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| **Author(s)/Contributor(s):**Andrew MeadowsAFSMO Dominic NguyeneSimplicity for AFSMOFumie WingoDON CIO Taylor King ACES for DON CIO | Phone: 334-467-4720E-mail: andrew.meadows.1@us.af.milPhone: 703-606-7394E-mail: dominic.nguyen@esimplicity.comPhone: 703-697-0066E-mail: [fumie.n.wingo.civ@us.navy.mil](fumie.n.wingo.civ%40us.navy.mil)Phone: 443-966-0550E-mail: [taylor.king@aces-inc.com](taylor.king%40aces-inc.com) |
| **Purpose/Objective:** The purpose of this document is to propose a revision of Recommendation ITU-R M.2089-0. |
| **Abstract:** ITU-R Recommendation M.2089-0 contains characteristics of aeronautical mobile service (AMS) in the frequency band 14.5-15.35 GHz. It was last revised in 2015. This contribution begins the process of revising the Recommendation to document AMS characteristics for use in the studies under WRC-27 agenda item 1.7. In particular, this document proposes updates to the characteristics to reflect the current operational parameters of airborne, and ground systems. |
| **Fact Sheet Preparer:** Dominic Nguyen |

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| **Radiocommunication Study Groups** |  |
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| Working document towards a Preliminary draft revision of Recommendation ITU-R M.2089-0 |

The United States of America would like to propose the attached revision of ITU-R Recommendation M.2089-0, ‘Technical characteristics and protection criteria for aeronautical mobile service systems in the frequency range 14.5-15.35 GHz’, in order to provide updated parameters of currently operating radars.

RECOMMENDATION ITU-R M.2089-0

**Technical characteristics and protection criteria for aeronautical mobile service systems in the frequency range 14.5‑15.35 GHz**

(2015)

**Scope**

This Recommendation provides information on the technical characteristics and protection criteria for systems operating in the aeronautical mobile service (AMS), planned to or currently operating in the frequency range 14.5‑15.35 GHz for use in sharing and compatibility studies as needed.

**Keywords**

Aeronautical Mobile Service, Technical Characteristics, Protection Criteria, Ku‑band

**Abbreviations/Glossary**

ADL AMS data link

ADT Airborne data terminal

AMS Aeronautical mobile service

GDT Ground data terminal

RLOS Radio line‑of‑sight

UAS Unmanned aircraft system

The ITU Radiocommunication Assembly,

*considering*

*a)* that systems and networks operating in the AMS are used for broadband, airborne data links to support remote sensing applications in the areas of, e.g. earth sciences, land management, and energy distribution. Examples of these applications include e.g. monitoring sea ice thickness and distribution, local and national law enforcement, forest fire mapping, petroleum pipeline monitoring, agricultural and urban land use and natural resource surveys;

*b)* that systems and networks operating in the AMS are used for narrow‑band, airborne command and control data links;

*c)* that there are increasing numbers of various planned and operating systems and networks in the AMS;

*d)* that administrations conducting ITU‑R sharing or compatibility studies addressing new allocation proposals in any part of the frequency range 14.5-15.35 GHz should take into account operations of incumbent services in the band, including aeronautical mobile service,

*recognizing*

*a)* that the frequency range 14.5-15.35 GHz is globally allocated on a primary basis to the mobile service;

*b)* that the aeronautical mobile service is a mobile service between aeronautical stations and aircraft stations, or between aircraft stations;

*c)* that the frequency range 14.5-15.35 GHz is also globally allocated on a primary basis to fixed service;

*d)* that the frequency range 14.5-14.8 GHz is also globally allocated on a primary basis to the fixed‑satellite service (Earth-to-space) under the provisions of RR No.**5.510**,

*recognizing further*

*a)* that in Regions 1 and 3, the use of the frequency range 14.5-14.8 GHz by the broadcasting satellite service for feeder links (Earth-to-space), is reserved for countries outside Europe operating under the provisions and associated plans of Appendix **30A** to the Radio Regulations;

