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| **US Radiocommunication Sector**  **FACT SHEET** | |
| **Working Party:** ITU-R WP 5B | **Document No:** USWP5B-29/14 |
| **Reference:** 5B/531 Annex 11; Annex 16 | **Date:** 2 June 2022 |
| **Document Title:** Working Document Towards a Preliminary Draft Revision of Recommendation ITU-R M.2116-0, “**Technical characteristics and protection criteria for the aeronautical mobile service systems operating within the 4 400-4 990 MHz frequency range”** | |
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| **Purpose/Objective:** The purpose of this document is to continue the revision to Recommendation ITU-R M.2116-0. | |
| **Abstract:** Recommendation ITU-R M.2116-0 contains characteristics for the aeronautical mobile service systems operating within the 4400-4990 MHz frequency range. This contribution seeks to address comments and editor’s notes provided at the previous meeting. We are also proposing to elevate to Preliminary Draft Revision. | |
| **Fact Sheet Preparer:** Taylor King | |

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| Working document for a Preliminary draft revision to Recommendation itu-r M.2116-0 | |
| **Technical characteristics and protection criteria for the aeronautical mobile service systems operating within the 4 400-4 990 MHz frequency range** | |

**1 Introduction**

At the previous meeting of Working Party 5B the meeting discussed several input contributions and made progress on a revision to Recommendation ITU-R M.2116. This contribution seeks to continue the development of this revision.

**2 Proposal**

The United States proposes the following edits to the working document for a preliminary draft revision to Recommendation ITU-R M.2116-0 which are contained in Attachment 1. The United States also proposes the following edits and comments to the table of open issues contained in 5B/531 Annex 16 which are contained in Attachment 2. The proposed edits are highlighted in yellow.

The United States is also proposing to elevate the status of this document to Preliminary Draft Revision.

**Attachment:** 2

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| **Annex 11 to the Working Party 5B Chairman's Report** |
| PRELIMINARY DRAFT REVISION TO RECOMMENDATION ITU-R M.2116-0 |
| **Technical and operational characteristics and protection criteria for systems operating in the aeronautical mobile service and maritime mobile service within the 4 400-4 990 MHz frequency range** |

(2018-20XX)

*Summary of revision*

*TBD*

*[Editor’s note: It is necessary to further review this document at future meetings of WP 5B with a view to inter alia reconcile the Views expressed as well as addressing the concerns expressed in editor's note in the document.]*

**Scope**

This Recommendation provides information on the technical and operational characteristics and protection criteria for systems operating in the aeronautical mobile service (AMS) and maritime mobile service (MMS) planned to or currently operating within the frequency range 4 400-4 990 MHz for use in sharing and compatibility studies as needed .

**Keywords**

Aeronautical mobile service, maritime mobile service, technical characteristics, protection criteria

**Abbreviations/Glossary**

AMDL Aeronautical mobile data link

AMS Aeronautical mobile service

MDL Maritime mobile service data link

MMS Maritime mobile service

RR: Radio Regulations

UAV: Unmanned aerial vehicle

**Related ITU-R Recommendations and Reports**

*Recommendation:*

[ITU-R SM.329](https://www.itu.int/rec/R-REC-SM.329/en) *Unwanted emissions in the spurious domain*

[ITU-R M.1851](https://www.itu.int/rec/R-REC-M.1851/en) *Mathematical models for radiodetermination radar systems antenna patterns for use in interference analyses*

*Reports:*

[ITU-R M.2119](https://www.itu.int/rec/R-REC-SM.329/en) Sharing between aeronautical mobile telemetry systems for flight testing and other systems operating in the 4 400-4 940 and 5 925-6 700 MHz bands and 5 925-6 700 MHz bands

The ITU Radiocommunication Assembly,

*considering*

*a)* that systems and networks operating in the aeronautical mobile service (AMS) are used for broadband, data-links including aircraft to aircraft links or ship to aircraft links to support various applications such as remote sensing, for earth sciences, land management, and energy distribution;

