| **US Radiocommunication Sector**  **FACT SHEET** | | | |
| --- | --- | --- | --- |
| **Study Group:** USWP 5B | | **Document No:** USWP5B-19 | |
| **Reference:** [Document 5B/225](https://www.itu.int/md/R19-WP5B-C-0225/en) Annex 28 | | **Date:** 30 March 2021 | |
| **Document Title:** Updates to Working document towards a preliminary draft new  report ITU-R [NON-SAFETY AMS] | | | |
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| **Purpose/Objective**:  Propose updates to Working document towards a preliminary draft new  report ITU-R [NON-SAFETY AMS], building upon discussions and proposals at the November 2020 WP 5B meeting. | | | |
| **Abstract**:  At the November 2020 meeting of WP 5B, a Working Document towards Preliminary Draft New Report ITU-R M.[NON-SAFETY AMS] was initiated and attached to the WP 5B Chairman’s Report. It contains relevant characteristics from ITU-R Recommendations of systems of the incumbent services, recommended propagation models as well as preliminary characteristics of proposed systems for the potential new AMS allocation for non-safety of life application.  Some additional parameters may be necessary to conduct the sharing and compatibility studies between non-safety AMS and the incumbents. This contribution comments on those additional parameters.  This contribution also seeks to further this work by beginning studies of adjacent band compatibility between the potential new AMS allocation in 22-22.21 GHz and EESS (passive) in 22.21-22.5 GHz. | | | |
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| **Radiocommunication Study Groups** |  |
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| |  | | --- | | Updates to Working document towards a preliminary draft new report ITU-R [NON-SAFETY AMS] | |  | | |

**1 Introduction**

At the November 2020 meeting of WP 5B a WD towards PD new Report ITU-R M.[NON-SAFETY AMS] has been initiated and attached to the WP 5B Chairman’s Report. It contains various characteristics from ITU-R Recommendations of systems in the incumbent services, recommended propagation models as well as preliminary characteristics of systems in the possible new AMS allocation for non-safety of life application. The United States of America proposes the missing technical characteristics of non-safety aeronautical mobile service (AMS) as placeholders for other administration to fill in in support of WRC-23 AI 1.10. See yellow highlights in table 1.

This contribution seeks to further this work by beginning studies of adjacent band compatibility between the possible new AMS allocation in 22-22.21 GHz and EESS (passive) in 22.21-22.5 GHz.

**Attachment:** 1

|  |  |
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| **Radiocommunication Study Groups** |  |
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| Source: Document 5B/TEMP/65  Subject: WRC-23 agenda item 1.10 | **Annex 28 to Document 5B/225-E** |
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| Annex 28 to Working Party 5B Chairman’s Report | |
| Working document towards a preliminary draft new  report ITU-R [NON-SAFETY AMS]  [ELEMENTS TO A Working document related to  WRC-23 Agenda Item 1.10] | |
| Technical study for new non-safety aeronautical mobile applications | |

*[Editor’s note: These elements to a working document related to WRC-23 agenda item 1.10 may be considered later as a candidate for the baseline for draft ITU-R Report.]*

*[Editor’s note: Following a compilation of input contributions received in July and November 2020 WP 5B meetings which have been presented and has not yet been agreed.]*

Scope

The Report presents the technical characteristics, the methodology and scenarios as well as the results of technical studies undertaken to address the sharing and compatibility studies under the agenda item 1.10 in accordance with Resolution **430 (WRC-19)**.