*b)* that the use of the frequency range 14.5-14.8 GHz by the AMS in no way restricts or limits the operation of feeder link to broadcasting satellite service referred to in *recognizing further a)* above;

*c)* that the use of the frequency range 14.5-15.35 GHz by the AMS must take into account the operation of the fixed service referred to in *recognizing c)* above,

*recommends*

**1** that the technical and operational characteristics of the systems operating in the AMS described in the Annex should be considered representative of those operating in the frequency range 14.5-15.35 GHz;

**2** that the technical characteristics and protection criteria for AMS receiving and transmitting stations given in the Annex should be used in performing sharing and compatibility analyses as needed.

**Annex

Technical characteristics and protection criteria for aeronautical mobile
service systems in the frequency range 14.5‑15.35 GHz**

**1 Introduction**

Systems and networks operating in the AMS are increasingly used by local and national governments, as well as civil sector and educational entities, for broadband, airborne data links to support remote sensing applications e.g. earth sciences, land management, and energy distribution. Examples of these applications include, e.g. monitoring Arctic sea ice thickness and distribution, local and national law enforcement, forest fire mapping, pipeline monitoring, agricultural and urban land use, and natural resource surveys). The remote sensing equipment may be on board either manned aircraft or unmanned aeronautical systems (UAS). In the case where the remote sensing equipment is on board a UAS, systems and networks operating in the AMS may be used for narrow‑band, airborne command and control data links. These narrow‑band data links may be used to command and control either or both the remote sensor equipment and the UAS.

**2 Operational deployment**

In the frequency range 14.5-15.35 GHz, the mobile service is allocated on a primary basis in all three ITU‑R regions. The AMS is a mobile service between aeronautical stations and aircraft stations, or between aircraft stations platforms equipped with AMS data links (ADL) can be deployed anywhere within a country whose administration has authorized their use in accordance with the authorization.

An ADL may exist between an airborne data terminal (ADT), which is an aircraft station, and a ground data terminal (GDT), which is an aeronautical station, or between two ADTs. ADLs are bidirectional by design and may operate in either a narrow‑band or wideband mode in one or both directions depending upon operational requirements.

The GDT may be at a single permanent location or they may be transportable. Transportable GDTs can be moved to meet operational needs. The duration that a transportable GDT remains at a particular location is dependent upon operational requirements.

The link distance for the ADL is generally limited by the radio-line-of-sight (RLoS) horizon which is a function of the terrain in the vicinity of the GDT and the altitude of the ADT. The operational altitude of airborne platforms equipped with these ADLs depends on specific operational requirements and can vary up to approximately 20 km. Although some of the link lengths may be relatively short, many of the link distances approach RLoS horizon distance. For an air-to-ground link, this link distance may be approximately 450 km for an AMS data link at an altitude of approximately 20 km.

The link between two ADTs operates in the same manner as the link between a GDT and an ADT with the exception that the link distance is a function of the operating altitude of the two ADTs. In the case of a direct air-to-air link, this link distance may be approximately 900 km. Other factors to consider, such as atmospheric losses (rain attenuation, gases, etc.) and clutter losses, as described in the ITU‑R Recommendations P‑series, could reduce the maximum distance of the link between two aircraft. Depending on the environmental conditions and locations of the aircraft, the crosslink distance might be shorter than 900 km.

A single ground terminal may support several aeronautical terminals via different links. If the ADLs are operating in a narrow-band mode, multiple data links may be supported through frequency separation. If the data links are operating in a wideband mode, multiple data links may be supported through geographic separation using multiple high-gain, narrow-beam antennas.

The duration of the link can span the entire flight duration, i.e. take-off/landing, transit to/from the operational area, and the time used for data collection in the operational area. Thus, the time duration during which an ADL can be active may extend for many hours.