*b)* that systems and networks operating in the maritime mobile service (MMS) are used, for broadband maritime data-links to support various applications, such as [remote sensing for earth sciences, land management, and energy distribution];

*[Editor’s note: relevance of these applications to MMS needs to be clarified]*

*c)* that systems and networks operating in the AMS and maritime mobile service (MMS) are also used for narrow-band data-links,

*recognizing*

*a)* that the frequency range 4 400-4 990 MHz is allocated on a primary basis in all three ITU Regions to the mobile service;

*b)* that other radio services are allocated on either a primary or secondary basis in all or parts of the frequency range 4 400-4 990 MHz all three ITU regions;

*c)* that the Radio Regulations (RR) No. **5.442** provides restrictions for the use of AMS in the frequency bands 4 825-4 835 MHz and 4 950-4 990 MHz;

*d)* that AMS systems in the 4 400-4 990 MHz band are not standardised by ICAO;

*e)* that the frequency band 4 400-4 990 MHz is not considered for distress and safety communications for the global maritime distress and safety system in accordance with the Radio Regulations;

*f)* that the use of the AMS and MMS in the frequency range 4 400-4 990 MHzdoes not preclude the use of this frequency band by any current and planned application of the services to which it is allocated and does not establish any priority in the Radio Regulations;

*g)* that the regulatory aspects of AMS and MMS are addressed in relevant provisions of RR (Chapter VIII and IX respectively),

*[Editor’s note: Recognising h is proposed in order to remove references to regulatory provisions in the text of this Recommendations]*

*recommends*

**1** that the technical and operational characteristics and protection criteria for systems operating in the AMS given in Annex 1 should be used in performing sharing and compatibility analyses.

**2** that the technical and operational characteristics and protection criteria for systems operating in the MMS are given in Annex 2 should be used for performing sharing and compatibility analyses.

**3** that the following Note is considered as part of this Recommendation.

NOTE – The characteristics and protection criteria should not have any adverse effect to Appendix **30B** of the Radio Regulations.

**Annex 1  
  
Technical and operational characteristics and protection criteria for systems operating in the aeronautical mobile service**

**1 Introduction**

Systems and networks operating in the AMS are used for broadband, data-links including aircraft to aircraft to support various applications, such as remote sensing for earth sciences, land management, and energy distribution.

These aeronautical mobile systems operating throughout the 4 400‑4 990 MHz frequency range or portions thereof may also be used to support security, law enforcement, and humanitarian assistance efforts. These tasks are of an unpredictable nature and immediate operations can be required at any time, however some of these operations can be planned in advance. Additionally, some operations can also take place outside national territories (e.g. to fight against piracy, to escort ships, for deep sea rescue, for search and rescue/emergency operations at sea, etc.). It should be noted however that these systems are not considered as safety-of-life systems.

**2 Operational deployment**

Aeronautical mobile data links (AMDL) are operated between aeronautical stations and aircraft stations, between aircraft stations or between aircraft stations and ship stations with (AMDL and can be deployed anywhere within a country whose administration has authorized their use or outside national borders airspace and waters. The stations outside national borders airspace and waters are authorized by the administration of the flag state of the aircraft and/or ship.

Depending on the area outside national airspace some of these operations can be planned in advance, whereas some other operations may take place at an unpredictable time and location.

AMDL includes transmission from and to, either aircraft stations or an aeronautical station. These transmissions could use bidirectional air‑to‑ground links, or relay through another airborne platform using an air‑to‑air data link. Links can be either simplex or duplex. The link lengths may vary greatly. The operational altitude of aircraft equipped with these AMDLs can vary from ground/sea level to 20 000 m. In case of using directional antennas the direction of the airborne antenna’s main lobe when communicating with its aeronautical station is normally pointing away from the territory of another coastal state.

