RECOMMENDATION ITU-R M.1465

CHARACTERISTICS OF AND PROTECTION CRITERIA FOR RADARS OPERATING IN THE RADIODETERMINATION SERVICE IN THE FREQUENCY BAND 3 100-3 700 MHz

(Questions ITU-R 216/8 and ITU-R 226/8)

(2000)

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 the radionavigation service is a safety service as specified by RR No. S4.10 and harmful interference to it cannot be accepted;

d) that considerable radiolocation and radionavigation spectrum allocations (amounting to about 1 GHz) have been removed or downgraded since WARC-79;

e) that some ITU-R technical groups are considering the potential for the introduction of new types of systems (e.g. fixed wireless access and high density fixed and mobile systems) or services in bands between 420 MHz and 34 GHz used by radars in the radiodetermination service;

f) that representative technical and operational characteristics of systems operating in bands allocated to the radiodetermination service are required to determine the feasibility of introducing new types of systems;

g) that procedures and methodologies are needed to analyse compatibility between radars operating in the radiodetermination service and systems in other services;

h) that the frequency band 3 100-3 400 MHz is allocated to the radiolocation service on a primary basis in all three Regions;

j) that the frequency band 3 400-3 600 MHz is allocated to the radiolocation service on a secondary basis in Region 1;

k) that the frequency band 3 400-3 600 MHz is allocated to the radiolocation service on a primary basis in Regions 2 and 3;

l) that RR No. S5.433 provides a primary allocation to the radiolocation service in the frequency band 3 400-3 600 MHz in Regions 2 and 3 and urges administrations to cease radiolocation system operations by 1985;

m) that the frequency band 3 600-3 700 MHz is allocated to the radiolocation service on a secondary basis in Regions 2 and 3;

n) that the frequency band 3 100-3 300 MHz is also allocated to the radionavigation service on a primary basis in the countries listed in RR No. S5.428,

recommends

1 that the technical and operational characteristics of the radiolocation radars described in Annex 1 be considered representative of those operating in the frequency band 3 100-3 700 MHz;

2 that Recommendation ITU-R M.1461 be used as a guideline 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 be used as the required protection level for the radiolocation systems, and that this represents the net protection level if multiple interferers are present.

NOTE 1 – This Recommendation will be revised as more detailed information becomes available.

ANNEX 1

Technical and operational characteristics of radiolocation radars operating in the frequency band 3 100-3 700 MHz

1 Introduction

The characteristics of radiolocation radars operating in the frequency band 3 100-3 700 MHz are presented in Table 1, and are discussed further in the following paragraphs.

TABLE 1

Table of characteristics of radiolocation systems in the band 3 100-3 700 MHz

Parameter	Land-based systems		Ship systems		Airborne system
	A	B	A	B	A
Use	Surface and air search	Surface search	Surface and air search		Surface and air search
Modulation	P0N/Q3N	P0N	P0N	Q7N	Q7N
Tuning range (GHz)	3.1-3.7		3.5-3.7	3.1-3.5	3.1-3.7
Tx power into antenna (kW) (Peak)	640	1 000	850	4 000	1 000
Pulse width (μs)	160-1 000	1.0-15	0.25, 0.6	6.4-51.2	1.25(1)
Repetition rate (kHz)	0.020-2	0.536	1.125	0.152-6.0	2
Compression ratio	48 000	Not applicable	Not applicable	64-512	250
Type of compression	Not available	Not applicable	Not applicable	CPFSK	Not available
Duty cycle (%)	2-32	0.005-0.8	0.28, 0.67	0.8-2.0	5
Tx bandwidth (MHz) (–3 dB)	25/300	2	4, 16.6	4	> 30
Antenna gain	39	40	32	42	40
Antenna type	Parabolic		Parabolic	PA	SWA
Beamwidth (H,V) (degrees)	1.72	1.05, 2.2	5.8, 4.5	1.7, 1.7	1.2, 3.5
Vertical scan type	Not available	Not applicable	Not applicable	Random	Not available
Maximum vertical scan (degrees)	93.5	Not applicable	Not applicable	90	±60

TABLE 1 *(end)*

Parameter	Land-based systems		Ship systems		Airborne system
	A	B	A	B	A
Vertical scan rate (degrees/s)	15	Not applicable	Not applicable		Not available
Horizontal scan type	Not applicable	Rotating	Rotating	Random	Rotating
Maximum horizontal scan (degrees)	360		360		360
Horizontal scan rate (degrees/s)	15	25.7	24	Not applicable	36
Polarization	RHCP	V	H	V	Not available
Rx sensitivity (dBm)	Not available	–112	–112	Not available	Not available
S/*N* criteria (dB)	Not applicable	0	14	Not available	Not available
Rx noise figure (dB)	3.1	Not available	3	Not available	3
Rx RF bandwidth (MHz) (–3 dB)	Not available	2.0	Not available		Not available
Rx IF bandwidth (MHz) (–3 dB)	380	0.67	8	Matched to emission	1
Deployment area (1 000 km^2)	32	1 468	188	511	Worldwide
Number of systems per area	1	6	1-2	7	36

(1) 100 ns compressed.