During the flight, tracking of directional AMS antennas (both GDT and ADT) are maintained using information exchanged through the link. In case of link loss, antenna tracking information is also lost, and due to aircraft movement, the correct antennas pointing could be no longer maintained. In this case, a full link recovery procedure must be initiated, and the duration of that interruption of service depends on the aircraft speed and the position of the pre‑planned rendezvous point that the aircraft must reach to resume the communication.

**3 Technical characteristics of aeronautical mobile systems**

Representative technical characteristics for airborne data links in the AMS for the frequency range 14.5-15.35 GHz are provided in Table 1.

**3.1 Transmitter characteristics**

The aeronautical mobile systems operating or planned to operate in the frequency band 14.5‑15.35 GHz typically use digital modulations. A given transmitter may be capable of radiating more than one waveform. Solid-state power amplifier output devices are typically used in the transmitters. The trend towards use of solid-state transmitters in new mobile systems will continue for the foreseeable future due to the wide bandwidth, low level of generated spurious emissions, low power consumption, and reliability of these devices.

Typical transmitter RF emission (3 dB) bandwidths of mobile systems operating or planned to operate in the frequency band 14.5-15.35 GHz range from about 0.3-120 MHz. Transmitter peak output powers range from 0.001 W (0 dBm) to 100 W (50 dBm) and are adjustable. However, the maximum power level at the input to the antenna is limited to 10 dBW in the 14.5-14.8 GHz frequency range by RR Article **21.5**. Within the frequency range of 14.5-14.8 GHz, the transmitted power can be adjusted such that it operates within the isotropically radiated power of 45 dBW when the direction of maximum radiation of the antenna is within 1.5 degrees of the geostationary-satellite orbit by RR Article **21.2**.

**3.2 Receiver characteristics**

The newer generation of aeronautical mobile systems in the frequency range 14.5-15.35 GHz use digital signal processing to enhance system performance.

The signal processing in the newer generation of aeronautical mobile systems may use direct sequence spread spectrum or other advanced techniques to produce a processing gain for the desired signal and may also provide suppression of undesired signals.

**3.3 Antenna characteristics**

A variety of different types of antennas are used by systems in the frequency range 14.5-15.35 GHz. Antennas in this band are generally of a variety of sizes and vary between the airborne component of the link and the ground based component of the link. The airborne antennas gain is typically in the range −3 to 27.5 dBi. The ground-based antenna gain is typically in the range 0‑45 dBi. Horizontal, vertical and circular polarizations are used.

If antenna characteristics provided in Table 1 are sufficient, these characteristics should be used in sharing analyses. If additional characteristics are required, the first source of the data should be measured antenna characteristics. Otherwise the antenna data in Table 1 in conjunction with Recommendation ITU‑R M.1851 should be used.

**4 Protection criteria for the aeronautical mobile service in the frequency range 14.5‑15.35 GHz**

When operating near the maximum radio line-of-sight distance separation between the transmitter and receiver, the performance of the communication link is often noise limited. An increase in receiver effective noise of 1 dB would constitute significant degradation communication range, equivalent to a reduction in communication range of approximately 10% in a free‑space propagation environment.

Such an increase effective receiver noise 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 from interference due to another radiocommunication service. If multiple potential interference sources are present, protection of the AMS requires that this criterion is not exceeded due to the aggregate interference from the multiple sources.

It is noted that, in the case where an administration wishing to operate an AMS system does not have bilateral coordination agreements with affected administrations, the level of interference from existing stations in the fixed service may exceed this protection criteria. Sharing studies should take this into account.

