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| U.S. Radiocommunications Sector  Fact Sheet | |
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| **Document Title:** WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW RECOMMENDATION ITU-R M.[15.4-15.7\_GHz\_ARNS] - Characteristics of and protection criteria for radars operating in the aeronautical radionavigation service in the frequency band 15.4-15.7 GHz | |
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| **Purpose/Objective:** The purpose of this contribution is to continue to develop a new recommendation for aeronautical radionavigation systems, including unmanned aircraft systems (UAS) Detect and Avoid (DAA) radar systems, in the 15.4-15.7 GHz band. | |
| **Abstract:** This contribution will continue the process of developing a new recommendation containing characteristics of and protection criteria for systems that operate in the 15.4-15.7 GHz aeronautical radionavigation service allocation including UAS DAA systems. This contribution will be an update to the new report found in Annex 22 of the Chairman’s Report of the 14 June 2021 Document 5B/355-E meeting. | |

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| **Radiocommunication Study Groups** |  |
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| **14 June 2021** |
| **English only** |
| Annex 22 to Working Group 5B Chairman’s Report | |
| WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW  RECOMMENDATION ITU-R M.[15.4-15.7\_GHZ\_ARNS] | |
| Characteristics of and protection criteria for radars operating in the  aeronautical radionavigation service in the frequency  band 15.4-15.7 GHz | |

(202X)

Scope

This Recommendation specifies the characteristics and protection criteria of radars operating in the aeronautical radionavigation service (ARNS) in the frequency band 15.4-15.7 GHz. The technical and operational characteristics should be used in analysing compatibility between radars operating in the aeronautical radionavigation service and systems in other services.

Keywords

15.4-15.7 GHz, radar, characteristics, protection.

Abbreviations/Glossary

ARNS Aeronautical radionavigation service

DAA:= Detect and avoid

e.i.r.p Effective isotropically radiated power

FMCW Frequency-Modulated Continuous Wave

LFM Linear Frequency Modulation

MESA Multi-Role Electronically Scanned Array

PSD Power spectral density

UA Unmanned aircraft

UAS Unmanned aircraft system

Related ITU Recommendations, Reports

*Recommendation*

ITU-R[S.1340](https://www.itu.int/rec/R-REC-S.1340-0-199710-I/en) Sharing between feeder links for the mobile-satellite service and the aeronautical radionavigation service in the Earth-to-space direction in the band 15.4-15.7 GHz

The ITU Radiocommunication Assembly,

considering

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

*b)* that the technical characteristics of radars operating in the aeronautical radionavigation service (ARNS) are determined by the mission of the system and vary widely even within a frequency band,

recognizing

*a)* that the frequency band 15.4-15.7 GHz is allocated on a primary basis to aeronautical radionavigation, and radiolocation services, and that the fixed-satellite service (Earth-to-space) is also allocated on a primary basis in the frequency band 15.43-15.63 GHz;

*b)* that the radiolocation services operating in the frequency band 15.4-15.7 GHz shall not cause harmful interference to, or claim protection from the aeronautical radionavigation service;

*c)* that the fixed-satellite service (Earth-to-space) operating in the frequency band 15.43‑15.63 GHz is limited to feeder links of non-geostationary systems in the mobile-satellite service and is subject to coordination under RR No. **9.11A**;

*d)* that stations operating in the aeronautical radionavigation service shall limit the effective isotropically radiated power (e.i.r.p). in accordance with Recommendation ITU-R S.1340;

*e)* that for stations operating in the fixed-satellite service (Earth-to-space), the minimum coordination distance required to protect the aeronautical radionavigation stations (RR No. **4.10** applies) from harmful interference from feeder-link earth stations and the maximum e.i.r.p. transmitted towards the local horizontal plane by a feeder-link earth station shall be in accordance with Recommendation ITU-R S.1340,

recommends

1 that the technical and operational characteristics of the radars operating in the ARNS described in the Annex should be considered representative of those operating in the frequency band 15.4-15.7 GHz and used in studies of compatibility with systems in other services;

2 that the criterion of interfering signal power to radar receiver noise power level (*I*/*N)* of [−6 dB/−10 dB], should be used as the required protection level for the aeronautical radionavigation radars, and that this represents the aggregate protection level if multiple interferers are present.

Annex  
  
Technical and operational characteristics of radars operating in the  
aeronautical radionavigation service in the  
frequency band 15.4-15.7 GHz

# 1 Introduction

ARNS system operates worldwide on a primary basis in the frequency band 15.4-15.7 GHz. This Annex presents the technical and operational characteristics of representative ARNS radars operating in this frequency band.

ARNS systems are installed in unmanned aircraft (UA) or on the ground to detect non-cooperative aircraft as the surveillance component of an UA detect and avoid (DAA) system. These radars are used for collision avoidance on-board UA and are a vital part of the integration of unmanned aircraft system (UAS) in non-segregated airspace.

