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| U.S. Radiocommunication SectorFact Sheet |
| **Working Party:** ITU-R WP 7C | **Document No:** US 7C/27-013NC |
| **Ref:** WRC-27 AI 1.18/Res. 712 (WRC-23) | **Date:** 12 August 2024 |
| **Document Title:** Draft framework of working document for sharing and compatibility studies of EESS (passive) in bands above 76 GHz on WRC-27 agenda item 1.18. |
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| **Purpose/Objective:** To develop a framework for compatibility and sharing studies as well as to collect relevant technical and operational characteristics for studies to be performed under WRC-27 agenda item 1.18 (resolves 1) in accordance with Resolution 712 (WRC-23). |
| **Abstract:** Pursuant to Resolution 712 (WRC-23), Working Party (WP) 7C is the responsible group for WRC-27 agenda item 1.18 (resolves 1) and is assembling relevant system characteristics to conduct studies under this agenda item. This document will provide the framework to collect operational and system characteristics from other Working Parties and a method to organize study results.  |
| **Fact Sheet Preparer**: Jason Szklany, ADS for NASA |

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| **Radiocommunication Study Groups** |  |
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| WORKING DOCUMENT towards preliminary draft new report ITU-R [EESS(passive) compatibility above 76 GHz] |
| Resolves 1 of Resolution 712 (WRC-23) calls for the completion of studies on compatibility between the Earth exploration-satellite service (passive) in certain bands above 76 GHz and active services in adjacent and nearby frequency bands. This document is intended to contain study results and the systems and characteristics required to complete these studies |

**Attachment:** 1

Attachment 1

WORKING DOCUMENT towards preliminary draft new report ITU-R [EESS(passive) compatibility above 76 GHz]

Contents

[Glossary and abbreviations 4](#_Toc173498741)

[1 Introduction 4](#_Toc173498742)

[1.1 Table of EESS (passive) bands under consideration 4](#_Toc173498743)

[1.2 References and related ITU-R documents 5](#_Toc173498744)

[1.4 Information on the services allocated in and adjacent to the frequency bands studied under WRC-27 agenda item 1.18 and related footnotes 5](#_Toc173498745)

[2 Technical and operational characteristics for EESS (passive) systems above 76 GHz 8](#_Toc173498746)

[2.1 Cold Calibration characteristics 8](#_Toc173498747)

[2.2 86-92 GHz systems 8](#_Toc173498748)

[2.3 114.25-116 GHz systems 14](#_Toc173498749)

[2.4 164-167 GHz systems 17](#_Toc173498750)

[2.5 200-209 GHz systems 22](#_Toc173498751)

[3 Protection criteria for EESS (passive) 23](#_Toc173498752)

[4 General overview of the active systems under consideration 23](#_Toc173498753)

[Table 4.5.1.1 Characteristics of radars in the 94-100 GHz range 24](#_Toc173498754)

[5 Simulations 28](#_Toc173498755)

[5.1 Simulations 1…END [TBD] 28](#_Toc173498756)

[6 Summary 29](#_Toc173498757)

Simulation study matrix TOC

|  |  |
| --- | --- |
|  | **Active service type** |
| **EESS (passive) Band (GHz)** | **MS** | **RLS** | **FSS** | **MSS** | **ISS** | **RNS** | **RNSS** | **FS** |
| **86-92**  | section [TBD] | section [TBD] | section [TBD] | N/A | N/A | N/A | N/A | section [TBD] |
| **114.24-116**  | section [TBD] | N/A | N/A | N/A | N/A | N/A | N/A | section [TBD] |
| **164-167** | section [TBD] | N/A | section [TBD] | section [TBD] | section [TBD] | N/A | N/A | section [TBD] |
| **200-209** | section [TBD] | N/A | section [TBD] | N/A | section [TBD] | section [TBD] | section [TBD] | section [TBD] |

# Glossary and abbreviations

[TBD]

# Introduction

In *resolves* 1.18of Resolution **813 (WRC-23)**, the 2023 World Radiocommunication Conference (WRC-23) resolved “to consider, based on the results of ITU Radiocommunication Sector studies, possible regulatory measures regarding the protection of the Earth exploration-satellite service (passive) and the radio astronomy service in certain frequency bands above 76 GHz from unwanted emissions of active services, in accordance with Resolution **712 (WRC-23)**” as part of the agenda for WRC-27.

The WRC-2000 conference introduced several allocation changes in frequency bands above 71 GHz. Including primary allocations for the Earth exploration-satellite service (EESS) under certain conditions. Additionally, primary allocations were assigned to active services in frequency bands neighbouring those allocated to passive EESS above 86 GHz, also subject to specific conditions including No. **5.340**.

### Table of EESS (passive) bands under consideration

###

TABLE X

EESS (passive) frequency bands to be studied and corresponding active services to be included in this report

|  |  |  |
| --- | --- | --- |
| EESS (passive) frequency band | Active service frequency band | Active satellite service (space-to-Earth) |
| 86-92 GHz | 81-86 GHz | Fixed-satellite service (FSS), (Earth-to-space), mobile service (MS) |
| 92-94 GHz | MS, radiolocation service (RLS) |
| 114.25-116 GHz | 111.8-114.25 GHz | Fixed service (FS), MS |
| 164-167 GHz | 158.5-164 GHz | FS, FSS (space-to-Earth), MS, mobile-satellite service (MSS) (space-to-Earth) |
| 167-174.5 GHz | FS, FSS (space-to-Earth), inter-satellite service (ISS), MS |
| 200-209 GHz | 191.8-200 GHz | FS, ISS, MS, MSS, radionavigation service (RNS), radionavigation-satellite service (RNSS) |
| 209-217 GHz | FS, FSS (Earth-to-space) |