TABLE 1

**Representative technical characteristics of the aeronautical mobile service systems in the frequency range 14.5‑15.35 GHz**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | **Units** | **System 1 Airborne** | **System 1Ground** | **System 2 Airborne** | **System 2 Ground** |
| **Transmitter** |
| Tuning range | GHz | 15.15‑15.35 | 14.50‑14.83 | 14.50‑14.83 | 15.15‑15.35 |
| Power output 1 | dBm | 0 to 30 | 30 to 50 | 20 | 30 to 50 |
| Bandwidth  | 3 dB | MHz | 0.354 / 3.5 / 10 / 120 | 0.354 / 3.5 / 10 / 60 / 120 | 0.354 / 3.5 / 10 / 60 / 120 | 0.354 / 3.5 / 10 / 120 |
| 20 dB | MHz | 21 / 21.4 / 57.4 / 285 | 21 / 25 / 60 / 190 / 400 | 21 / 25 / 60 / 190 / 400 | 21 / 21.4 / 57.4 / 285 |
| 60 dB | MHz | 108 / 181 / 219 / 630 | 100 / 110 / 120 / 240 / 480 | 100 / 110 / 120 / 240 / 480 | 108 / 181 / 219 / 630 |
| Harmonic attenuation  | dB | 65 | 60 | 60 | 65 |
| Spurious attenuation  | dB | 80 | 52 | 52 | 80 |
| Modulation |  | OQPSK | OQPSK | OQPSK | OQPSK |
| **Receiver** |
| Tuning range | GHz | 14.50‑14.83 | 15.15‑15.35 | 15.15‑15.35 | 14.50‑14.83 |
| RF selectivity  | 3 dB | MHz | 520 | 440 | 440 | 520 |
| 20 dB | MHz | 580 | 587 | 587 | 580 |
| 60 dB | MHz | 720 | 700 | 700 | 720 |
| IF selectivity  | 3 dB | MHz | 36 / 140 | 27 / 150 | 27 / 150 | 36 / 140 |
| 20 dB | MHz | 67 / 400 | 46 / 210 | 46 / 210 | 67 / 400 |
| 60 dB | MHz | 173 / 850 | 113 / 600 | 113 / 600 | 173 / 850 |
| NF | dB | 4 | 5 | 5 | 4 |
| Sensitivity  | dBm | −75 to −80 | −105 to −110 | −105 to −110 | −75 to −80 |
| Image rejection  | dB | 80 | 100 | 100 | 80 |
| Spurious rejection  | dB | 60 | 50 | 50 | 60 |

TABLE 1 (*continued*)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | **Units** | **System 1 Airborne** | **System 1Ground** | **System 2 Airborne** | **System 2 Ground** |
| **Antenna** |
| Antenna gain  | dBi | 24 | 40 | 27  | 7.2 | 44 | 3 |
| 1st sidelobe | dBi | 5.5 @ 21° | 20 @ 2.5° | 9.7 @ 12°  | N/A2 | 21 @ 2.3° | N/A2 |
| Polarization |  | RHCP3 | RHCP3 & LHCP4 | RHCP3 & LHCP4  | Not available | RHCP3 | Vertical |
| Antenna pattern/type |  | RF lens | Parabolic reflector | Parabolic reflector | Biconical dipole | Parabolic reflector | Dipole |
| Horizontal BW  | degrees | 12 | 1.5 | 8  | 360 | 1.7  | 360 |
| Vertical BW  | degrees | 12 | 1.5 | 8  | 16 | 1.7  | 42 |
| Antenna model |  | Recommendation[ITU‑R M.1851](http://www.itu.int/rec/R-REC-M.1851/en)5(Uniform distribution) | Recommendation[ITU‑R M.1851](http://www.itu.int/rec/R-REC-M.1851/en)5(Cosine distribution) | Recommendation[ITU‑R M.1851](http://www.itu.int/rec/R-REC-M.1851/en)5(Uniform distribution)  | Omnidirectional | Recommendation[ITU‑R M.1851](http://www.itu.int/rec/R-REC-M.1851/en)5(Cosine distribution) | Omnidirectional |
| Notes:(1) In the frequency band 14.5‑14.8 GHz, RR Articles **21** (§§ 21.2, 21.3 and 21.5) apply.(2) N/A – Not applicable.(3) RHCP – Right Hand Circularly Polarized.(4) LHCP – Left Hand Circularly Polarized.(5) Recommendation ITU‑R M.1851 provides several patterns based on the field distribution across the aperture of the antenna. The suggested distribution for modelling the antennas is shown in the parenthetical text based on guidance in Recommendation ITU‑R M.1851. |