Glossary of abbreviations

XXX To be completed

# 1 Relevant ITU-R Recommendations and Reports

|  |  |
| --- | --- |
| *Recommendations* | |
| [ITU-R F.758](https://www.itu.int/rec/R-REC-F.758/en) | System parameters and considerations in the development of criteria for sharing or compatibility between digital fixed wireless systems in the fixed service and systems in other services and other sources of interference |
| [ITU-R M.1730](https://www.itu.int/rec/R-REC-M.1730-1-200910-I/en) | Characteristics of and protection criteria for the radiolocation service in the frequency band 15.4-17.3 GHz |
| [ITU-R RA.517](https://www.itu.int/rec/R-REC-RA.517-4-200605-I/en) | Protection of the radio astronomy service from transmitters operating in adjacent bands. |
| [ITU-R RA.769](https://www.itu.int/rec/R-REC-RA.769-2-200305-I/en) | Protection criteria used for radio astronomical measurements |
| [ITU-R RA.1513](https://www.itu.int/rec/R-REC-RA.1513-2-201503-I/en) | Levels of data loss to radio astronomy observations and percentage-of-time criteria resulting from degradation by interference for frequency bands allocated to the radio astronomy service on a primary basis |
| [ITU-R RA.1631](https://www.itu.int/rec/R-REC-RA.1631-0-200305-I/en) | Reference radio astronomy antenna pattern to be used for compatibility analyses between non-GSO systems and radio astronomy service stations based on the epfd concept |
| [ITU-R RS.1028](https://www.itu.int/rec/R-REC-RS.1028-2-200305-W/en) | Performance criteria for satellite passive remote sensing |
| [ITU-R RS.1029](https://www.itu.int/rec/R-REC-RS.1029-2-200305-W/en) | Interference criteria for satellite passive remote sensing |
| [ITU-R RS.1813](https://www.itu.int/rec/R-REC-RS.1813-1-201102-I/en) | Reference antenna pattern for passive sensors operating in the Earth exploration-satellite service (passive) to be used in compatibility analyses in the frequency range 1.4-100 GHz |
| [ITU-R RS.1861](https://www.itu.int/rec/R-REC-RS.1861/en) | Typical technical and operational characteristics of Earth exploration-satellite service (passive) systems using allocations between 1.4 and 275 GHz |
| [ITU-R RS.2017](https://www.itu.int/rec/R-REC-RS.2017/en) | Performance and interference criteria for satellite passive remote sensing |
| [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 |
| [ITU-R S.1341](https://www.itu.int/rec/R-REC-S.1341-0-199710-I/en) | Sharing between feeder links for the mobile-satellite service and the aeronautical radionavigation service in the space-to-Earth direction in the band 15.4‑15.7 GHz and the protection of the radio astronomy service in the band 15.35-15.4 GHz |
| [ITU-R SA.509](https://www.itu.int/rec/R-REC-SA.509-3-201312-I/en) | Space research earth station and radio astronomy reference antenna radiation pattern for use in interference calculations, including coordination procedures, for frequencies less than 30 GHz |
| [ITU-R SA.510](https://www.itu.int/rec/R-REC-SA.510-3-201707-I/en) | Feasibility of frequency sharing between the space research service and other services in bands near 14 and 15 GHz - Potential interference from data relay satellite systems |
| *Reports* |  |
| [ITU-R M.2170](https://www.itu.int/pub/R-REP-M.2170-2009) | Compatibility analysis and results for radiolocation systems planned to operate in the 15.4 to 17.3 GHz band and aircraft landing system operating in the 15.4‑15.7 GHz band as well as the radio astronomy service operating in the adjacent band 15.35-15.40 GHz, FSS systems and aeronautical radionavigation systems |
| [ITU-R M.2229](https://www.itu.int/pub/R-REP-M.2229-2011) | Compatibility study to support line-of-sight control and non-payload communications links for unmanned aircraft systems proposed in the frequency band 15.4-15.5 GHz |
| [ITU-R M.2230](https://www.itu.int/pub/R-REP-M.2230-2011) | Frequency sharing between unmanned aircraft systems for beyond line of sight control and non-payload communications links and other existing and planned services in the frequency bands 13.25-13.40 GHz, 15.4-15.7 GHz, 22.5‑22.55 GHz and 23.55-23.60 GHz |
| [ITU-R RA.2131](https://www.itu.int/pub/R-REP-RA.2131-2009) | Supplementary information on the detrimental threshold levels of interference to radio astronomy observations in Recommendation ITU-R RA.769 |

WDPDN 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

# 2 Introduction

WRC-19 approved WRC-23 agenda item 1.10 “to conduct studies on spectrum needs, coexistence with radiocommunication services and regulatory measures for possible new allocations for the aeronautical mobile service for the use of non-safety aeronautical mobile applications, in accordance with Resolution **430 (WRC-19)**”. Resolution **430 (WRC-19)** invites inter alia to conduct sharing and compatibility studies on possible new primary allocations to the aeronautical mobile service for non-safety aeronautical applications in the frequency band 15.4-15.7 GHz, while ensuring the protection of primary services in the considered frequency bands and, as appropriate, adjacent frequency bands.

# 3 Current use of the identified frequency bands and in adjacent bands

## 3.1 Frequency bands 15.4-15.7 GHz

This Resolution notes that the frequency band 15.4-15.7 GHz is allocated to the radiolocation, aeronautical radionavigation and, part of, to the fixed-satellite (Earth-to-space) service on a primary basis and that the frequency band 15.4-15.7 GHz is adjacent to the frequency band 15.35-15.4 GHz which is allocated to the radio astronomy service on a primary basis and is subject to RR No. **5.340** prohibiting all emissions in 15.35-15.4 GHz band. Resolution **430** **(WRC-19)** also invites in *resolves to invite ITU-R* 4 to determine appropriate protection for passive services and radio astronomy allocated in adjacent bands from unwanted emission of AMS.