The ground terminals (aeronautical stations) may be either at a permanent location or transportable. Transportable ground terminals can be moved to meet operational needs and the duration of use, while the length of time they remain at a particular location is dependent upon operational requirements. In certain instances, an aeronautical station may be located, for example, on board ship or on a platform at sea.

A single ground terminal may simultaneously support several aircraft stations at the same time via different links.

The application of system 6 is an automated unmanned aerial vehicle (UAV) based wide area ocean surface exploration system used to conduct multiple activities including maritime search and rescue, disaster relief support activities and support to air crash investigations conducted in territorial and outside national waters. The system consists of multiple UAVs conducting video surveillance of a wide ocean surface area. In order to achieve the required coverage that satisfies large video surveillance footprints, the UAVs form a mesh network to deliver high resolution video to either a ship or land based command and monitoring centers. The received video data are used to identify objects of interest, such as, aircraft debris and distressed personnel. The frequency selection for individual UAVs depends on the number of UAVs participating in a task and their bandwidth requirements.

*(Editor’s note: The typical number of UAVs and their bandwidths requirements needs to be determined)*

The mesh network can be configured in multiple ways depending on the task requirements, either as a single network or multiple sub-networks assigned with dedicated frequency channels and bandwidths. Figure 1 depicts the above mentioned system and its application. Table 1 contains the characteristics of the radio systems used for payload communications. It should be noted that Table 1 only depicts radio systems used for payload communications as part of this application and those used for non-payload communications are not indicated in this table. *(Editor’s note: Is it related to all systems in Table 1 or to system 6 only?)* In Table 1 for System 6, Airborne 1 and Airborne 2 represent two UAVs with similar radio system characteristics and are used to identify two ends of a single hop communication link within the mesh network.

Figure 1

**Operation of unmanned aerial vehicles based wide area ocean surface exploration system**



The application of System 7 in Table 1 is earth surface exploration operating in national territories and outside national airspace to conduct or support activities including maritime search and rescue, disaster relief and rescue in national territories and outside national waters. Once the visual monitoring results are taken by any aircraft, the captured video is delivered from one aircraft to the other by using 5 MHz AMDL and any audio communication between aircrafts is delivered by using 8 kHz AMDL as depicted in Figure 2. The details of technical characteristics are given in Table 1. The center frequency for two AMDLs will be selected in the tuning range. In Figure 2 two aircrafts are operating in one set. There could be multiple sets.

Figure 2

**Example of configuration of two aeronautical datalinks by system 7**

A screenshot of a video game

Description automatically generated

The System 8 is designed to be used both on national territory and outside national airspace and outside national waters.

The main application of this system:

– exchange of various information, including the transfer of high-speed data, with aircraft and ships performing various commercial and science missions;

– organization of monitoring of linear and area hazardous production facilities and areas.

Direct communication between aircraft and ships is also possible.

With regard to outside national waters and outside national airspace, the use of this system is intended to conduct planned research missions in local areas, for example, scientific studies of the sea surface or the atmosphere.

The construction of this system is planned on the basis of modern commercially available state-of-art telecommunication equipment.In accordance with Resolution 416, aeronautical mobile telemetry (AMT) in the band 4400 – 4940 MHz operates in the air-to-ground direction only.  AMT consists of the wireless transmission and reception of data during flight tests. Data on the health and performance of an aircraft under test are transmitted to ground-based equipment; the data are monitored by engineers on a real-time basis. Table 1, below, provides typical technical characteristics of representative aeronautical mobile systems (AMS).  Within the Table, certain systems reflect a range of parameters that can meet the EIRP limitations for AMT specified in Res. 416. For example, System 2 can match the highest data bandwidths (20 MHz) with the lowest airborne power levels (35 dBm).

**3 Technical characteristics of aeronautical mobile systems**

Typical technical characteristics for representative airborne data links for the frequency range 4 400-4 990 MHz are provided in Table 1.

