating in the radiodetermination service with systems in other services;

3 that the criterion of interfering signal power to radar receiver noise power level, I/N, of –6 dB should be used as the required protection level for the aeronautical radionavigation radars, and that this represents the net protection level if multiple interferers are present.

Annex 1

Technical and operational characteristics of radars operating in the aeronautical radionavigation service in the frequency band 5 150-5 250 MHz

1 Introduction

The ARNS operates worldwide on a primary basis in the frequency band 5 150-5 250 MHz. This Annex describes the technical and operational characteristics of representative radionavigation pulsed Doppler radars operating in the ARNS in this frequency band.

2 Characteristics of aeronautical radionavigation sense and avoid systems

The safe flight operation of unmanned aircraft (UA) necessitates advanced techniques to detect and track nearby aircraft, terrain, and obstacles to navigation. Like manned aircraft, UA must avoid these objects. Remote pilots will need to be aware of the aircrafts' operating environment, be able to identify the potential threats to the safe operation of the aircraft, and take the appropriate action to circumvent the hazard. The primary function of sense and avoid radar is to provide the capability to detect, track and report air traffic information to the remote pilot in order to maintain adequate separation from other aircraft/obstructions. The system utilizes a "Pilot-in-the-Loop" approach in which the ground-based unmanned aircraft system (UAS) pilot will have final authority regarding unmanned aircraft system avoidance manoeuvres. Table 1 provides the technical parameters of aeronautical radionavigation radars operating in the frequency band 5 150-5 250 MHz.

TABLE 1

Technical parameters of aircraft based sense and avoid radar

Parameter	Radar No. 1
Platform	Unmanned aircraft vehicle
Platform height (km)	Up to 20
Radar type	Air to air traffic collision avoidance system
The range of measured ground speed (km/h)	Up to 1 500
Frequency tuning range (MHz)	5 150-5 250
Emission type	Linear FM (LFM) pulse
LFM chirp bandwidth (MHz)	20
Pulse width (μs)	5-11
Pulse rise and fall times (μs)	0.1-0.2
RF emission bandwidth –3 dB –20 dB (MHz) –40 dB	18 22 26
Pulse repetition frequency (pps)	31 500-33 500
Peak transmitter power (W)	80.0
Average transmitter power (W)	16
Receiver IF –3 dB bandwidth (MHz)	30

TABLE 1 *(fin)*

Parameter	Radar No. 1
Sensitivity (dBm)	−133
Receiver noise figure (dB)	5
Antenna type	Phased array
Antenna placement	Nose and cheek of aircraft
Antenna gain (dBi)	33-36
First antenna side lobe (dBi)	18-20
Horizontal beamwidth (degrees)	8
Vertical beamwidth (degrees)	8
Polarization	Vertical
Vertical antenna scan (degrees)	±45
Horizontal antenna scan (degrees)	±45
Protection criteria (dB)	−6

3 Sense and avoid operation

Manned aircraft have long relied upon the eyesight of a human pilot in the cockpit as the primary method to sense other aircraft and avoid mid-air collisions even when transponders or radar systems are present. UAS do not have the advantage of this on-board safety feature. UA are envisioned to be fully integrated with manned aircraft across the full range of applications. UAS applications that have been demonstrated or planned come from such areas as agriculture, communication relays, aerial photography, mapping, emergency management, scientific research, environmental management, and law enforcement. Therefore, UAS must have this sense and avoid (S&A) function to operate on a routine basis in non-segregated airspace. Maintaining the sensitivity of the S&A sensor system is critical in ensuring aircraft in the vicinity of the UAS will be detected in a timely manner to avoid collisions.

Ensuring a safe separation distance from other aircraft requires an active search function to maintain a clear distance from other aircraft. The search function parameters may include time, distance, rate of closure, angle of approach and manoeuvrability. The self-separation function acts within a sufficient timeframe to manoeuvre the UAS to avoid activation of the collision avoidance function.