### References and related ITU-R documents

* 1. **Propagation models and technical and operational characteristics of other services and systems**

|  |  |  |
| --- | --- | --- |
| Source | Services/Applications/Models | Information available at [Link to the received document] |
| WP5B | Radiolocation and Radionavigation Services | [7C/61](https://www.itu.int/md/R23-WP7C-C-0061/en) |
| WP4C | Mobile-Satellite Service | [7C/46](https://www.itu.int/md/R23-WP7C-C-0046/en) |
| WP4C | Radionavigation-satellite | [7C/46](https://www.itu.int/md/R23-WP7C-C-0046/en) |
| WP3J/3M | Propagation aspects | [7C/81](https://www.itu.int/md/R23-WP7C-C-0081/en) |
|  |  |  |
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### Information on the services allocated in and adjacent to the frequency bands studied under WRC-27 agenda item 1.18 and related footnotes

Table of Frequency Allocations

|  |
| --- |
| Allocation to services |
| Region 1 | Region 2 | Region 3 |
| 81-84 FIXED 5.338A FIXED-SATELLITE (Earth-to-space) MOBILE MOBILE-SATELLITE (Earth-to-space) RADIO ASTRONOMY Space research (space-to-Earth)  5.149 5.561A |
| 84-86 FIXED 5.338A FIXED-SATELLITE (Earth-to-space) 5.561B MOBILE RADIO ASTRONOMY 5.149 |

5.338AIn the frequency bands 1 350-1 400 MHz, 1 427-1 452 MHz, 22.55-23.55 GHz, 24.25-27.5 GHz, 30-31.3 GHz, 49.7‑50.2 GHz, 50.4-50.9 GHz, 51.4-52.4 GHz, 52.4-52.6 GHz, 81-86 GHz and 92-94 GHz, Resolution **750** **(Rev.WRC‑19)** applies.     (WRC‑19)

5.149 In making assignments to stations of other services to which the bands:

|  |  |  |
| --- | --- | --- |
| 13 360-13 410 kHz,25 550-25 670 kHz,37.5-38.25 MHz,73-74.6 MHz in Regions 1 and 3,150.05-153 MHz in Region 1,322-328.6 MHz,406.1-410 MHz,608-614 MHz in Regions 1 and 3,1 330-1 400 MHz,1 610.6-1 613.8 MHz,1 660-1 670 MHz,1 718.8-1 722.2 MHz,2 655-2 690 MHz,3 260-3 267 MHz,3 332-3 339 MHz,3 345.8-3 352.5 MHz,4 825-4 835 MHz, | 4 950-4 990 MHz,4 990-5 000 MHz,6 650-6 675.2 MHz,10.6-10.68 GHz,14.47-14.5 GHz,22.01-22.21 GHz,22.21-22.5 GHz,22.81-22.86 GHz,23.07-23.12 GHz,31.2-31.3 GHz,31.5-31.8 GHz in Regions 1 and 3,36.43-36.5 GHz,42.5-43.5 GHz,48.94-49.04 GHz,76-86 GHz,92-94 GHz,94.1-100 GHz, | 102-109.5 GHz,111.8-114.25 GHz,128.33-128.59 GHz,129.23-129.49 GHz,130-134 GHz,136-148.5 GHz,151.5-158.5 GHz,168.59-168.93 GHz,171.11-171.45 GHz,172.31-172.65 GHz,173.52-173.85 GHz,195.75-196.15 GHz,209-226 GHz,241-250 GHz,252-275 GHz |

are allocated, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. 4.5 and 4.6 and Article 29).     (WRC‑07)

5.561A The 81-81.5 GHz band is also allocated to the amateur and amateur-satellite services on a secondary basis.     (WRC‑2000)

|  |
| --- |
| 111.8-114.25 FIXED MOBILE RADIO ASTRONOMY SPACE RESEARCH (passive) 5.562B 5.149 5.341 |

5.562B In the frequency bands 105-109.5 GHz, 111.8-114.25 GHz and 217-226 GHz, the use of this allocation is limited to space-based radio astronomy only.     (WRC‑19)

5.341 In the bands 1 400-1 727 MHz, 101-120 GHz and 197-220 GHz, passive research is being conducted by some countries in a programme for the search for intentional emissions of extraterrestrial origin.

|  |
| --- |
| 158.5-164 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth) |

|  |
| --- |
| 167-174.5FIXED FIXED-SATELLITE (space-to-Earth) INTER-SATELLITE MOBILE 5.558 5.149 5.562D |

5.558 In the bands 55.78-58.2 GHz, 59-64 GHz, 66-71 GHz, 122.25-123 GHz, 130-134 GHz, 167-174.8 GHz and 191.8-200 GHz, stations in the aeronautical mobile service may be operated subject to not causing harmful interference to the inter-satellite service (see No. **5.43**).     (WRC‑2000)

5.562D *Additional allocation*:  In Korea (Rep. of), the frequency bands 128-130 GHz, 171-171.6 GHz, 172.2‑172.8 GHz and 173.3-174 GHz are also allocated to the radio astronomy service on a primary basis. Radio astronomy stations in Korea (Rep. of) operating in the frequency bands referred to in this footnote shall not claim protection from, or constrain the use and development of, services in other countries operating in accordance with the Radio Regulations.     (WRC‑15)

|  |
| --- |
| 191.8-200 FIXED INTER-SATELLITE MOBILE 5.558 MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE 5.149 5.341 5.554 |