**3.1 Transmitter and receiver characteristics**

The aeronautical mobile systems operating or planned to operate within the frequency range 4 400‑4 990 MHz typically use digital modulations. A given transmitter may be capable of radiating more than one waveform. The out-of-band and spurious emissions of these aeronautical systems are compliant with Recommendation ITU-R SM.1541 (Annex 11) and Recommendation ITU-R SM.329 (Category A), respectively.

**3.2 Antenna characteristics**

A variety of different types of antennas are used by systems in the frequency range 4 400‑4 990 MHz. Antennas in this range generally differ in size and vary between the airborne component of the link and the ground based component of the link. The airborne antenna gains are typically between +3 dBi and 19 dBi. The ground based antenna gain is typically between 3 dBi and 31 dBi. Horizontal, and vertical polarizations could be used.

Antenna characteristics available in the Table 1 should be used for studies unless measured data is available. The shipborne antenna height as described for Systems 3 5, 6, and 8 in Table 1 is in the range of 10 to 30 metres.

**4 Protection criteria**

An increase in receiver effective noise of 1 dB would result in significant degradation in communication range.

Such an increase in effective receiver noise level corresponds to an (*I* + *N*)/*N* ratio of 1.26, or an *I/N* ratio of about −6 dB. This represents the required protection criterion for the AMS systems referenced herein from interference due to another radiocommunication service or another application in the mobile service. If multiple potential interference sources are present, protection of the AMS systems requires that this criterion is not exceeded due to the aggregate interference from the multiple sources.

TABLE 1

**Typical technical characteristics of representative systems operating in the aeronautical mobile service in the frequency range 4 400-4 990 MHz**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Units** | **System 1**  **Airborne** | **System 1**  **Ground** | | | **System 2**  **Airborne** | **System 2**  **Ground** | | |
| Transmitter | | | | | | | | | |
| Tuning range | MHz | 4 400-4 990(1) | 4 400-4 990(1) | | | 4 400-4 990(1) | 4 400-4 990(1) | | |
| Power output | dBm | 45 | 45 | | | 35-39 | 30-39 | | |
| Bandwidth (3 dB) | MHz | 1 | 1 | | | 6 / 10 / 20 | 6 / 10 / 20 | | |
|  |  |  |  | | |  |  | | |
| Receiver(4) | | | | | | | | | |
| Tuning range | MHz | 4 400-4 990(1) | 4 400-4 990(1) | | | 4 400-4 990(1) | 4 400-4 990(1) | | |
| Selectivity (3 dB) | MHz | 1 | 1 | | | 6 / 10 / 20 | 6 / 10 / 20 | | |
| Noise figure | dB | 3.5 | 3 | | | 3.5 | 3 | | |
| Thermal noise level | dBm | −110.5 | −111 | | | −102.5 to −97.5 | −103 to −98 | | |
| Antenna(4) | | | | | | | | | |
| Antenna type |  | Omnidirectional | Omni-directional | Directional | | Omnidirectional | Omni-directional | Directional | |
| Antenna gain | dBi | 3 | 3 | 19 | 31 | 3 | 6 | 19 | 31 |
| 1st sidelobe | dBi | N/A(2) | N/A(2) | 6 | 11 | N/A(2) | N/A(2) | 6 | 11 |
| Polarization |  | Vertical | Vertical | Vertical | | Vertical | Vertical | Vertical | |
| Antenna pattern |  | N/A(2) | N/A(2) | Uniform distribution(3) | | N/A(2) | N/A(2) | Uniform distribution(3) | |
| Horizontal beamwidth | Degrees | 360 | 360 | 16 | 3.3 | 360 | 360 | 16 | 3.3 |
| Vertical beamwidth | Degrees | 90 | 90 | 16 | 3.3 | 90 | 90 | 16 | 3.3 |