## 3.2 Frequency bands 22-22.21 GHz

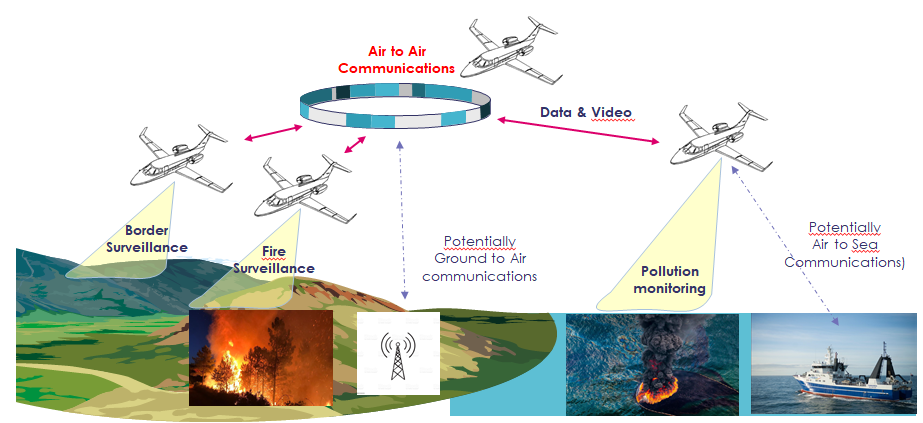
This Resolution notes that the frequency band 22-22.21 GHz is allocated on a primary basis to the mobile except aeronautical mobile service, this frequency band is adjacent to the frequency band 22.21-22.5 GHz which is allocated to radioastronomy service, EESS and SRS passive service on a primary basis and that the frequency bands 22.01-22.21 GHz and 22.21-22.5 GHz are covered by RR No. **5.149**. This footnote urges administrations to take all practicable steps to protect radioastronomy service from harmful interference and states that “Emissions from spaceborn or airborne stations can be particularly serious sources of interference to the radioastronomy service”. Resolution **430 (WRC-19)** also invites in *resolves to invite ITU-R* 4 to determine appropriate protection for passive services and radioastronomy allocated in adjacent bands from unwanted emission of AMS. Frequency band 22-22.21 GHz is also allocated on a primary status to the fixed service.

# 4 Studies on spectrum needs for non-safety aeronautical mobile applications

[To be populated later]

## 4.1 Operational configuration for non-safety AMS

The following figure provides one preliminary AMS operational deployment**.**



4.1.1 Deployment density for non-safety AMS

TBD

[Editor’s note: This section will provide the deployment density of the non-safety AMS to be used for sharing studies]

## 4.2 Spectrum need

[To be populated later]

Annex 1

Sharing and compatibility studies in the frequency band 15.4-15.7 GHz

# A1.1 Scenarios of sharing and compatibility studies

## A1.1.1 Technical characteristics of the new non-safety AMS systems

Preliminary structure for airborne data links technical characteristics in the non–safety AMS is provided in Table 1.

TABLE 1

Preliminary technical characteristics of the non-safety aeronautical mobile service systems   
in the frequency band 15.4-15.7 GHz

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | System 1 | System 2 | System 3 | |
| Station location | Airborne | Airborne and Ground | Airborne | Ground |
| Communication direction | Air-Air | Air-to-Air, Air-to-Ground or Ground-to-Air | Air-to-Air or Air-to-Ground | Ground-to-Air |
| Transmitter power output (dBm) | Variable in the range [0 to 30] dBm | Up to 50 dBm | Up to 51 dBm | Up to 43 dBm |
| Transmitter bandwidth (MHz) | From [30 to 300 MHz] | Up to 300 MHz | Up to 300 MHz | |
| Transmitter Out of Band |  | t.b.d. | t.b.d. | t.b.d. |
| Transmitter spurious |  | t.b.d. | t.b.d. | t.b.d. |
| Transmitter modulation | PSK | t.b.d. | t.b.d. | t.b.d. |
| Receiver tuning range (GHz) | 15.4-15.7 | Programmable | Programmable | Programmable |
| Receiver selectivity (MHz) |  | Programmable according to selected mode | Programmable according to selected mode | Programmable according to selected mode |
| Receiver noise figure (dB) |  | Typ. 5 -10 dB | Typ. 5 -10 dB | Typ. 5 -10 dB |
| Receiver rejection (dB) |  | t.b.d. | t.b.d. | t.b.d. |
| Protection criteria |  | t.b.d. | t.b.d. | t.b.d. |
| Antenna gain (dBi) | From [-3 to 25] | Up to 40 dBi | 2 dBi | 10 dBi |
| Antenna polarization |  | Horizontal, vertical, circular | Horizontal, vertical, circular | Horizontal, vertical, circular |
| Antenna pattern/type |  | Directional | Omnidirectional | Directional |
| Vertical beamwidth (Degrees) |  |  |  |  |
| Horizontal beamwidth (Degrees) |  |  |  |  |
| ITU-R Recommendation antenna pattern |  |  |  |  |
| Station altitude |  |  |  |  |
| RF bandwidth |  |  |  |  |

[Editor’s note: It was noted that additional parameters such as operational altitude and antenna pattern (e.g., reference to ITU-R Recommendation) will be needed for studies and are expected to be provided at the next WP 5B meeting]

[Editor’s note: the following table will be removed and the study updated when technical information of the new non-safety AMS systems will become available]

Before the parameters of non-safety AMS are determined, characteristics of aeronautical mobile service systems are taken from Table 1 of Recommendation ITU-R M.2089-0, system 6 is taken as a example.