5.554 In the bands 43.5-47 GHz, 66-71 GHz, 95-100 GHz, 123-130 GHz, 191.8-200 GHz and 252-265 GHz, satellite links connecting land stations at specified fixed points are also authorized when used in conjunction with the mobile-satellite service or the radionavigation-satellite service.     (WRC‑2000)

|  |
| --- |
| 209-217FIXED FIXED-SATELLITE (Earth-to-space) MOBILE RADIO ASTRONOMY 5.149 5.341 |

Relevant ITU-R Recommendations and Reports

*Recommendations*

ITU-R RS.1813-2 *Reference antenna pattern for passive sensors operating in the Earth exploration-satellite service (passive) to be used in compatibility analyses in the frequency range 1.4-450 GHz*

ITU-R RS.1858 *Characterization and assessment of aggregate interference to the Earth exploration-satellite service (passive) sensor operations from multiple sources of man made emissions*

ITU-R RS.1861-1 *Typical technical and operational characteristics of Earth exploration-satellite service (passive) systems using allocations between 1.4 and 275 GHz*

ITU-R RS.2017-0 *Performance and interference criteria for satellite passive remote sensing*

*Contributed Recommendations*

[ITU-R M.2162-0](https://www.itu.int/rec/R-REC-M.2162/en) *Technical and operational characteristics of radiolocation systems operating in the frequency range 92-100 GHz and radionavigation systems operating in the frequency range 95-100 GHz.*

# Technical and operational characteristics for EESS (passive) systems above 76 GHz

## 2.1 Cold Calibration characteristics

[TBD]

## 2.2 86-92 GHz systems

Typical parameters of passive sensors operating in the 86-92 GHz frequency band

The 86-92 GHz frequency band is essential for the measurement of clouds, oil spills, ice, snow, and rain. It is also used as a reference window for temperature soundings near 118 GHz. Tables 2.2.1 and 2.2.2 summarize the parameters of passive sensors that are or will be operating within the 86 and 92 GHz frequency band.

TABLE 2.2.1

EESS (passive) sensor characteristics operating in the 86-92 GHz frequency band

|  | Sensor L1 | Sensor L4 | Sensor L5 | Sensor L6 | Sensor L7 | Sensor L8 | Sensor L9 | Sensor L10 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sensor type | Conical scan | Mechanical nadir scan | Mechanical nadir scan | Mechanical nadir scan | Conical scan | Conical scan | Mechanical nadir scan | Conical scan |
| **Orbit parameters** |
| Altitude (km) | 867 | 833822 \* | 833822 \* | 824 | 835 | 700 | 83 | 830 |
| Inclination (degree) | 20 | 98.698.7 \* | 98.698.7 \* | 98.7 | 98.85 | 98.2 | 98.7 | 98.7 |
| Eccentricity | 0 | 00.001\* | 00.001\* | 0 | 0 | 0.002 | 0.001 | 0.001 |
| Repeat period (days) | 7 | 929 \* | 929 \* | 9 |  | 16 | 29 | 29 |
| **Sensor antenna parameters** |
| Number of beams | 1 | 30 earth fields per 8 s scan period | 30 earth fields per 8 s scan period1 beam (steerable in 90 earth fields per scan period)\* | 2 | 2 | 2 | 1 | 1 |
| Antenna size (m) | 0.65 | 0.15 | 0.30.22 \* | 0.203 | 0.65 | 2 | 0.35 | 0.76 |
| Maximum beam gain (dBi) | 50 | 34.4 | 4744.8 \* | 37.9 | 52.5 | 62.4 | 43 | 55.1 |
| Polarization | H, V | HQV \* | HQV \* | QV | H, V | H, V | QH/QV | V, H |
| −3 dB beamwidth (degree) | 0.43 | 3.3 | 1.1 | 2.2 | 0.6 | 0.15 | 1.15 | 1 |

TABLE 2.2.1 (*cont.*)

|  | Sensor L1 | Sensor L4 | Sensor L5 | Sensor L6 | Sensor L7 | Sensor L8 | Sensor L9 | Sensor L10 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Instantaneous field of view (km) | 10 km × 17 km | Nadir FOV: 48.5 kmOuter FOV: 149.1 × 79.4 km147 × 79 km\* | Nadir FOV: 16 km (1.1°)Outer FOV: 53 × 27 km\* | Nadir FOV: 31.6 km × 31.6 kmOuter FOV: 136.7 × 60 km | 17 km × 40 km | A: 5.1 km × 2.9 kmB: 5.0 km × 2.9 km | Nadir FOV: 17 km(218 km²)Outer FOV: 55 × 28 km(1 225 km²) | 22 × 36 km(625 km²) |
| Off-nadir pointing angle (degree) | 44.5 | ±48.33 cross-track | ±48.9549.4\* | ±52.725 cross-track | 53.3 | 47.5° | ±49.31 cross-track | 44.8 |
| Incidence angle at Earth (degree) | 53.5° | 30 positions57.5°\* | Various angles from 0° 59°\* |  | 65° | 55° | 0° (nadir)58.9° | 52.8° |
| Swath width (km) | 1 700 | 2 343 2 186 \* | 2 343 2 193 \* | 2 500 | 1600 | 1 450 | 2 220 | 1 700 |
| Antenna efficiency | 0.27 | 0.14 | 0.64 | 0.17 | 0.81 | 0.52 | 0.6 | 0.6 |
| Beam dynamics | 20 rpm | 8 s scan period | 8/3 s scan period | 8/3 s scan period cross-track; 96 earth fields per scan period | 2.5 s scan period, clockwise | 40 rpm | 2.254 s | 45 rpm (1.33 s) |
| Sensor antenna pattern |  |  |  |  |  |  | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain (dBi) | N/A | 34.4 | 34.444.8 \* | 37.9 | 44 | 43.4 |  |  |
| Cold calibration angle (degrees re. satellite track) | N/A | 90°−90° ± 3.9°\* | End of scan (at 48.95°)−90° ± 3.9°\* | 0 | 315° | 115.5º | 78° to 83° | 165.5° to 203° |
| Cold calibration angle (degrees re. nadir direction) | N/A | 83.33° | 83.33°73.6(66° to 81°)\* | 82.175° | 90° | 97.0º |  |  |