CPFSK: continuous-compression FSK

PA: phased array

SWA: slotted waveguide array

2 Technical characteristics

The band 3 100-3 700 MHz is used by radars with installations on land, on ships and on aircraft. In general, the predominant use by mobile radars is on ships and aircraft while the fixed, land-based systems are operated at test ranges and are often deployed aboard tethered balloons for surveillance over land or coastal areas. Functions performed include search for both near-surface and high altitude airborne objects, sea surveillance, tracking of airborne objects, and for multi-purpose test range instrumentation. Both unmodulated and angle modulated pulse modulation is employed and the typical peak transmitter power ranges from 500 kW to 4 MW. Low duty cycles are employed for search radar functions with typical values ranging less than 1%. Receiver noise figures typically range from 3.1 dB to 16 dB. Table 1 contains representative characteristics for three land-based radar systems, one ship system and one airborne system operating in the band 3 100-3 700 MHz.

2.1 Land-based radars

2.1.1 Land-based radar operations

Land-based radars operating in the band 3 100-3 700 MHz are employed usually for test operations on and off test ranges. Many of these radars are mobile in the sense that they are often mounted on wheeled vehicles to relocate the radar to provide search and tracking functions for airborne vehicles along extended flight paths. Others are installed in fixed locations at test ranges where they also provide both search and tracking functions. Land-based system B, in Table 1, is tethered at up to 4 600 m altitude to provide extended range surveillance of up to 275 km. Land-based system A depicted in Table 1 operates mainly during daylight hours in good flying weather with occasional night operations while the tethered balloon borne radars operate continuously.

2.1.2 Transmitter

Transmitters are tunable and are subject to operating anywhere within the band 3 100-3 700 MHz. Unmodulated pulse, single-channel angle modulated and multichannel angle-modulated modulations are employed.

2.1.3 Receiver

Many of the test range radar receivers have special gating circuits for correlation of video data and data feed to various displays, operator consoles and recording devices. The video data received by the tethered balloon radar is relayed to ground operator facilities by both radio (fixed service) and wire.

2.1.4 Antenna

Antennas are designed for their special purpose on the test range but operate with main beam gain up to 40 dBi, are electronically steered and are usually directed skyward in random directions increasing the possibility of illuminating space borne objects and receiving energy from them. The tethered balloon radars direct their antennas at the horizon to a few degrees above it.

2.2 Shipborne radar

2.2.1 Ship-based operations

Two representative types of shipboard radars operating in the 3.4-3.65 GHz band are depicted in Table 1 as ship System A and System B. System A is used as a primary carrier air traffic control (CATC) system. System B is a multifunction radar deployed aboard escort ships. Operational areas of these shipboard radars include littoral and high seas. These radars are typically operated on a round-the-clock schedule. When providing escort for other ships, it is not uncommon to find up to ten of these radars operating simultaneously. In addition to the shipboard systems there are fixed systems on land that are used for training and testing. Also, routine maintenance and testing operations require that these radars be operated occasionally in certain port areas. A System A equipped ship is almost always accompanied by at least one System B equipped ship.

2.2.2 Transmitter

System A transmits in the 3 500-3 700 MHz band with a peak power of 850 kW. System B transmits in the 3 100-3 500 MHz band with a peak power of 4 MW and utilizes a combination of phase modulation and frequency hopping. Emissions are frequency agile over ten bands, each 40 MHz wide, designated as bands 1 through 10. The sequence of variable pulse widths is random.

2.2.3 Receiver

System A receivers are as described in Table 1 and have the usual features of air traffic control (ATC) systems for false target/clutter reduction, moving target indication (MTI), short/long range selection and video feed to planned position indicator (PPI) scopes; its tuning range is the same as the transmitter. The System B receiver operates in the band 3 100-3 500 MHz. The receiver characteristics are not available but are assumed to be modern receivers with much processing gain needed to detect multiple and varied objects at extended ranges, in heavy clutter and in adverse weather.

2.2.4 Antenna

System A uses a mechanically rotating reflector type antenna with an azimuth beamwidth of 1.5° and fan beam in elevation from 5.8° to 45° with a mainbeam gain of 32 dBi. The nominal antenna height is 46 m above mean sea level (AMSL). System B uses four planar electronically-steered phased-array antennas to provide 360° coverage with a mainbeam gain of 42 dBi. The nominal height of the Radar B antenna is 20 m AMSL.

2.3 Airborne radar

Airborne radars found in this band take advantage of the spectrum properties found at this wavelength to conduct long-range surveillance, target tracking and ATC. The spectrum characteristics for typical airborne radar found in this band are depicted in Table 1. This system is a multifunction, phased-array radar that is deployed on surveillance aircraft of a number of administrations. The antenna of this system is a large, slotted waveguide array assembly mounted atop of the airframe. It provides 40 dBi mainbeam gain and its sidelobe gain has been estimated to be –10 dBi. The aircraft carrying these radars are capable of worldwide operations. In addition to their air surveillance and ATC functions they also have a sea surveillance mode. This airborne system is typically operated at about 9 000 m in altitude and can be operated for extended hours of up to 12 h depending upon aircrew availability. In some situations constant surveillance is maintained on a 24 h per day basis by replenishment aircraft.

3 Protection criteria

The desensitizing effect on radiodetermination radars from other services of a CW 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 ratio of about –6 dB. This represents the aggregate effect of multiple interferers, when present; the tolerable 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. If CW interference were received from most azimuth directions, a lower I/N ratio 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.