TABLE 1

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

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | | Units | System 6 Airborne / Ground / Shipboard terminals |
| Transmitter | | | |
| Tuning range | | GHz | 14.5‑15.35 |
| Power output | | dBm | 20 to 43 |
| Bandwidth | 3 dB | MHz | 0.8 to 100 |
| 20 dB | MHz | 1.2 to 120 |
| 60 dB | MHz | 9.8 to 160 |
| Harmonic attenuation | | dB | 60 |
| Spurious attenuation | | dB | 60 |
| Modulation | |  | PSK/QPSK/8PSK |
| **Receiver** | | | |
| Tuning range | | GHz | 14.5‑15.35 |
| RF selectivity | 3 dB | MHz | 100 |
| 20 dB | MHz | 120 |
| 60 dB | MHz | 160 |
| IF selectivity | 3 dB | MHz | 0.85 to 120 |
| 20 dB | MHz | 1.3 to 120 |
| 60 dB | MHz | 3.2 to 160 |
| NF | | dB | 3.5 |
| Sensitivity | | dBm | Up to −108 |
| Image rejection | | (dB) | 65 |
| Spurious rejection | | (dB) | 60 |
| Antenna | | | |
| Antenna gain | dBi | | 0 to 12 |
| 1st sidelobe | dBi | | N/A2 |
| Polarization |  | | Vertical / RHCP3 |
| Antenna pattern/type |  | | Dipole / Phase array |
| Horizontal BW | Degrees | | 360 to 45 |
| Vertical BW | Degrees | | 90 to 45 |
| Antenna model |  | | Not available |

## A1.1.2 Technical characteristics of the systems in the incumbent services

### A1.1.2.1 Characteristics of radiolocation service

The following characteristics of radiolocation systems are taken from Table 1 of Report ITU-R M.2170.

TABLE 1

Radiolocation systems characteristic in the frequency band 15.4-15.7 GHz

| Characteristics | System‑6 |
| --- | --- |
| Function | Search, track and ground-mapping  (multi-function) |
| Platform type | Airborne (typical operational  height = 8 500 m) |
| Tuning range (GHz) | 15.4-17.3 |
| Modulation | Linear FM chirp |
| Transmit peak power (W) | 500 |
| Pulse width (s) | 0.05-50 |
| Pulse rise/fall time (ns) | 5-100 |
| Pulse repetition rate (pps) | 200-20 000 |
| Maximum duty cycle | Up to 0.2 |
| Output device | Travelling wave tube |
| Antenna pattern type | Pencil |
| Antenna type | Phased array |
| Antenna polarization | Linear |
| Antenna gain (dBi) | 35 |
| Antenna elevation beamwidth (degrees) | 3.2 |
| Antenna azimuthal beamwidth (degrees) | 3.2 |
| Antenna horizontal scan rate | 1-30°/s |
| Antenna horizontal scan type (continuous, random, sector, etc.) | ±45° (electronic) |
| Antenna vertical scan rate | 1, 5°/s |
| Antenna vertical scan type | +5° to −45° (electronic) |
| Antenna 1st side-lobe level | 3.5 dBi at 5.2° |
| Antenna height | Aircraft altitude |
| 1st/2nd receiver IF −3 dB bandwidths (MHz) | 25 |
| Receiver noise figure (dB) | 5 |
| Minimum discernible signal (dBm) | −100 |
| Chirp bandwidth (MHz) | < 1 900 |
| Transmitter RF emission bandwidth (MHz):  −3 dB  −20 dB | 1 850 1 854 |

[Editor’s note: Recommendation ITU-R M.1730 system 6 is revised 3 parameters: Platform type, antenna peak power, and antenna pattern.]

## A1.1.2.2 Characteristics of aeronautical radionavigation service

Parameters of Surface based radars (SBR), Aircraft landing systems (ALS), Aircraft multipurpose radars (MPR) and Radar sensing and measurement systems (RSMS) are presented in Recommendation ITU-R S.1340. This released has been published in 1997 and an update of these parameters would be necessary.

Parameters of an ALS system which is implemented by some administrations are provided in Report ITU-R M.2170.

A working document preliminary draft new Recommendation has been initiated and would contain the characteristics to be addressed in this study.

## A1.1.2.3 Characteristics of radioastronomy

Protection criteria for radioastronomy service are taken from Table 2 of Recommendation ITU‑R RA.769.