TABLE 2.2.1 (*end*)

|  | Sensor L1 | Sensor L4 | Sensor L5 | Sensor L6 | Sensor L7 | Sensor L8 | Sensor L9 | Sensor L10 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sensor receiver parameters** |
| Sensor integration time (ms) | 2 | 180165 \* | 18518 \* | 18 | 5 | 1.2 | 13.7 | 1 to 8 |
| Channel bandwidth (MHz) | 2 700 MHz centred at 89 GHz | 6 000 MHz centred at 89 GHz | Centred at 89 GHz ±500 MHz, each with a bandwidth of 1 000 MHz2 800 MHz centred at 89 GHz\* | 2 000 MHz centred at 87‑91.9 GHz | 2.5 GHz centred at 91.655 GHz | 3 000 MHz centred at 89 GHz | 4 000 MHzCentred at 89 GHz | 4 000 MHz Centred at 89 GHz |
| **Measurement spatial resolution** |
| Horizontal resolution (km) | 10 | 40.548 \* | 40.516 \* | 32 | 16 | 2.9 |  |  |
| Vertical resolution (km) | N/A | 48 | 16 | 32 | 16 | 5.1 |  |  |
| NOTE – \* indicates that a particular sensor is flown on different missions, with different orbit and sensor parameters. |

TABLE 2.2.2

EESS (passive) sensor characteristics operating in the 86-92 GHz frequency band

|  | Sensor L11 | Sensor L12 | Sensor L13 | Sensor L14 | Sensor L15 | Sensor L16 | Sensor L17 | Sensor GSO-L1 | Sensor GSO-L2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sensor type | Conical scan | Conical scan | Cross-track nadir scan | Conical scan | Mechanical nadir scan | Nadir | Conical scan | Wide strip and thin circle combined scanning radiometer | Interferometric radiometer |
| **Orbit parameters** |
| Altitude (km) | 830 | 407 | 595 | 407 | 550 | 1 336 | 665.96 | 35800 | 35800 |
| Inclination (degree) | 98.85 | 50 | 97.79 | 65 | 30 | 66 | 98.06 | N/A | N/A |

TABLE 2.2.2 (*cont.*)

|  | Sensor L11 | Sensor L12 | Sensor L13 | Sensor L14 | Sensor L15 | Sensor L16 | Sensor L17 | Sensor GSO-L1 | Sensor GSO-L2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Eccentricity | 0 | 0.003 | 0.001 | 0 | 0 | 0 | 0.0015 | N/A | N/A |
| Repeat period  |  |  | 9 days/30 min (single satellite/constellation) | 43.5 days | 18.6 days | 9.92 days | 3 days | N/A | N/A |
| **Sensor antenna parameters** |
| Number of beams | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| Antenna size (m) | 1 | 1.1 | 0.16 | 1.22 | 0.083 | 1 | 2 | 5 | 5 |
| Maximum beam gain (dBi) | 57.4 | 58 | 41.3 | 53.8 | 35.0 | 57.0 | 62.4 | 69.5 | 71.1 |
| Polarization | V, H | H, V | QH/QV | H/V | H/V | Single Linear | H, V | V | V |
| −3 dB beamwidth (degree) | 0.27 | 0.4 | 1.75 | 0.38 | 2.89 | 0.31 | 0.15 | 0.07 | 0.05 |
| Instantaneous field of view (km) | 8 × 18(105 km²) | 7.5 × 4.5 | Nadir FOV: 18 (259 km²)Outer FOV: 35 × 76 (2 076 km²)  | 7.2 × 4.4 | Nadir IFOV: 27.7 Outer IFOV: 195.6 × 65.6 | 7 × 7  | A: 5 × 3B: 5 × 3 | 39 × 39  | N/A |
| Off-nadir pointing angle (degree) | 53.3 | 48.6 | 54.4 | 48.5 | ±60 cross-track | 3.4 along-track | 47.7 | N/A | N/A |
| Incidence angle at Earth (degree) | 65 | 53 | 0 (nadir)62.8 | 52.8 | ≤ 70.2 | 4.1 | 55 | N/A | N/A |
| Swath width (km) | 2 200 | 800 | 1 900 | 921 | 2480 | 7 | 1535 | 8 scan stripes, each strip 0.9×7.2, thin circle diameter 1.1 | Full disk |
| Antenna efficiency | 0.63 | 0.60 |  |  | 0.53 | 0.56 | 0.50 | 0.60 | 0.60 |
| Beam dynamics | 2.5 s scan period, counter clockwise | 30 rpm | 1.1 s (45 rpm) | 32 rpm | 2 s scan period | N/A | 40 rpm | General scan:0.64/minLocal scan:25.75 rpm | Full disk: 10 min |
| Sensor antenna pattern | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑RRS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain (dBi) | 45  | 55  | 41.3  | 37.7  | 35.0  | N/A | 43.4  |  |  |

