International Telecommunication Union

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Radiocommunication Sector of ITU

Recommendation ITU-R M.1462-1
(01/2019)

Characteristics of and protection criteria for radars operating in the radiolocation service in the frequency range 420-450 MHz

M Series

Mobile, radiodetermination, amateur and related satellite services

International Telecommunication Union

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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.1462-1

Characteristics of and protection criteria for radars operating in the radiolocation service in the frequency range 420-450 MHz

(2000-2019)

Scope

This Recommendation contains the technical and operational characteristics of the radiolocation systems operating in the frequency range 420-450 MHz. The parameters are intended to be used as a guideline in analyzing compatibility between radars operating in the radiodetermination service with systems in other services.

Keywords

Radar, characteristics, protection criteria

Abbreviations/Glossary

IF: Intermediate Frequency

I/N: Interfering to noise ratio

RF: Radio Frequency

Related ITU Recommendations, Reports

Recommendation ITU-R M.1372 – Efficient use of the radio spectrum by radar stations in the radiodetermination service

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

The ITU Radiocommunication Assembly,

considering

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

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

c) that propagation and target detection characteristics to achieve these functions are optimum in certain frequency bands, and that 420-450 MHz is particularly useful for very long range (e.g. space) object identification, tracking, and cataloguing by terrestrial radars,

recognizing

a) that the frequency bands 420-450 MHz, or portions thereof, are allocated globally to the fixed, radiolocation, amateur, Earth exploration-satellite (active) and mobile except aeronautical mobile services;

b) that there are several other allocations in the frequency range 420-450 MHz made by footnotes to the table of allocation, *noting*

that when the radiolocation service, is allocated on a secondary basis, mitigation techniques or operational measures may need to be applied to protect services which are allocated on a primary basis,

recommends

1 that the technical and operational characteristics of the radiolocation systems described in Annex 1 should be considered representative of those operating in the frequency range 420-450 MHz;

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

3 that an interfering signal power to radar receiver noise power level, I/N of −6 dB should be used as the required protection level for the radiolocation systems, and that this I/N represents the net protection level if multiple interferers are present (see Note 1).

4 that the following Note should be considered part of this Recommendation.

NOTE 1 – The protection criterion given in *recommends* 3 should not be applied to the space object tracking radars described in Annex 1; these are highly sensitive radars that cannot tolerate the resulting 6% degradation in detection range (corresponding to a 19% loss of surveillance volume). Specialized studies of compatibility with these radars are required.

Annex 1

Technical and operational characteristics of radiolocation systems operating in the frequency range 420-450 MHz

1 Introduction

High power airborne, shipborne and ground radars operate in the frequency range 420-450 MHz. Their operational and technical characteristics are described in the following sections.

2 Characteristics of radars in the 420-450 MHz range

Representative characteristics of radiolocation systems in the band 420-450 MHz are provided in the following paragraphs. The information presented in this Annex is sufficient for general calculations to assess the compatibility between these radars and other systems.

2.1 Ground radars

The frequency band 420-450 MHz provides unique characteristics that are ideal for long range detection, identification, and tracking of objects.

Radar A tracks and catalogues space objects using transmitter output powers of up to 5 MW and high antenna gains. The radars operate continuously; around the clock and year round. They scan from a surveillance “fence” from around 3° up to 60° in elevation, in 120° sectors in azimuth. The radar receivers are very sensitive in order to detect returns from exo-atmospheric and space objects.

Because of their specialized function and requisite design characteristics (e.g. very large antenna arrays) these particular ground radars are not numerous, but because of their sensitivity and function they deserve special recognition and protection. Table 1 gives the characteristics of the radars, and Table 2 gives the identified locations for many of these radars.

Radar B is a system to accomplish high altitude surveillance and tracking functions, at fixed locations and transportable on vehicles.

Radar C is a transportable system for surface and air search of moving objects at short range around the radar location.

TABLE 1

Characteristics of ground radars in the 420-450 MHz range

Parameter	Radar A	Radar B	Radar C
Application	Space object tracking	High altitude surveillance	Surface and air search
Deployment area	Worldwide, fixed site	Worldwide, fixed site and transportable	Worldwide, fixed site and transportable
Tuning type; range (MHz)	Frequency agile; 420-450	Frequency agile; 420-450	Frequency agile; 420-450
Peak RF output power (MW)	1-5	0.3	0.01
Polarization	Circular	Circular	Linear
Pulse duration (ms)	0.25, 0.5, 1, 2, 4, 8, 16	0.01-16	0.001-1
Duty cycle (average) (%)	25	1-25	1-10
Pulse frequency modulation	Search: 100-350 kHz chirp track: 1 or 5 MHz linear chirp	2 MHz linear chirp	1 or 0.3 MHz linear chirp
Pulse repetition rate (Hz)	Up to 41	15-400	100-3 000
Antenna type	Planar array; 22+ metre diameter	Phased array	Phased array
Radar height relative to the ground (m)	15	5-20	5-10
Antenna gain (dBi)	38.5	28-40	10
Antenna scan	3-85° elevation; ±60° azimuth per each of 2 planar arrays for total 240° azimuth scan	Sector ±60° azimuth scan, with rotating or random modes 3-85° elevation	Omnidirectional 360° azimuth scan
Antenna beamwidth in azimuth (degrees)	2.2	Typical 1.8	80
Antenna beamwidth in elevation (degrees)	2.2	Typical 1.8	60