# 2 Characteristics of aeronautical radionavigation detect and avoid radar

The safe flight operation of UA necessitates advanced techniques to detect and track nearby aircraft, terrain, and obstacles to navigation. UA must avoid these objects in the same manner as manned aircraft. The remote pilot will need to be aware of the environment within which the aircraft is operating, be able to identify the potential threats to the continued safe operation of the aircraft and take the appropriate action. The DAA radar is part of an unmanned aircraft collision avoidance system whose primary function is to provide the capability to detect, track and report non-cooperative air traffic information to the remote pilot in order to maintain adequate separation from intruders. The system utilizes a “Pilot-in-the-Loop” approach in which the ground-based UA pilot will have final authority regarding UAS manoeuvres to avoid other aircraft (manned or unmanned). The technical parameters are provided in Table 1.

TABLE 1

Representative Technical parameters of radionavigation radar

| Parameter | Units | Radar 1 | Radar 2 | Radar 3 | Radar 4 |
| --- | --- | --- | --- | --- | --- |
| Platform |  | Aircraft / Ground (on and off airports) | Aircraft / Ground (on and off airports) | Ground (on and off airports) | Airborne / Ground |
| Platform height | km | Up to 20 (Air)  0 (Ground) | Up to 20 (Air)  0 (Ground) | 0 | Up to 20(Air) 0 (Ground) |
| Spectral usage |  | Air-to-air and Ground-to-Air aeronautical radionavigation DAA radar | Air-to-air and Ground-to-Air aeronautical radionavigation DAA radar | Ground-to-air aeronautical radionavigation DAA radar | Air-to-air and Ground-to-Air aeronautical radionavigation DAA radar |
| Radar type |  | FMCW | FMCW | FMCW | Pulse-Doppler |
| Range class |  | Short range | Short range | Medium range | Medium range |
| Operating range | km | 0.8 (small UAS)  2.0 (small General Aviation aircraft) | 1.8 (small UAS)  4.5 (small General Aviation aircraft) | 6 (small UAS)  15 (small General  Aviation aircraft) | 9 |
| **Parameter** | **Units** | **Radar 1** | **Radar 2** | **Radar 3** | **Radar 4** |
| Maximum number of drones within the same operating area |  | 10 to 20 (Air)  32 (Ground) | 10 to 20 (Air)  32 (Ground) | 32 | 3 (Air)  12 (Ground) |
| Ground speed | km/h | 200 (Air) 0 (Ground) | 200 (Air) 0 (Ground) | 0 | < 700(Air) 0 (Ground) |
| Frequency tuning range | GHz | 15.4-15.7  (Note 1) | 15.4-15.7  (Note 1) | 15.4-15.7  (Note 1) | 15.4-15.7  (Note 2) |
| Channel selection method between radars |  | (Note 1) | (Note 1) | (Note 1) | SW selectable  (Note 3) |
| Emission type |  | QXN | QXN | QXN | FXN |
| Modulation |  | FMCW | FMCW | FMCW | LFM |
| Pulse width  (1 meter range resolution) | μs | 220 | 197 | 250 | 0.25 to 20  (Note 4) |
| Pulse rise and  fall times | us | 5/5 | 0.5/0.5 | N/A | < 0.1 |
| RF emission bandwidth   −3 dB  −20 dB  −40 dB | MHz | 176  184  201 | 152  164  269 | 152  164  269 | 110% BWchirp  120% BWchirp  130% BWchirp  (in dBc) |
| Pulse repetition frequency | pps | 4000 | 4000 | 4000-20000 | 1-200 |
| Average transmitter power  (conducted) | W | 2 | 5.6 | 100 | 30 |
| Out-of-band emission characteristics | dBc | < 50 | < 40 | < 50 | <-75 (through 3rd harmonic) |
| Spurious emission characteristics  (conducted) | dBc | -72 | -87 | -90 | <88 (dBuV/m in 1MHz BW) |
| Receiver IF bandwidth  −3 dB  −20 dB  −60 dB | MHz | 15  32  58 | 15  32  58 | 160  190  280 | <200  <300  <400 |
| Sensitivity | dBm | -147 | -141 | [TBD] | -121 |
| Receiver noise figure | dB | 1.5 | 1.5 | 1.5 | 4 |
| Calculated Rx noise power | dBW | -130.7 | -130.7 | -120.5 | -133  (Note 5) |
| **Parameter** | **Units** | **Radar 1** | **Radar 2** | **Radar 3** | **Radar 4** |
| Saturation level | dBW / m2 | [TBD] | -30 | [TBD] | -40 |
| Effective Incident RX Thermal Noise power | dBW / m2 | -176.6 | -176.6 | -166.4 | [TBD] |
| Antenna type |  | Bi-Static  Phased Array | Bi-Static Phased Array | Bi-Static Phased Array | MESA (Note 6) |
| Antenna placement |  | Aircraft (manned or   unmanned)  Tower (<20m) | Aircraft (manned   or unmanned) Tower (<20m) | Tower (<20m) | Aircraft (manned   or unmanned)  Tower (<20m)  (internally sealed package) |
| RX Element gain | dBi | 2 | 2 | 2 | [TBD] |
| Antenna gain | dBi | 12 | 15 | 25 | 27 |
| First TX antenna side lobe | dBi | -3 at 50° | -1 at 52° | +10 at 50° | <-20 |
| Horizontal beamwidth | degrees | 40 | 32 | 2.5 | 4 |
| Vertical beamwidth | degrees | 40 | 28 | 40 | 2 |
| Polarization |  | Vertical | Horizontal | Linear | Horizontal |
| Horizontal Antenna scan | degrees | ±60 | ±60 | ±60 | ± 65 |
| Vertical Antenna scan | degree | ±20 | ±60 | ±60 | -40, +50 |
| Protection criteria [*I/N* or false detection ratio] | dB | [TBD] | [TBD] | [TBD] | [TBD] |