TABLE 2.2.2 (*end*)

|  | Sensor L11 | Sensor L12 | Sensor L13 | Sensor L14 | Sensor L15 | Sensor L16 | Sensor L17 | Sensor GSO-L1 | Sensor GSO-L2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Cold calibration angle (degrees re. satellite track) | 315° | 180° | 78° to 83° | 206.7° (CCW) | 0° | N/A | 118.7º |  | N/A |
| Cold calibration angle (degrees re. nadir direction) | 90° | 90° |  | 107.5° | 120° | N/A | 94.6º |  |  |
| **Sensor receiver parameters** |
| Sensor integration time (ms) | 5 | 2.08 | 2 | 3.6 | 8.3 | 125 | 1.2 |  | 20 |
| Channel bandwidth | 2.5 GHz centred at 91.655 GHz | 3000 MHz centred at 89 GHz | 4 000 MHz centred at 89 GHz | 6 000 MHz centred at 89 GHz | 1 000 MHz centred at 90.256 GHz | 5 GHz centred at 90 GHz | 3 000 MHz centred at 89 GHz | 2000 MHz centred at 88.2 GHz | 2000 MHz centred at 88.2 GHz |
| **Measurement spatial resolution** |
| Horizontal resolution (km) | 16 | 8.7 |  | 4.4 | 27.7 | 7 | 3 | 39 (nadir) | 30 (nadir) |
| Vertical resolution (km) | 16 | 7.5 |  | 7.2 | 27.7 | 7 | 5 | 39 (nadir) | 30 (nadir) |

## 2.3 114.25-116 GHz systems

Typical parameters of passive sensors operating in the 114.25-122.25 GHz frequency band

The frequency range 114.25-122.25 GHz is of primary interest for atmospheric temperature profiling (O2absorption lines). Table 2.3.1 summarizes the parameters of passive sensors that are or will be operating in the frequency range of 114.25 and 122.25 GHz.

TABLE 2.3.1

EESS (passive) sensor characteristics operating in the 114.25 - 122.25 GHz frequency band

|  | Sensor M1 | Sensor M2 | Sensor M3 | Sensor M4 | Sensor M5 | Sensor M6 | Sensor GSO-M1 | Sensor GSO-M2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sensor type | Limb sounder | Conical scan | Conical scan | Nadir scan | Mechanical nadir scan | Conical scan | Raster scan | Wide strip and thin circle combined scan |
| **Orbit parameters** |
| Altitude (km) | 705 | 407 | 836 | 836 | 550 | 830 | 35 800 | 35 800 |
| Inclination (degree) | 98.2 | 50 | 98.75 | 98.75 | 30 | 98.7 | N/A | N/A |
| Eccentricity | 0 | 0.003 | 0.003 | 0.003 | 0 | 0.001 | N/A | N/A |
| Repeat period (days) | 16  |  | 5.5  | 5.5  | 18.6  | 29  | N/A | N/A |
| **Sensor antenna parameters** |
| Number of beams | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Antenna size (m) | 1.6 (V) × 0.8 (H) | 1.1 | 1.1 | 0.22 | 0.083 | 0.76 | 3 | 5 |
| Maximum beam gain (dBi) | 62 | 60.5 | 60.5 | 46.5 | 37.8 | 55.5 | 69.2 | 70.5 |
| Polarization | H, V | V | V | H | H/V | V | H | H |
| −3 dB beamwidth (degree) | 0.119 × 0.245 | 0.35 | 0.35 | 1.8 | 2.41 | 0.33 | 0.06 | 0.055 |
| Instantaneous field of view (km) | 6.5 × 13 | 5.8 × 3.7 | 11.5 × 7.4 | Nadir: 26  | Nadir IFOV: 23.1Outer IFOV: 162.6 × 54.7 | 7 × 12(68 km²) | Nadir: 37  | Nadir: 34  |
| Off-nadir pointing angle | Limb | 46.1° | 42.6° | ±53.35° cross-track | ±60° cross-track | 44.8° | N/A | N/A |
| Incidence angle at Earth (degree) | N/A | 50 | 50 | 0 (nadir) | ≤ 70.2 | 52.8 | N/A | N/A |
| Swath width (km) | N/A | 800 | 1 400 | 2 000 | 2 480 | 1 700 | Full disk | 8 scan stripes, each strip 0.9×7.2, thin circle diameter 1.1 |
| Antenna efficiency | 0.80 | 0.604 | 0.604 | 0.604 | 0.56 | 0.6 | 0.60 | 0.60 |
| Beam dynamics | Scans continuously in tangent height from the surface to ~92 km in 24.7 s, 240 scans/orbit | 30 rpm | 30 rpm | 8/3 s scan period1.71 s for 96 earth fields per scan period | 2 s scan period | 45 rpm (1.33 s) | Full disk: 45 min | General scan:0.64°/minLocal scan:25.75 rpm |
| Sensor antenna pattern | See Rec. ITU-R RS.1813 with minor mods (see NOTE below) | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain (dBi) | N/A | 57.5 | 57.5 | 46.5 | 37.8 |  |  |  |
| Cold calibration angle (degrees re. satellite track) | N/A | 180° | 180° | 90° | 0° | 165.5° to 203° | N/A |  |
| Cold calibration angle (degrees re. nadir direction) | N/A | 90° | 90° | 74° | 120° |  |  |  |
| **Sensor receiver parameters** |
| Sensor integration time | 0.166 s | 2.08 ms | 2.08 ms | 17 ms | 8.3 ms | 1 to 8 ms | 10 ms |  |
| Channel bandwidth | See Table 36 | See Table 37 | See Table 37 | See Table 38 | See Table 39 | See Table 40 | See Table 38 | See Table 41 |
| **Measurement spatial resolution** |
| Horizontal resolution (km) | 13 | 7.7 | 15.3 | 42 (nadir) | 23.1 |  | 49 (nadir) |  |
| Vertical resolution (km) | 6.5 | 5.8 | 11.5 | 26 (nadir) | 23.1 |  | 37 (nadir) |  |

NOTE – The antenna model from Recommendation ITU-R RS.1813-1 can be adjusted to support elliptical reflectors with the following modifications:

• The maximum antenna gain be defined as: $G\_{max}=10log\_{10}\left(ηπ^{2}\frac{D\_{max}D\_{min}}{λ^{2}}\right)$.