TABLE 1 (*continued*)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | **Units** | **System 3Airborne** | **System 3Ground** | **System 4Airborne** | **System 4Ground** |
| **Transmitter** |
| Tuning range | GHz | 14.50‑15.35 | 14.83‑15.35 | 14.50‑14.83 | 15.15‑15.35 |
| Power output1 | dBm | 0 to 30 | 40 | 40 | 50 |
| Bandwidth  | 3 dB | MHz | 0.354 / 3.5 / 40 | 34 | 3.4 / 10.3 / 20.6 / 27.8 / 42.9 | 9.15 |
| 20 dB | MHz | 21 / 21.4 / 85 | 44 | 7 / 18.8 / 37.6 / 78.5 / 112 | 36.6 |
| 60 dB | MHz | 108 / 181 / 190 | 45.6 | 20 / 67.2 / 134 / 281 / 320 | 76.6 |
| Harmonic attenuation  | dB | 65 | 65 | 65 | 65 |
| Spurious attenuation  | dB | 80 | 80 | 80 | 80 |
| Modulation |  | OQPSK | 16 APSK | QPSK, OQPSK | OQPSK |
| **Receiver** |
| Tuning range | GHz | 14.83‑15.35 | 14.50‑15.35 | 15.15‑15.35 | 14.50‑14.83 |
| RF selectivity  | 3 dB | MHz | 520 | 440 | 307 | 340 |
| 20 dB | MHz | 580 | 587 | 325 | 400 |
| 40 dB |  | Not available | Not available | 399 | 540 |
| 60 dB | MHz | 720 | 700 | Not available | Not available |
| IF selectivity  | 3 dB | MHz | 50 | 50 | 130 | 36.5 |
| 20 dB | MHz | 85 | 70 | 400 | 59.1 |
| 60 dB | MHz | 135 | 120 | 1 200 | 103.7 |
| NF | dB | 5 | 4 | 4.5 | 6 |
| Sensitivity  | dBm | −99 | −105 to −110 | −106 | −92 |
| Image rejection  | (dB) | 100 | 100 | 80 | 85 |
| Spurious rejection  | (dB) | 50 | 50 | 60 | 85 |

TABLE 1 (*continued*)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | **Units** | **System 3 Airborne** | **System 3Ground** | **System 4 Airborne** | **System 4 Ground** |
| **Antenna** |
| Antenna gain  | dBi | 24 | 45 | 3.7 | 19.5 | 3 | 40 |
| 1st sidelobe | dBi | 5.5 @ 21° | 20 | N/A2 | 3.5 @ 20° (azimuth)4.0 @ 23° (elevation) | N/A1 | 22 |
| Polarization |  | RHCP 3 | RHCP3 | RHCP3 | RHCP3 | RHCP3 | RHCP3 |
| Antenna pattern/type |  | RF lens | Parabolic reflector | Biconical dipole | RF lens | Biconical dipole | Parabolic reflector |
| Horizontal BW  | Degrees | 12 | 1.11 | 360 | 12 | 360 | 3.8 |
| Vertical BW  | Degrees | 12 | 1.11 | 40 | 12 | 42 | 3.8 |
| Antenna model |  | Recommendation [ITU‑R M.1851](http://www.itu.int/rec/R-REC-M.1851/en)5(Uniform distribution) | Recommendation [ITU‑R M.1851](http://www.itu.int/rec/R-REC-M.1851/en)5(Cosine distribution) | Omnidirectional | Recommendation ITU‑R M.18515(Uniform distribution) | Omnidirectional | Recommendation ITU‑R M.18515(Uniform distribution) |
| Notes:(1) In the frequency band 14.5‑14.8 GHz, RR Articles **21** (§§ 21.2, 21.3 and 21.5) apply.(2) N/A – Not applicable.(3) RHCP – Right Hand Circularly Polarized.(4) LHCP – Left Hand Circularly Polarized.(5) Recommendation [ITU‑R M.1851](http://www.itu.int/rec/R-REC-M.1851/en) provides several patterns based on the field distribution across the aperture of the antenna. The suggested distribution for modelling the antennas is shown in the parenthetical text based on guidance in Recommendation [ITU‑R M.1851](http://www.itu.int/rec/R-REC-M.1851/en). |