TABLE 2

Threshold levels of interference detrimental to radio astronomy continuum observations

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Centre  frequency *fc* (MHz) | Assumed bandwidth *f* (MHz) | Minimum antenna noise temperature *TA* (K) | Receiver noise temperature *TR* (K) | System sensitivity(noise fluctuations) | | Threshold interference levels | | |
| Temperature *T* (mK) | Power spectral density *P* (dB(W/Hz)) | Input power *PH* (dBW) | pfd *SH* *f* (dB(W/m2)) | Spectral pfd *SH* (dB(W/(m2  Hz))) |
| 15 375 | 50 | 15 | 15 | 0.095 | –269 | –202 | –156 | –233 |

Typical radio telescopes for which compatibility studies might be performed

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Administration | Name | N. Latitude | E. Longitude | Height AMSL (m) | Diameter (m) |
| Germany | Effelsberg | 50° 31' 29" | 06° 53' 03" | 369 | 100 |
| South Africa | MeerKAT | −30° 43 16" | 21° 24' 40" | 1 054 | 64 × 13.5 m |
| USA | Green Bank Telescope | 38° 25' 59" | −79° 50' 23" | 250 | 100 |
| USA | Jansky VLA | 33° 58' 22" to 34° 14' 56" | −107° 24' 40" to  −107° 48' 22" | 2 000 | 27 × 25 m |
| Australia | Parkes | −33º 00' 00" | 148º 15' 44" | 372 | 64 |
| China | Tianma | 31° 05′ 13" | 121° 09′ 48" | 5 | 65 |
| Japan | Nobeyama | 35º 56' 40" | 138º 28' 21" | 1 350 | 45 |
| France | Plateau de Bure | 44º 38' 02" | 05° 55' 28.5" | 2 250 | 12 × 15 m |

## A1.1.2.4

## A1.1.3 Scenarios of sharing and compatibility studies

[To be populated later]

## A1.1.4 Propagation

Working Party 3K and WP 3M noted in their liaison statement that:

“Recommendation [ITU-R P.528-4](http://www.itu.int/rec/R-REC-P.528/en) can be used for modelling the basic transmission loss for air-to-air, ground-to-air, and air-to-ground paths. This Recommendation has an upper validity limit of 15.5 GHz, which does not cover all the frequency ranges of interest to WP 5B. Recommendation ITU-R P.528-4 can be used for initial preliminary studies at 15.5 GHz. Working Parties 3K and 3M would like to bring to the attention of WP 5B that Recommendation ITU-R P.528-4 does not include effects such as hydrometeors and diffraction due to irregular terrain.

Working Party 3K and WP 3M recognize the urgency of WP 5B’s work and would wish to draw to the attention of WP 5B the work of [Correspondence Group (CG) 3K-3M-9](https://extranet.itu.int/rsg-meetings/sg3/wp3m/CG-3K-3M-9/default.aspx). This CG has updated Terms of Reference and will be studying the modelling of air-to-ground paths in the intersessional period.”

# A1.2 Results of the sharing and compatibility studies

## A1.2.1 Studies with radiolocation service

The analysis calculates the interference of AMS airborne and ground stations to the radiolocation system.

The protection criteria for the radiolocation service is assumed to be *I*/*N*=–6 dB.

The following equation can be used to determine if interference to the radiolocation system 6 receiver from AMS System‑6 transmissions is likely to occur and what separation distance is required to eliminate the interference:

*I* = *PTx* + *GTx* + *GRx* – *LTrans* – *FDR* (1)

where:

*I* : interference power at the receiver (dBm),

*PTx*: power of the interfering system (dBm), 30 dBm is used as an example,

*GTx* : antenna gain of the interfering transmitter in the direction of the victim receiver (dBi),we assume that the antenna of the AMS system is omni directional and the antenna gain is 0 dB,

*GRx* : antenna gain of the victim receiver in the direction of the interfering transmitter (dBi),

*LTrans* : transmission loss between transmitting and receiving antennas (dB) using free space loss for air to air, and using Recommendation ITU-R P.528-2 for ground to air. Free space loss = 20 log(F) + 20 log(R) + 32.44,

*F* : frequency (MHz),

*R* : separation distance (km),

*FDRIF* : frequency-dependent rejection produced by the receiver IF selectivity curve on an unwanted transmitter emission spectra (dB).

The *FDRIF* value can be determined from Recommendation ITU-R SM.337-6. Since the radars will operate on a co-frequency basis, only the on-tune rejection (OTR) is considered. OTR for non‑coherent chirped pulsed signals is given by:

*OTR*  10 log (*Rx\_BW*/*Tx\_BW*) for *Rx\_BW* ≤ *Tx\_BW* (2)

Otherwise OTR = 0

where:

*Rx\_BW* : receiver bandwidth (MHz),

*Tx\_BW* : transmitter bandwidth (MHz).

When the transmitting bandwidth is set to be 50 MHz and the receiving bandwidth to be 25 MHz, *FDRIF  is* 3 dB.