• The antenna diameter be defined as: $D(α)=\sqrt{D\_{max}^{2}cos^{2}\left(α\right)+ D\_{min}^{2}sin^{2}\left(α\right)}$. Therefore, the antenna diameter becomes a function of the angle (α ϵ [0°, 90°]) in the plane that is perpendicular to the antenna boresight vector and between the intended direction of emission and the antenna beam’s major axis.

• The existing functions for G(φ) and φm should be evaluated for each point in the alpha/phi space.

TABLE 2.3.2

Sensor M1 passive sensor characteristics for channels between 114.25 and 116 GHz

|  |  |
| --- | --- |
| Centre frequency (GHz) | Channel bandwidth (MHz) |
| 115.3 | 500 |

TABLE 2.3.3

Sensor M2 and M3 passive sensor characteristics
for channels between 114.25 and 122.25 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency (GHz) | Channel bandwidth (MHz) | Polarization |
| 118.7503 ± 3.2 | 1 000 | V |

TABLE 2.3.4

Sensor M4 and GSO-M1 passive sensor characteristics for channels between
114.25 and 122.25 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency (GHz) | Channel bandwidth (MHz) | Polarization |
| 118.7503 ± 3.0 | 2 000 | H |

TABLE 2.3.5

Sensor M5 passive sensor characteristics for channels between 114.25 and 122.25 GHz

|  |  |
| --- | --- |
| Centre frequency (GHz) | Channel bandwidth (MHz) |
| 114.5 | 1000 |
| 115.95 | 800 |

TABLE 2.3.6

Sensor M6 passive sensor characteristics for channels between 114.25 and 122.25 GHz

|  |  |
| --- | --- |
| Centre frequency (GHz) | Channel bandwidth (MHz) |
| 118.75 ± 3.2 | 2 × 500 |

TABLE 2.3.7

Sensor GSO-M2 passive sensor characteristics for channels between 114.25 and 122.25 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency (GHz) | Channel bandwidth (MHz) | Polarization |
| 118.7503 ± 3.0 | 2 000 | H |
| 118.7503 ± 5.0 | 2 000 | H |

## 2.4 164-167 GHz systems

Typical parameters of passive sensors operating in the 164-167 GHz frequency band

The 164-167 GHz frequency band is of primary interest to measure N2O, cloud water and ice, rain, CO, and ClO. Tables 2.4.1 and 2.4.2 summarize the parameters of passive sensors that are or will be operating in the 164-167 GHz frequency band.

TABLE 2.4.1

EESS (passive) sensor characteristics operating in the 164-167 GHz frequency band

|  | Sensor P2 | Sensor P3 | Sensor P4 | Sensor P5 | Sensor P6 |
| --- | --- | --- | --- | --- | --- |
| Sensor type | Mechanical nadir scan | Conical scan | Conical scan | Conical scan | Nadir scan |
| **Orbit parameters** |
| Altitude (km) | 824 | 830 | 407 | 836 | 836 |
| Inclination (degree) | 98.7 | 98.85 | 50 | 98.75 | 98.75 |
| Eccentricity  | 0 | 0 | 0.003 | 0.003 | 0.003 |
| Repeat period (days) | 9 |  |  | 5.5 | 5.5 |
| **Sensor antenna parameters** |
| Number of beams | 2 | 1 | 1 | 1 | 1 |
| Antenna size (m) | 0.127 | 1 | 0.8 | 0.8 | 0.22 |
| Maximum beam gain (dBi) | 43.9 | 62.6 | 60.6 | 60.6 | 49.4 |
| Polarization | QH | V | V | V | V |
| −3 dB beamwidth (degree) | 1.1 | 0.15 | 0.35 | 0.35 | 1.2 |
| Instantaneous field of view | Nadir FOV: 15.8 kmOuter FOV: 68.4 × 30 km | 4 km × 9 km | 6.5 km × 3.9 km | 12.9 km × 7.8 km | Nadir: 18 km |
| Off-nadir pointing angle (degree) | ±52.725 cross-track | 53.3 | 48.6 | 44.9 | ±53.35 cross-track |
| Incidence angle at Earth (degree) | 0 | 65° | 53° | 53° | 0° (nadir) |
| Swath width (km) | 2 500 | 2 200 | 800 | 1 400 | 2 000 |
| Antenna efficiency | 0.51 | 0.61 | 0.597 | 0.597 | 0.61 |
| Beam dynamics | 8/3 s scan period cross-track; 96 earth fields per scan period | 2.5 s scan period, counter clockwise | 30 rpm | 30 rpm | 8/3 s scan period1.71 s for 96 earth fields per scan period |
| Sensor antenna pattern |  | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) |
| Cold calibration ant. gain (dBi) | 43.9 | 49.4 | 57.6 | 57.6 | 49.4 |
| Cold calibration angle (degrees re. satellite track) | 0° | 315° | 180° | 180° | 90° |
| Cold calibration angle (degrees re. nadir direction) | 82.175° | 90° | 90° | 90° | 74° |

TABLE 2.4.1 (*end*)

|  | Sensor P2 | Sensor P3 | Sensor P4 | Sensor P5 | Sensor P6 |
| --- | --- | --- | --- | --- | --- |
| **Sensor receiver parameters** |
| Sensor integration time (ms) | 18 | 5 | 2.08 | 2.08 | 17 |
| Channel bandwidth | 3 000 MHz centred at 164-167 GHz | 3 000 MHz centred at 165.5 GHz | 1 350 MHz centred at 165.5 ± 0.75 GHz | 1 350 MHz centred at 165.5 ± 0.75 GHz | 1 500 MHz centred at 166 GHz |
| **Measurement spatial resolution** |
| Horizontal resolution (km) | 32 | 32 | 8.1 | 16.1 | 34 (nadir) |
| Vertical resolution (km) | 32 | 32 | 6.5 | 12.9 | 18 (nadir) |