Notes:

1. Radar is pre-programmed at the factory to any center frequency inside this band. The set range resolution (RR), directly affects BW. Therefore, the RR will be a factor when programming the center frequency, to ensure that the spectral power is within the 15.4 to 15.7 GHz band. For radars set with larger RR (i.e. smaller BW’s), multiple radars can be programmed and operated inside the 15.4 to 15.7 GHz band, allowing for coverage of larger areas.
2. Utilized bandwidth - Inclusive of frequency-channel guard-bands.
3. Channel selection is purely SW-defined and can be on-the-fly dynamic. Some settings may allow radar to self-configure based on detected spectrum-conflict.
4. Waveform is software-defined on a CPI-by-CPI basis, and optimized for targets, and spectral environments.
5. Compressed bandwidth before processing gain.
6. High T/R ESA RF beamforming on both transmit and receive.

# 3 Characteristics of aeronautical radionavigation landing system

This system is an electronic landing aid that provides flight path data to an approaching aircraft as the aircraft flies into range of the landing system. There are two separate surface transmitters, one for azimuth and one for elevation, as well as a receiver installed on the aircraft. The system utilizes a one-way transmission where the angular information is displayed on a cross-point indicator allowing the aircraft to align itself with the runway.

The technical parameters are provided in Table 2.

TABLE 2

Technical parameters of landing system

| Parameter | Units | Transmitter | Receiver |
| --- | --- | --- | --- |
| Platform |  | Land/Ship | Aircraft |
| Platform height | km | Land: 0.01 Ship: 0.015-0.024 | Maximum: 2 |
| Ground speed | km/h | Land: 0 Ship: < 50 | < 350 |
| Number of aircraft per landing system |  | 1 | 1 |
| Frequency tuning range | GHz | 15.4-15.7 | 15.4-15.7 |
| Emission type |  | Pulse | Not applicable |
| Pulse width | μs | 0.3 | Not applicable |
| Pulse rise and fall times | ns | Rise Time: 25-50;  Fall Time: 25-200 | Not applicable |
| RF emission bandwidth at   −3 dB  −20 dB  −40 dB | MHz | 4.8  18.5  65 | Not applicable |
| Pulse repetition frequency | pps | 15000 | Not applicable |
| Out-of-band emission characteristics | [TBD] | [TBD] | [TBD] |
| Spurious emission characteristics | dBc | 65 | Not applicable |
| Average transmitter power | W | Peak: 2500;  Average: 7 | Not applicable |
| Receiver IF bandwidth at  −3 dB  −20 dB  −60 dB | MHz | Not applicable | 12  17  24 |
| Sensitivity | dBm | Not applicable | −72 |
| Receiver noise figure | dB | Not applicable | 11.5 |
| Calculated Rx noise power | dBW | Not applicable | −121.7 |
| Blocking characteristics/Saturation level | [TBD] | [TBD] | [TBD] |
| Antenna type |  | Parabolic Reflector | Horn |
| Antenna placement |  | Ground/Surface | Bottom of aircraft |
| Antenna gain | dBi | Horizontal: 32;  Vertical: 26 | 6 |
| First antenna side lobe | dBi | At least 17 dB below peak | At least 17 dB below peak |
| Horizontal beamwidth | degrees | Horizontal: 40;  Vertical: 2 | 70 |
| Vertical beamwidth | degrees | Horizontal: 1.3; Vertical: 6 | 36 |
| Polarization |  | Vertical | Vertical |
| Antenna scan | degrees | Sector Scan | Fixed |
| *I/N* Protection criteria | dB | N/A | [−10] |

# 4 Protection criteria

The desensitizing effect on 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 (PSD) can, to within a reasonable approximation, simply be added to the PSD of the radar receiver thermal noise. If PSD 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 PSD becomes simply *I*0 + *N*0.

[Editor’s note: further discussion is needed on this item. In Rec. ITU-R M.1461-2, it is stated that: “The effect of pulsed interference is more difficult to quantify and is strongly dependent on receivers/processor design and mode of operation. 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.”

Editor’s note: More information on the appropriate protection criteria will be provided once the technical and operational characteristics of radars in section 2 have been finalized.

– For typical radars 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* ratio of 1.26, or an I/N ratio of about −6 dB.

– For the radionavigation service considering the safety-of-life function, an increase of about 0.5 dB would constitute significant degradation. Such an increase corresponds to an (*I/N*) ratio of −10 dB.]

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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