The results for airborne AMS analysis are summarized in Table 3, and the ground / shipboard AMS analysis are summarized in Table 4. The assessment can be made regarding the separation distances that are required to ensure compatibility between the AMS system and the radiolocation system.

TABLE 3

The separation distance for the airborne aeronautical mobile service system interfering with radiolocation system

|  |  |
| --- | --- |
|  | Separation distances |
| The main lobe of radiolocation system | 219 km |
| 1st side-lobe level of radiolocation system | 5.8 km |

TABLE 4

The separation distance for the ground / shipboard aeronautical mobile service system interfering with radiolocation system

|  |  |
| --- | --- |
|  | Separation distances |
| The main lobe of radiolocation system | 187 km |
| 1st side-lobe level of radiolocation system | 1 km |

## A1.2.2 Studies with aeronautical radionavigation service

[TBD]

## A1.2.3 Studies with fixed-satellite service (Earth-to-space) in the frequency band 15.43-15.63 GHz

[TBD]

## A1.2.4 Studies with radioastronomy

[TBD]

# A1.3 Summary

[To be populated later]

Annex 2

Sharing and compatibility studies in the frequency band 22-22.21 GHz

# A2.1 Scenarios of sharing and compatibility studies

## A2.1.1 Technical characteristics of the new non-safety aeronautical mobile service systems

Preliminary structure for airborne data links technical characteristics in the non–safety AMS is provided in Table 1.

TABLE 1

Preliminary technical characteristics of the non-safety aeronautical mobile service systems   
in the frequency band 22‑22.21 GHz (to be completed)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | System 1 | System 2 | System 3 | |
| Station location | Airborne | Airborne and Ground | Airborne | Ground |
| Communication direction | Air-Air | Air-to-Air, Air-to-Ground or Ground-to-Air | Air-to-Air or Air-to-Ground | Ground-to-Air |
| Transmitter power output (dBm) | Variable in the range [0 to 30] dBm | Up to 50 dBm | Up to 51 dBm | Up to 43 dBm |
| Transmitter bandwidth (MHz) | From [30 to 210 MHz] | Up to 210 MHz | Up to 210 MHz | |
| Transmitter Out of Band |  | t.b.d. | t.b.d. | t.b.d. |
| Transmitter spurious |  | t.b.d. | t.b.d. | t.b.d. |
| Transmitter modulation | PSK | t.b.d. | t.b.d. | t.b.d. |
| Receiver tuning range (GHz) | 15.4-15.7 | Programmable | Programmable | Programmable |
| Receiver selectivity (MHz) |  | Programmable according to selected mode | Programmable according to selected mode | Programmable according to selected mode |
| Receiver noise figure (dB) |  | Typ. 5 -10 dB | Typ. 5 -10 dB | Typ. 5 -10 dB |
| Receiver rejection (dB) |  | t.b.d. | t.b.d. | t.b.d. |
| Protection criteria |  | t.b.d. | t.b.d. | t.b.d. |
| Antenna gain (dBi) | From [-3 to 25] | Up to 40 dBi | 2 dBi | 10 dBi |
| Antenna polarization |  | Horizontal, vertical, circular | Horizontal, vertical, circular | Horizontal, vertical, circular |
| Antenna pattern/type |  | Directional | Omnidirectional | Directional |

[Editor’s note: It was noted that additional parameters such as operational altitude and antenna pattern (e.g., reference to ITU-R Recommendation) will be needed for studies and are expected to be provided at the next WP 5B meeting]

## A2.1.2 Technical characteristics of the systems in the incumbent services

#### A2.1.2.1 Characteristics of fixed service

Parameters of typical fixed service systems are taken from Table 9 of Recommendation ITU‑R F.758.

TABLE 1

System parameters for PP FS systems in the frequency band 21.2-23.6 GHz

|  |  |  |
| --- | --- | --- |
| Frequency range (GHz) | 21.2-23.6 | |
| Reference ITU-R Recommendation | F.637 | |
| Modulation | FSK | 128-QAM |
| Channel spacing and receiver noise bandwidth (MHz) | 2.5, 3.5, 7, 14, **25**(2), 28, 50, 56, 112 | 2.5, 3.5, 7, 14, 28, **30**(2), 50, 56, 112 |
| Tx output power range (dBW) | −10 | −13 |
| Tx output power density range (dBW/MHz)(1) | −24.0 | −27.8 |
| Feeder/multiplexer loss range (dB) | 0…3 | … |
| Antenna gain range (dBi) | 34.8 | … |
| e.i.r.p. range (dBW) | 21.8… 24.8 | … |
| e.i.r.p. density range (dBW/MHz)(1) | 7.8…10.8 |  |
| Receiver noise figure typical | 11 | 6 |
| Receiver noise power density typical (=*NRX*) (dBW/MHz) | −133 | −138 |
| Normalized Rx input level for 1 × 10−6 BER (dBW/MHz) | −119.6 | −108.5 |
| Nominal long-term interference power density (dBW/MHz) | −133 + *I*/*N* | −138 + *I*/*N* |
| (1) To calculate the values for the Tx/e.i.r.p. densities, channel spacing/bandwidth needs to be identified. In these tables, the channel spacing indicated in the **bold text** is used.  (2) This channel spacing value is not specified in the reference Recommendation. | | |

32 fixed service stations have been registrered to the MIFR.