TABLE 2.4.2

EESS (passive) sensor characteristics operating in the 164-167 GHz frequency band

|  | Sensor P7 | Sensor P8 | Sensor P9 | Sensor P10 | Sensor P11 | Sensor P12 | Sensor GSO-P1 | Sensor GSO-P2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sensor type | Cross-track nadir scan | Conical scan | Nadir | Conical scan | Nadir scan | Conical scan | Raster scan | Wide strip and thin circle combined scan |
| **Orbit parameters** |
| Altitude (km) | 595 | 407 | 1 336 | 665.96 | 830 | 830 | 35 800 | 35 800 |
| Inclination (degree) | 97.79 | 65 | 66 | 98.06 | 98.7 | 98.7 | N/A | N/A |
| Eccentricity | 0.001 | 0 | 0 | 0.0015 | 0.001 | 0.001 | N/A | N/A |
| Repeat period | 9 days/30 min (single satellite/constellation) | 43.5 days | 9.92 days | 3 days | 29 days | 29 days | N/A | N/A |
| **Sensor antenna parameters** |
| Number of beams | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Antenna size (m) | 0.16 | 1.22 | 1 | 2 | 0.35 | 0.76 | 3 | 5 |
| Maximum beam gain (dBi) | 46.6 | 54.3 | 61.0 | 57.2 | 43 | 60 | 72.1 | 73 |
| Polarization | QH/QV | H/V | Single Linear | V | QH/QV | V | V | V |
| −3 dB beamwidth (degree) | 0.8 | 0.37 | 0.18 | 0.23 × 0.30 | 1.15 | 0.33 | 0.04 | 0.04 |
| Instantaneous field of view | Nadir FOV: 8 km(54 km²)Outer FOV: 16 × 35(433 km²) | 6.3 × 4.1 km | 4 × 4 km | 4 km × 9 km | Nadir FOV: 17 km(218 km²)Outer FOV: 55 × 28 km(1 225 km²) | 7 × 12 km(68 km²) | Nadir: 26 km | Nadir: 25 km |
| Off-nadir pointing angle (degree) | 54.4 | 45.4 | 3.4 along-track | 45.5 | ±49.31 cross-track | 44.8 | N/A | N/A |
| Incidence angle at Earth (degree) | 0 (nadir)62.8 | 49.2 | 4.1 | 51.9 | 0 (nadir)58.9 | 52.8 | N/A | N/A |

TABLE 2.4.2 (*end*)

|  | Sensor P7 | Sensor P8 | Sensor P9 | Sensor P10 | Sensor P11 | Sensor P12 | Sensor GSO-P1 | Sensor GSO-P2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Swath width (km) | 1900 | 819 | 4 | 1 398 | 2 220 | 1 700 | Full disk | 8 scan stripes, each strip 0.9×7.2, thin circle diameter 1.1 |
| Antenna efficiency |  |  | 0.42 |  | 0.6 | 0.6 | 0.60 | 0.60 |
| Beam dynamics | 1.1 s (45 rpm) | 32 rpm | N/A | 40 rpm | 2.254 s | 45 rpm (1.33 s) | Full disk: 45 min | General scan:0.64/minLocal scan:25.75 rpm |
| Sensor antenna pattern | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑RRS.1813 |
| Cold calibration ant. gain (dBi) | 46.6 | 43.1 | N/A | 37.0 |  | N/A |  |  |
| Cold calibration angle (degrees re. satellite track) | 78° to 83° | 206.7° (CCW) | N/A | 118.7° | 78° to 83° | 165.5° to 203° | N/A |  |
| Cold calibration angle (degrees re. nadir direction) |  | 107.5° | N/A | 94.6° |  | N/A |  |  |
| **Sensor receiver parameters** |
| Sensor integration time (ms) | 2 | 3.6 | 125 | 2.5 | 13.7 | 1 to 8 | 10 | 10 |
| Channel bandwidth | 2 800 MHz centred at 165.5 GHz | 4 000 MHz centred at 166 GHz | 6 GHzcentred at 166 GHz | 4 000 MHz centred at 165.5 GHz | 2 x 1 350 MHz centred at 165.5 ± 0.725 GHz | 2x1 425 MHz centred at165.5 ± 0.73 GHz | 3 000 MHz centred at 165.5 GHz | 3 000 MHz centred at 165.5 GHz |
| **Measurement spatial resolution** |
| Horizontal resolution (km) |  | 4.1 | 4 | 4 |  |  | 39 (nadir) | 35 (nadir) |
| Vertical resolution (km) |  | 6.3 | 4 | 9 |  |  | 26 (nadir) | 25 (nadir) |

## 2.5 200-209 GHz systems

Typical parameters of passive sensors operating in the 200-209 GHz frequency band

Table 2.5.1 summarizes the parameters of passive sensors that are or will be operating in the 200‑209 GHz frequency band.