TABLE 1 (*continued*)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Units** | **System 3**  **Airborne** | | **System 3**  **Ground and shipborne** | | **System 4**  **Airborne** | | **System 4**  **Ground** | |
| Transmitter | | | | | | | | | |
| Tuning range | MHz | 4 400-4 940(1) | | 4 400-4 940(1) | | 4 400-4 940(1) | | 4 400-4 940(1) | |
| Power output | dBm | 42-50 | | 42 | | 43 | | 37 | |
| Bandwidth (3 dB) | MHz | 0.158 / 0.97 / 1.23 / 4.0 | | 0.158 / 0.97 / 1.23 / 4.0 | | 0.158 / 2.4 / 4.8 / 9.6 | | 0.158 / 2.4 / 4.8 / 9.6 | |
|  |  |  | |  | |  | |  | |
| Receiver(4) | | | | | | | | | |
| Tuning range | MHz | 4 400-4 940(1) | | 4 400-4 940(1) | | 4 400-4 940(1) | | 4 400-4 940(1) | |
| Selectivity (3 dB) | MHz | 0.2 / 1 / 1.5 / 4.5 | | 0.2 / 1 / 1.5 / 4.5 | | 0.2 / 2.6 / 5.0 / 10 | | 0.2 / 2.6 / 5.0 / 10 | |
| Noise figure | dB | 2.5 | | 2.5 (ground)/ 6 (shipborne) | | 2.5 | | 3 | |
| Thermal noise level | dBm | −118.5 to −105.0 | | −118.5 to −105.0 | | −118.5 to −101.5 | | −118 to −101 | |
| Antenna(4) | | | | | | | | | |
| Antenna type |  | Omni-directional | Directional | Omni-directional | Directional | Omni-directional | Directional | Omni-directional | Directional |
| Antenna gain | dBi | 3.5 | 16 | 3 | 30 | 4.5 | 16 | 4 | 30 |
| 1st sidelobe | dBi | N/A(2) | 9 | N/A(2) | 17 | N/A(2) | 9 | N/A(2) | 17 |
| Polarization |  | Vertical | Vertical | Vertical | Vertical | Vertical | Vertical | Vertical | Vertical |
| Antenna pattern |  | N/A(2) | Uniform distribution(3) | N/A(2) | Uniform distribution(3) | N/A(2) | Uniform distribution(3) | N/A(2) | Uniform distribution(3) |
| Horizontal beamwidth | degrees | 360 | 33 | 360 | 4.4 | 360 | 33 | 360 | 4.4 |
| Vertical beamwidth | degrees | 35 | 33 | 40 | 4.4 | 35 | 33 | 60 | 4.4 |

TABLE 1 (*continued*)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Units** | **System 5**  **Airborne** | | **System 5 Ground and shipborne** | | |
| Transmitter | | | | | | |
| Tuning range | MHz | 4 400-4 990(1) | | 4 400-4 990(1) | | |
| Power output | dBm | 45 | | 45 | | |
| Bandwidth (3 dB) | MHz | 0.4 / 3 / 8.5 | | 0.4 / 3 / 8.5 | | |
|  |  |  | |  | | |
| Receiver(4) | | | | | | |
| Tuning range | MHz | 4 400-4 990(1) | | 4 400-4 990(1) | | |
| Selectivity (3 dB) | MHz | 0.4 / 3 / 17 | | 0.4 / 3 / 17 | | |
| Noise figure | dB | 3.5 | | 3.5 (ground) / 6 (shipborne) | | |
| Thermal noise level | dBm | −114.5 to −98 | | −114.5 to −98 | | |
| Antenna(4) | | | | | | |
| Antenna type |  | Omni-directional | Directional | Omni-directional | Directional | |
| Antenna gain | dBi | 3 | 19 | 3 | 19 | 31 |
| 1st sidelobe | dBi | N/A(2) | 6 | N/A(2) | 6 | 11 |
| Polarization |  | Vertical | Vertical | Vertical | Vertical | |
| Antenna pattern |  | N/A(2) | See equation(5) | N/A(2) | See equations(5) & (6) | |
| Horizontal beamwidth | degrees | 360 | 16 | 360 | 16 | 3.3 |
| Vertical beamwidth | degrees | 90 | 16 | 360 | 16 | 3.3 |