TABLE 1 (*continued*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **Units** | **System 5Airborne** | **System 5Ground** | **System 6Airborne / Ground / Shipboard terminals** |
| **Transmitter** |
| Tuning range | GHz | 14.5‑15.35  | N/A2 | 14.5‑15.35 |
| Power output | dBm | 10 to 50 | N/A2 | 20 to 43 |
| Bandwidth  | 3 dB | MHz | 0.8 / 8.6 / 11.6 / 40.6 / 43.6 | N/A2 | 0.8 to 100 |
| 20 dB | MHz | 1.2 / 12.1 / 16.1 / 57 / 61.2 | N/A2 | 1.2 to 120 |
| 60 dB | MHz | 9.8 / 24.4 / 32.6 / 114 / 122 | N/A2 | 9.8 to 160 |
| Harmonic attenuation  | dB | 65 | N/A2 | 60 |
| Spurious attenuation  | dB | 70 | N/A2 | 60 |
| Modulation |  | QPSK/8PSK | N/A2  | PSK/QPSK/8PSK |
| **Receiver** |
| Tuning range | GHz | N/A2 | 14.5‑15.35 | 14.5‑15.35 |
| RF selectivity  | 3 dB | MHz | N/A2 | 800 | 100 |
| 20 dB | MHz | N/A2 | 830 | 120 |
| 60 dB | MHz | N/A2 | 990 | 160 |
| IF selectivity  | 3 dB | MHz | N/A2 | 0.85 / 8.8 / 11.7 / 40.7 / 43.7 | 0.85 to 120 |
| 20 dB | MHz | N/A2 | 1.3 / 18 / 23 / 90 / 90 | 1.3 to 120 |
| 60 dB | MHz | N/A2 | 3;2 / 61; 81; 320 / 320 | 3.2 to 160 |
| NF | dB | N/A2 | 3.5 | 3.5 |
| Sensitivity  | dBm | N/A2 | Up to −111 | Up to −108 |
| Image rejection  | (dB) | N/A2 | 80 | 65 |
| Spurious rejection  | (dB) | N/A2 | 60 | 60 |

TABLE 1 (*end*)

|  |
| --- |
| **Antenna** |
| Antenna gain  | dBi | −3 to 27.5 | 42.5 | 0 to 12 |
| 1st sidelobe | dBi | N/A2 | 22.5 | N/A2 |
| Polarization |  | RHCP3 | RHCP3 | Vertical / RHCP3 |
| Antenna pattern/type |  | Dipole / Parabolic reflector  | Parabolic reflector | Dipole / Phase array |
| Horizontal BW  | Degrees | 360 to 7 | 1 | 360 to 45 |
| Vertical BW  | Degrees | 90 to 7 | 1 | 90 to 45 |
| Antenna model |  | Omnidirectional or Recommendation ITU‑R M.18515(Uniform distribution) | Recommendation ITU‑R M.18515(Cosine distribution) | Not available |
| Notes:(1) In the frequency band 14.5‑14.8 GHz, RR Articles **21** (§§ 21.2, 21.3 and 21.5) apply.(2) N/A – Not applicable.(3) RHCP – Right Hand Circularly Polarized.(4) LHCP – Left Hand Circularly Polarized.(5) Recommendation ITU‑R M.1851 provides several patterns based on the field distribution across the aperture of the antenna. The suggested distribution for modelling the antennas is shown in the parenthetical text based on guidance in Recommendation ITU‑R M.1851. |