## A2.1.2.2 Characteristics of radioastronomy

Protection criteria for radioastronomy service are taken from Tables 1 and 2 of Recommendation ITU-R RA.769.

TABLE 2

Threshold levels of interference detrimental to radio astronomy continuum and spectral-line observations

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Centre  frequency *fc* (MHz) | Assumed bandwidth *f* (MHz) | Minimum antenna noise temperature *TA* (K) | Receiver noise temperature *TR* (K) | System sensitivity(noise fluctuations) | | Threshold interference levels | | |
| Temperature *T* (mK) | Power spectral density *P* (dB(W/Hz)) | Input power *PH* (dBW) | pfd *SH* *f* (dB(W/m2)) | Spectral pfd *SH* (dB(W/(m2  Hz))) |
| 22 355 (continuum observation, central frequency) | 290 | 35 | 30 | 0.085 | –269 | –195 | –146 | –231 |
| 22 200 (spectral-line observation) | 250 | 35 | 30 | 2.91 | –254 | –210 | –162 | –216 |

Typical radio telescopes for which compatibility studies might be performed

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Administration | Name | N. Latitude | E. Longitude | Height AMSL (m) | Diameter (m) |
| Germany | Effelsberg | 50° 31' 29" | 06° 53' 03" | 369 | 100 |
| South Africa | MeerKAT | −30° 43 16" | 21° 24' 40" | 1 054 | 64 × 13.5 m |
| USA | Green Bank Telescope | 38° 25' 59" | −79° 50' 23" | 250 | 100 |
| USA | Jansky VLA | 33° 58' 22" to 34° 14' 56" | −107° 24' 40" to  −107° 48' 22" | 2 000 | 27 × 25 m |
| Australia | Parkes | −33º 00' 00" | 148º 15' 44" | 372 | 64 |
| China | Tianma | 31° 05′ 13" | 121° 09′ 48" | 5 | 65 |
| Japan | Nobeyama | 35º 56' 40" | 138º 28' 21" | 1 350 | 45 |
| France | Plateau de Bure | 44º 38' 02" | 05° 55' 28.5" | 2 250 | 12 × 15 m |

## A2.1.2.3 Characteristics of Earth exploration satellite service (passive) and space research service (passive)

The typical technical and operational characteristics of EESS (passive) sensors are captured in Recommendation ITU R RS.1861‑0. Working Party (WP) 7C is currently revising this report. Table 3 contains the characteristics of EESS (passive) sensors as included in the latest version of the working document towards a preliminary draft revision of Recommendation ITU-R RS.1861.

Table 3

EESS (passive) sensor characteristics in the 22.21-22.5 GHz range

|  | Sensor R1 |
| --- | --- |
| Sensor type | Conical |
| Orbit parameters |  |
| Altitude | 833 km |
| Inclination | 98.6° |
| Eccentricity | 0 |
| Repeat period | 25 days |
| Sensor antenna parameters |  |
| Number of beams | 1 |
| Antenna size | 0.61 m |
| Maximum beam gain | 40.0 dBi |
| Polarization | V |
| –3 dB beamwidth | 2.09° (max) |
| Instantaneous field of view | 46.5 x 73.6 (Footprint size due to 1x2 averaging) |
| Off-nadir pointing angle | 45° |
| Incidence angle at Earth | 53.1° |
| Swath width | 1707 km |
| Antenna efficiency | 0.50 |
| Beam dynamics | 1.9 s |
| Sensor antenna pattern | Rec. ITU R RS.1813 |
| Cold calibration ant. Gain | NA |
| Cold calibration angle (degrees re. satellite track) | NA |
| Cold calibration angle (degrees re. nadir direction) | NA |
| Total FOV cross/along-track | Effective field of view (EFOV): 44.8 km (along scan) x 73.6 km (90° to scan); 1x2 spatial averaging |
| Sensor receiver parameters |  |
| Sensor integration time | 4.22 ms (for a single {unaveraged} sample) |
| Channel bandwidth | 450 MHz (max) centred at 22.235 GHz |
| Measurement spatial resolution |  |
| Horizontal resolution | 73.6 km |
| Vertical resolution | 46.5 km |

Protection criteria for EESS (passive) are taken from Table 2 of Recommendation ITU-R RS.2017.