TABLE 1 (*continued*)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Units** | **System 6 Airborne 1** | **System 6 Airborne 2** | **System 6 Ship borne** | | **System 6 Ground** | |
| **Transmitter** | | | | | | | |
| Tuning range | MHz | 4 800-4 990 | 4 800-4 990 | 4 800-4 990 | | 4 800-4 990 | |
| Power output | dBm | 27-33 | 27-33 | 35 | | 35 | |
| Bandwidth (3 dB) | MHz | 5/10/20/40 (software configurable) | 5/10/20/40 (software configurable) | 5/10/20/40 (software configurable) | | 5/10/20/40 (software configurable) | |
|  |  |  |  |  | |  | |
| **Receiver**(4) | | | | | | | |
| Tuning range | MHz | 4 800-4 990 | 4 800-4 990 | 4 800-4 990 | | 4 800-4 990 | |
| Selectivity (3 dB) | MHz | 5/10/20/40 | 5/10/20/40 | 5/10/20/40 | | 5/10/20/40 | |
| Noise figure | dB | 6 | 6 | 6 | | 4 | |
| Thermal noise level | dBm | −101 to −92 | −101 to −92 | −103 to −94 | | −103 to −94 | |
| **Antenna**(4) | | | | | | | |
| Antenna type |  | Omnidirectional | Omnidirectional | Omni-directional | Directional | Omni-directional | Directional |
| Antenna gain | dBi | 4.7 | 4.7 | 6 | 11.8 | 6 | 11.8 |
| 1st sidelobe | dBi | N/A | N/A | N/A | Note 2 | N/A | Note 2 |
| Polarization |  | Vertical | Vertical | Vertical | Vertical | Vertical | Vertical |
| Antenna pattern |  | N/A | N/A | Note 1 | Note 2 | Note 1 | Note 2 |
| Horizontal beamwidth | Degrees | 360 | 360 | 360 | 30 | 360 | 30 |
| Vertical beamwidth | Degrees | 90 | 90 | 28 | 18 | 28 | 18 |

TABLE 1 (*continued*)

| **Parameter** | **Units** | **System 7 Airborne 1** | **System 7 Airborne 2** |
| --- | --- | --- | --- |
| **Transmitter** | | | |
| Tuning range | MHz | 4 400-4 990 | 4 400-4 990 |
| Power output | dBm | 30-43 | 30-43 |
| Bandwidth (3 dB) | MHz | 5 / 0.008 | 5 / 0.008 |
|  |  |  |  |
| **Receiver**(4) | | | |
| Tuning range | MHz | 4 400-4 990 | 4 400-4 990 |
| Selectivity (3 dB) | MHz | 5 / 0.008 | 5 / 0.008 |
| Noise figure | dB | 6 | 6 |
| Thermal noise level | dBm | -103 / −131 | -103/ −131 |
| **Antenna**(4) | | | |
| Antenna type |  | Directional | Directional |
| Antenna gain | dBi | 14 | 14 |
| 1st sidelobe | dBi | -1 | -1 |
| Polarization |  | Vertical | Vertical |
| Antenna pattern |  | Uniform distribution (Refer to Rec. ITU-R M.1851) | Uniform distribution (Refer to Rec. ITU-R M.1851) |
| Horizontal beamwidth | Degrees | 24 | 28 |
| Vertical beamwidth | Degrees | 24 | 28 |