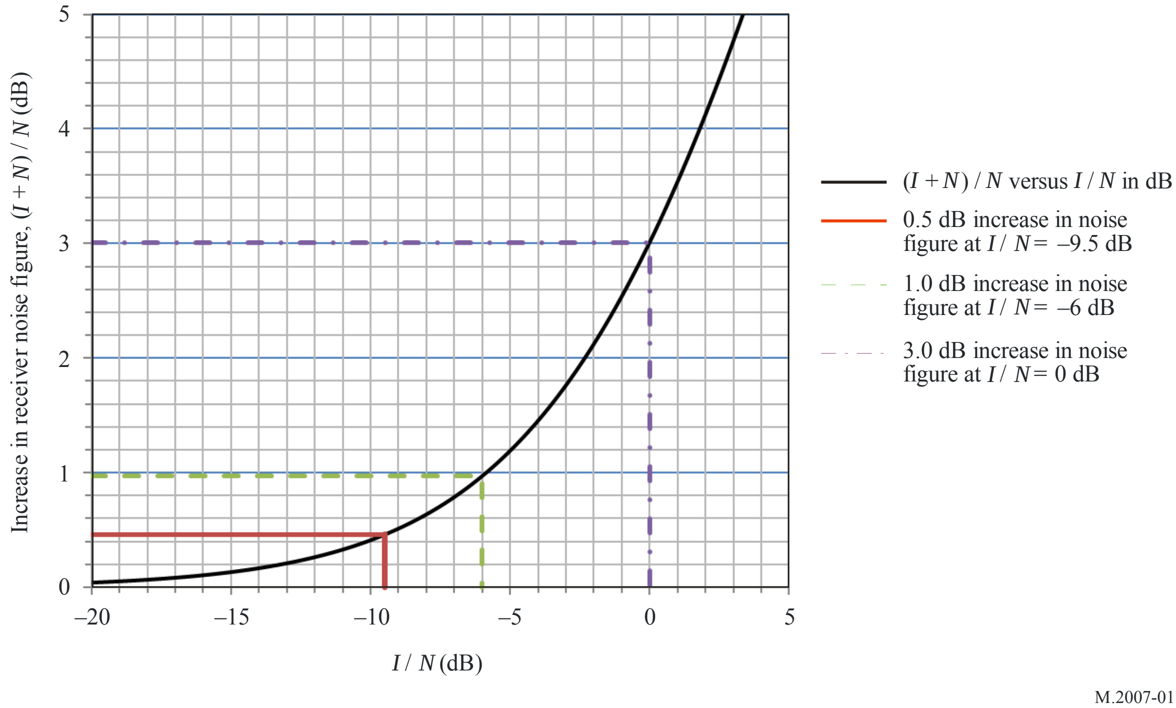
Collision avoidance is the last moment manoeuvring to avoid collision. This function only engages when all modes of separation assurance have failed to maintain safe distance. Again, its parameters may include time, distance, rate of closure, angle of approach and manoeuvrability. In this collision volume, UAS have little time to manoeuvre to avoid mid-air collisions. Its function must be capable of interpreting sensor data and generating appropriate manoeuvres accordingly. Sensor data may include aircraft radar cross section and range. If the signal-to-noise ratio is reduced, the detection range will also be reduced. In addition, there may be significant variation in atmospheric attenuation (even at 5 000 MHz) so a wide tolerance on operating range is also required.

4 Protection criteria

If interference is introduced into a radar receiver, the average power contribution from the interference, *I*, will sum with the radar inherent noise power, *N*, and that summed power will tend to mask the detection of desired targets. The ratio of the summed noise-plus-interference to inherent noise is $(I+N)/N$, and its behaviour relative to the ratio of I/N is portrayed graphically in Fig. 1.

FIGURE 1

The effective radar receiver noise as a function of *I/N*



As shown in Fig. 1, the receiver noise figure is increased by 0.5 dB when the average interference power is 9.5 dB below the nominal receiver noise level, and the receiver noise figure is increased by 1 dB when the average interference power is 6 dB below the nominal receiver noise level. These effective noise figure increases would represent equal increases in the minimum detectable signal level of radar receivers that are subjected to interference. Therefore, to fully protect ARNS radar operations in this frequency band, the I/N protection criteria should be equal to −6 dB[1].

These protection criteria represent the aggregate effects of multiple interferers, when present; the allowable I/N ratio for an individual interferer depends on the number of interferers and their geometry, and needs to be assessed in the course of analysis of a given scenario. The aggregation factor can be very substantial in the case of certain communication systems in which a great number of stations can be deployed.

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[1] Recommendation ITU-R M.1461-1 "Procedures for determining the potential for interference between radars operating in the radiodetermination service and systems in other services".

The effect of pulsed interference is more difficult to quantify and is strongly dependent on receiver/processor design and mode of operation. In particular, the differential processing gains for valid-target return that is synchronously pulsed, and interference pulses, which are usually asynchronous, often have important effects on the impact of given levels of pulsed interference. Several different forms of performance degradation can be inflicted by such desensitization; assessing it will be an objective for analyses of interactions between specific radar types. Techniques for suppression of low-duty cycle pulsed interference are contained in Recommendation ITU-R M.1372.