TABLE 4

Interference criteria for satellite passive remote sensing

| Frequency band(s)  (GHz) | Reference bandwidth (MHz) | Maximum interference level  (dBW) | Percentage of area or time permissible interference level may be exceeded(1) (%) | Scan mode  (N, C, L)(2) |
| --- | --- | --- | --- | --- |
| 22.21-22.5 | 100 | −169 | 0.1 | N |
| (1) For a 0.01% level, the measurement area is a square on the Earth of 2 000 000 km2, unless otherwise justified; for a 0.1% level, the measurement area is a square on the Earth of 10 000 000 km2 unless otherwise justified; for a 1% level, the measurement time is 24 h, unless otherwise justified.  (2) N: Nadir, Nadir scan modes concentrate on sounding or viewing the Earth’s surface at angles of nearly perpendicular incidence. The scan terminates at the surface or at various levels in the atmosphere according to the weighting functions. L: Limb, Limb scan modes view the atmosphere “on edge” and terminate in space rather than at the surface, and accordingly are weighted zero at the surface and maximum at the tangent point height. C: Conical, Conical scan modes view the Earth’s surface by rotating the antenna at an offset angle from the nadir direction. | | | | |

## A2.1.3 Scenarios of sharing and compatibility studies

[To be populated later]

## A2.1.4 Propagation

Working Party 3K and WP 3M noted in their liaison statement that:

“Recommendation [ITU-R P.528-4](http://www.itu.int/rec/R-REC-P.528/en) can be used for modelling the basic transmission loss for air-to-air, ground-to-air, and air-to-ground paths. This Recommendation has an upper validity limit of 15.5 GHz, which does not cover all the frequency ranges of interest to WP 5B. Recommendation ITU-R P.528-4 can be used for initial preliminary studies at 15.5 GHz. Working Parties 3K and 3M would like to bring to the attention of WP 5B that Recommendation ITU-R P.528-4 does not include effects such as hydrometeors and diffraction due to irregular terrain.

Working Party 3K and WP 3M recognize the urgency of WP 5B’s work and would wish to draw to the attention of WP 5B the work of [Correspondence Group (CG) 3K-3M-9](https://extranet.itu.int/rsg-meetings/sg3/wp3m/CG-3K-3M-9/default.aspx). This CG has updated Terms of Reference and will be studying the modelling of air-to-ground paths in the intersessional period.”

# A2.2 Results of the sharing and compatibility studies

# A2.2.1 EESS (passive) Adjacent Band Compatibility Analysis: Dynamic analysis based on interference with spacecraft orbit simulation

## A.2.2.1.1 Calculation of Aggregate Interference

An assessment of the aggregate RFI expected from non–safety AMS systems into EESS (passive) is achieved by a dynamic simulation. The analysis will be conducted in which the orbit of the EESS (passive) spacecraft under investigation is dynamically simulated. Calculations will be performed to determine the potential interference from the proposed non–safety AMS systems into the EESS (passive) band and will consider the aggregate effect from multiple sources. The simulation will propagate the satellite based on its orbital parameters, and the time step is selected to be an irrational number to ensure that the beam dynamics of the passive sensor do not exhibit periodic behavior.. At each time step, the simulation will compute the directional vectors from each source to the EESS (passive) and then compute the gain of the transmit and receive antennas using their respective antenna patterns.

The interfering signal power level, (W), received by a spaceborne radiometer at the timestep from the active transmitter is calculated from:

where:

: source transmitter power in the EESS (passive) band (W);

: source antenna gain towards spaceborne sensor;

: spaceborne receive antenna gain towards terrestrial source;

 : attenuation due to atmospheric absorption;

*:* Free Space Path Loss;

: losses due to polarization mismatch.

The aggregate interference at the timestep, (W), is calculated by the summation of the received interference from active stations within line of sight of EESS (passive):

Thus, the aggregate interference can be represented in the logarithmic domain as:

Based on time series values for the interfering signal power level, a CCDF curve will be generated in order to assess if the result exceeds the recommended performance and interference criteria that are defined in Recommendation ITU-R RS.2017-0. The criteria will used as a metric to assess the impact the non–safety AMS identification would have on the EESS (passive) systems operating 22.21-22.5 GHz band. From Recommendation ITU-R RS.2017-0, outlined in Section A2.1.2.3, the following is prescribed:

– For frequency range: 22.21-22.5 GHz, reference bandwidth: 100 MHz,

• Maximum interference level: -169 dBW,

• Percentage of area or time permissible interference level may be exceeded: 0.1%. The area analyzed should be 10 000 000 km2.

The selection of the simulation area will be chosen to reflect the operational area of sensors operating in the 22.21-22.5 GHz band.

# A.2.2.1.2 Simulation

[TBD]

*{Editor’s note: Additional parameters such as operational altitude, antenna pattern (e.g., reference to ITU-R Recommendation), and transmitter out-of-band information will be needed for studies with respect to EESS (passive)}*

# A.2.2.1.3 Results of Analysis

[TBD]

# A2.3 Summary

[To be populated later]