TABLE 1 (*end*)

Parameter	Radar A	Radar B	Radar C
Receiver noise temperature (K)	≤ 450	≤ 435	≤ 435
Noise factor (dB)		≤ 2.5	≤ 2.5
Receiver RF bandwidth (MHz)		30	30
Receiver IF bandwidth (MHz)	1 or 5 (see chirp width)	2	1 or 0.3

TABLE 2

Location of space object tracking radars operating in the 420-450 MHz range

Radar Location	Latitude	Longitude
Massachusetts (United States of America)	41.8°N	70.5°W
Texas (United States of America)	31.0°N	100.6°W
California (United States of America)	39.1°N	121.5°W
Georgia (United States of America)	32.6°N	83.6°W
Florida (United States of America)	30.6°N	86.2°W
N. Dakota (United States of America)	48.7°N	97.9°W
Alaska (United States of America)	64.3°N	149.2°W
Thule (Greenland)	76.6°N	68.3°W
Fylingdales Moor (United Kingdom)	54.5°N	4.0°W

2.2 Airborne radars

Three lower radiolocation bands (420-450 MHz, 1 215-1 400 MHz and 3 100-3 700 MHz) have been and will continue to be essential for the development and operation of airborne radar surveillance systems. These systems operate worldwide, for extended periods (hours to days) once in their intended areas of operation. Long range object detection, acquisition, and tracking are essential functions to sense and control air traffic. Ground-based radars are extremely limited by the radar horizon, and the employment of long-range radars on airborne platforms is an excellent way to extend an individual radar's capability. Similar to ground air surveillance radars, airborne radars employ rotating scans in azimuth and scan over a specified range in elevation either by electronically scanning in elevation or by using a relatively wide elevation beamwidth. The radar will be operating during aircraft ascent and descent as well as at operating altitudes; aircraft ceiling altitude is around 9 km. Table 3 gives the characteristics of a representative airborne radar system operating in the frequency band 420-450 MHz.

TABLE 3

Characteristics of airborne radars operating in the 420-450 MHz range

Parameter	Radar 1	Radar 2
Tuning type; range	Fixed frequency or frequency agile; 420-450 MHz	Frequency agile; 420-450 MHz
Peak RF output power (MW)	2	2.5
Polarization	Horizontal	Horizontal
Pulse duration (μs)	1, 2, 4, 8	30, 35, 100
Pulse modulation	Unmodulated pulses	Linear FM
Pulse repetition rate (kHz)	0.1-2	Up to 3
Antenna type	Yagi element array or planar array	Linear Array
Antenna gain (dBi)	22	19
Antenna scan	±60° elevation (mechanically positioned or electronically scanned); 360° azimuth at 3-7 rpm	Fixed ±45° elevation (electronically scanned, mechanically fixed); 360° azimuth
Antenna beamwidth	6-20° elevation (depending upon scan type); 6° azimuth	Up to 60° Eelevation 7° Azimuth
Receiver noise figure (dB)	5	3
Receiver IF bandwidth (MHz)	1	33

2.3 Shipborne radars

Shipborne surveillance radars are also operated in the frequency range 420-450 MHz. They normally operate at sea, though operations in coastal waters as well in naval ports should be expected. As is typical with surveillance radars, the system scans 360° in azimuth, and operations are on a continuous basis. Table 4 gives the characteristics of a representative shipborne radar in the frequency band 420-450 MHz.

TABLE 4

Characteristics of shipborne radars operating in the 420-450 MHz range

Parameter	Value
Tuning type; range	Fixed frequencies; 420-450 MHz
Peak RF output power (MW)	2
Pulse modulation	Unmodulated pulses
Antenna gain (dBi)	30 (mainbeam) 0 (median sidelobe)
Transmitter RF emission curve	−3 dB 2 MHz −20 dB 3 MHz −70 dB 20 MHz
Receiver IF selectivity	−3 dB 2 MHz −103 dB 20 MHz
Receiver noise level (dBW)	−136
Antenna type	Parabolic reflector

3 Protection criteria

The desensitizing effect on radiodetermination radars from other services of a continuous-wave or noise-like type modulation is predictably related to its intensity. In any azimuth sectors in which such interference arrives, its power spectral density can, to within a reasonable approximation, simply be added to the power spectral density of the radar receiver thermal noise. If power spectral density of radar-receiver noise in the absence of interference is denoted by N_0 and that of noise-like interference by I_0, the resultant effective noise power spectral density becomes simply $I_0 + N_0$. An increase of about 1 dB would constitute significant degradation, equivalent to a detection-range reduction of about 6%. Such an increase corresponds to an $(I + N)/N$ ratio of 1.26, or an I/N of about −6 dB. This represents the aggregate effect of multiple interferers, when present; the tolerable I/N 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. If continuous-wave interference were received from most azimuth directions, a lower I/N would need to be maintained.

The aggregation factor can be very substantial in the case of certain communication systems in which a great number of stations can be deployed.

The effect of pulsed interference is more difficult to quantify and is strongly dependent on receivers/processor design and mode of operation. In particular, the differential processing gains for valid-target return, which 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. In general, numerous features of radiodetermination radars can be expected to help suppress low-duty cycle pulsed interference, especially from a few isolated sources. Techniques for suppression of low-duty cycle pulsed interference are contained in Recommendation ITU-R M.1372 – Efficient use of the radio spectrum by radar stations in the radiodetermination service.