TABLE 1 *(end)*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **Units** | **System 8 Airborne** | **System 8 Ground** | **System 8 Shipborne** |
| **Transmitter** | | | | |
| Tuning range | MHz | 4 800-4 990 | 4 800-4 990 | 4 800-4 990 |
| Power output | dBm | 26 | 46 | 46 |
| Bandwidth (3 dB) | MHz | 40/50/60/80/100 (software configurable) | 40/50/60/80/100 (software configurable) | 40/50/60/80/100 (software configurable) |
|  |  |  |  |  |
| **Receiver**(4) | | | | |
| Tuning range | MHz | 4 800-4 990 | 4 800-4 990 | 4 800-4 990 |
| Selectivity (3 dB) | MHz | 40/50/60/80/100 | 40/50/60/80/100 | 40/50/60/80/100 |
| Noise figure | dB | 9 | 5 | 5 |
| Thermal noise level | dBm | −89 … -85 | −93 … -89 | −93 … -89 |
| **Antenna**(4) | | | | |
| Antenna type |  | Omnidirectional | Directional (steerable, MIMO) | Directional (steerable, MIMO) |
| Antenna gain | dBi | 0 | 15 | 15 |
| 1st sidelobe | dBi | N/A | N/A | N/A |
| Polarization |  | Vertical | Vertical | Vertical |
| Antenna pattern |  | N/A | Rec. ITU-R F.1336 | Rec. ITU-R F.1336 |
| Horizontal beamwidth | Degrees | 360 | 65 | 65 |
| Vertical beamwidth | Degrees | 90 | 90 | 90 |

Notes:

(1) RR No. **5.442** applies.

(2) N/A – Not applicable.

(3) Refer to Recommendation ITU-R M.1851.

(4)  The feeder loss associated with these systems is [0 to 3] dB.

(5) For antenna gain 19 dBi: and otherwise. Here, (x in radians) and .

(6) For antenna gain 31 dBi: Gψ= 20.log10𝑠𝑖𝑛𝑐15.5𝜋sin𝜓+31.0 ∀ψ∈−64.25°,64.25° and otherwise. Here, (x in radians) and .

In the Table “-“ means range of values, and “/” means discrete values.

*[Editor’s notes:*

1. *The need of this equation should be confirmed. One possible solution is to keep using footnote (3) in case of uniform distribution*
2. *The noise figure in some parts of Table 1 needs to be further clarified]*

**Annex 2  
  
Technical and operational characteristics and protection criteria for systems operating in the maritime mobile service**

**1 Introduction**

Systems and networks operating in the MMS are used for broadband data-links to support various applications, such as [remote sensing for earth sciences, land management, and energy distribution.]

These maritime mobile systems operating throughout the 4 400‑4 990 MHz frequency range or portions thereof may also be used to support security, law enforcement, and humanitarian assistance efforts. These tasks are of an unpredictable nature and immediate operations can be required at any time, however some of these operations can be planned in advance. Additionally, some operations can also take place outside national territories (e.g. to fight against piracy, to escort ships, for deep sea rescue, for search and rescue/emergency operations at sea, etc.). It should be noted however that these systems are not considered as safety-of-life systems.

It can be single link involving MMS stations (between coast stations and ship stations, or between ship stations) or a mesh networks involving several MMS stations.

**2 Operational deployment**

The maritime mobile systems listed in Table 2 uses maritime mobile service data links to create a network between ship stations and coast stations to transfer data between nodes. These transmissions could include ship-to-ship, ship-to-coast, or coast-to-ship datalinks. This system can be deployed near a coast or outside national waters. The stations outside national waters are only authorized by the administration of the flag state of ship.

The usage of this systems supports several operations, such as maritime search and rescue, disaster relief, and surveillance. These radio systems may be based on ship stations and coast stations to allow for datalinks required to transfer data such as imaging and video amongst the users of this mesh network. The mesh network allows for the ships to communicate with other vessels both near port and out in open waters with enough bandwidth capacity to facilitate multiple users over large areas. The links utilized are expected to extend to radio-line of sight only, however there may be multiple nodes and if the mesh network is used the deployment may cover an area larger (e.g. line-of-sight link) than any one individual desired link.

Depending on the area outside national airspace some of these operations can be planned in advance, whereas some other operations may take place at an unpredictable time and location.

**3 Technical characteristics of systems operating in the maritime mobile service**

Typical technical characteristics for representative maritime data links for the frequency range 4 400-4 990 MHz are provided in Table 2.

**3.1 Transmitter and receiver characteristics**

The maritime mobile systems operating or planned to operate within the frequency range 4 400‑4 990 MHz typically use digital modulations. A given transmitter may be capable of radiating more than one waveform. The out-of-band and spurious emissions of these maritime systems are compliant with Recommendation ITU-R SM.1541 (Annex 11) and Recommendation ITU-R SM.329 (Category A), respectively.

**3.2 Antenna characteristics**

The maritime mobile systems listed in Table 2 may use a variety of types of antennas that can be installed on either the ship station or ground station. These antenna gains are typically between 2.5 and 15 dBi.

The shipborne antenna height as described in Table 2 is in the range of 10 to 30 metres.

**4 Protection criteria**

An increase in receiver effective noise of 1 dB would result in significant degradation in communication range.

Such an increase in effective receiver noise level corresponds to an (*I* + *N*)/*N* ratio of 1.26, or an *I/N* ratio of about −6 dB. This represents the required protection criterion for the MMS systems referenced herein from interference due to another radiocommunication service or another application in the mobile service. If multiple potential interference sources are present, protection of the MMS systems requires that this criterion is not exceeded due to the aggregate interference from the multiple sources.

TABLE 2

**Typical technical characteristics of representative systems operating in the maritime mobile service   
in the frequency range 4 400-4 990 MHz**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Units** | **System 1 Shipborne** | | | **System 1 Ground** | | | **System 2 Shipborne** | **System 2 Ground** |
| **Transmitter** | | | | | | | | | |
| Tuning range | MHz | 4 400-4 940 | | | 4 400-4 940 | | | 4 800-4 990 | 4 800-4 990 |
| Power output | dBm | 39 | | | 39 | | | 46 | 46 |
| Bandwidth (3 dB) | MHz | 5.6/11.3/22.6 | | | 5.6/11.3/22.6 | | | 40/50/60/80/100 (software configurable) | 40/50/60/80/100 (software configurable) |
|  |  |  | | |  | | |  |  |
| **Receiver**(2) | | | | | | | | | |
| Tuning range | MHz | 4 400-4 940 | | | 4 400-4 940 | | | 4 800-4 990 | 4 800-4 990 |
| Selectivity (3 dB) | MHz | 5.6/11.3/22.6 | | | 5.6/11.3/22.6 | | | 40/50/60/80/100 | 40/50/60/80/100 |
| Noise figure | dB | 6 | | | 6 | | | 5 | 5 |
| Thermal noise level | dBm | −100.5 to −94.5 | | | −100.5 to −94.5 | | | −93 … −89 | −93 … −89 |
| **Antenna**(2) | | | | | | | | | |
| Antenna type |  | Omnidirectional | | | Omni-directional | | | Directional (steerable, MIMO) | Directional (steerable, MIMO) |
| Antenna gain | dBi | 6 | 4.2 | 2.5 | 6 | 4.2 | 2.5 | 15 | 15 |
| 1st sidelobe | dBi | N/A(1) | | | N/A(1) | | | N/A(1) | N/A(1) |
| Polarization |  | Vertical | | | Vertical | | | Vertical | Vertical |
| Antenna pattern |  | N/A(1) | | | N/A(1) | | | Rec. ITU-R F.1336 | Rec. ITU-R F.1336 |
| Horizontal beamwidth | Degrees | 360 | | | 360 | | | 65 | 65 |
| Vertical beamwidth | Degrees | 30 | 37 | 69 | 30 | 37 | 69 | 90 | 90 |
| Notes:   1. N/A – Not applicable. 2. The feeder loss associated with these systems is [0 to 3] dB. | | | | | | | | | |

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