TABLE 2.5.1

EESS (passive) sensor characteristics operating in the 200-209 GHz frequency band

|  | Sensor S1 | Sensor S2 |
| --- | --- | --- |
| Sensor type | Mechanical nadir scan | Limb sounder |
| **Orbit parameters** |  |
| Altitude (km) | 550 | 705 |
| Inclination (degree) | 30 | 98.2 |
| Eccentricity | 0 | 0 |
| Repeat period (days) | 18.6 | 16 |
| **Sensor antenna parameters** |  |
| Number of beams | 1 | 1 |
| Antenna size (m) | 0.083 | 1.6 (V) × 0.8 (H) |
| Maximum beam gain (dBi) | 44.1 | 65 |
| Polarization | H/V | V |
| −3 dB beamwidth (degree) | 1.64 | 0.078 × 0.152 |
| Instantaneous field of view (km) | Nadir IFOV: 15.7Outer IFOV: 110.2 × 37.2 | 4.1 × 8.0 |
| Off-nadir pointing angle | ±60° cross-track | N/A |
| Incidence angle at Earth (degree) | ≤ 70.2 | N/A |
| Swath width (km) | 2 480 | N/A |
| Antenna efficiency | 0.81 | 0.55 |
| Beam dynamics | 2 s scan period | Scans continuously in tangent height from the surface to ~92 km in 24.7 s, 240 scans/orbit |
| Sensor antenna pattern | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 with minor mods(see NOTE in § 6.14) |
| Cold calibration ant. gain (dBi) | 44.1 | N/A |
| Cold calibration angle (degrees re. satellite track) | 0° | N/A |
| Cold calibration angle (degrees re. nadir direction) | 120° | N/A |
| **Sensor receiver parameters** |  |
| Sensor integration time | 8.3 ms | 0.166 s |
| Channel bandwidth | 2 000 MHz centred at 204.80 GHz | 1 250 MHz centred at 200.9798, 204.3566, and 206.1367 GHz |
| **Measurement spatial resolution** |  |
| Horizontal resolution (km) | 15.7 | 8.0 |
| Vertical resolution (km) | 15.7 | 4.1 |

# P**rotection criteria for EESS (passive)**

Introduction

[TBD]

Protection criteria

| 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) |
| --- | --- | --- | --- | --- |
| 86-92 | 100 | −169 | 0.01 | N, C |
| 114.25-116 | 10 | −189 | 1 | L |
| 164-167 | 200/10(3) | −163/−189(3) | 0.01/1(3) | N, C, L |
| 200-209 | 3 | −194 | 1 | L |

(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.

(3) First number for nadir or conical scanning modes and second number for microwave limb sounding applications.

(4) This band is needed until 2018 to accommodate existing and planned sensors.

# 4 General overview of the active systems under consideration

Introduction

This section provides technical characteristics of the active services that are envisaged to be considered under this agenda item for the purpose of conducting the compatibility and sharing studies. To avoid lengthening this document, the information received from the expert groups will be included in the document using hyperlinks.

**4.1** **Mobile-Satellite Service**

The expert working group noted in Document 7C/46 there is no technical and operational parameters for this band and that information can be found in relevant ITU filings.

**4.2** **Radionavigation-satellite**

The expert working group noted in Document 7C/46 there is no technical and operational parameters for this band and that information can be found in relevant ITU filings. Working Party 4C also suggested using Recommendation ITU-R M.1583 to model the RNSS systems.

**4.3** **Fixed Satellite Services**

**4.4** **Inter-Satellite Services**

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**4.5** **Radiolocation and Radionavigation Services**

Working Party 5B noted in Document 7C/61 that the technical and operation characteristics could be found in Recommendation [ITU-R M.2162-0](https://www.itu.int/rec/R-REC-M.2162/en). Recommendation ITU-R M.2162-0 only contains systems up to 100 GHz, which covers just a portion of the bands that are considered in Resolution **813 (WRC-23)**.

**4.5.1 Ground Weather Radars**

Recommendation ITU-R M.2162-0 includes the technical and operational characteristics of the ground weather radar at 94-100 GHz, which is shown in Table 4.5.1.1.

# Table 4.5.1.1 Characteristics of radars in the 94-100 GHz range

|  |  |
| --- | --- |
| **Parameter**  | **Radar A**  |
| Application  | Weather (heavy rainfall detection)  |
| Deployment area  | Worldwide, fixed site  |
| Tuning range (GHz)  | 94-100  |
| Transmitter type  | Solid state  |
| Tx power into antenna (peak) (W)  | 0.5-1  |
| Polarization  | Linear  |
| Pulse duration (ms)  | 0.04-0.16  |
| Frequency modulation  | FMCW  |
| Pulse repetition period (µs)  | 80-160  |
| Antenna type  | Parabolic  |
| Radar height relative to the ground (m)  | 1  |
| Antenna gain (dBi)  | 54  |
| Antenna diameter (m)  | 0.6  |
| Antenna beamwidth in azimuth (degrees)  | 0.4  |
| Antenna beamwidth in elevation (degrees)  | 0.4  |
| Antenna peak side-lobe (SL) levels (dBi)  | 24  |
| Antenna pattern type  | Rec. ITU-R M.1851, COS2 pattern  |
| Receiver noise floor (dBm) (see M.1461 below eq. (4))  | −105 … −93.2  |
| Receiver noise figure (dB)  | 7  |
| RF emission bandwidth (MHz)  | Up to 24  |
| Receiver IF 3 dB bandwidth (MHz)  | 1.5-24  |
| *I*/*N* protection criterion (dB)  | −6  |

**4.5.2 Airport foreign object debris detection in 92-100 GHz Band**

 Recommendation ITU-R M.2162-0 includes the technical and operational characteristics of the foreign object debris detection radars at 92-100 GHz, which is shown in Table 4.5.2.1. The channel plan for the foreign object debris detection radars is showing in Figure 4.5.2.1.

**Table 4.5.2.1 Characteristics of foreign object debris detection system radars in the 92-100 GHz**

|  |  |
| --- | --- |
| **Parameters**  | **Values**  |
| Frequency range (GHz)  | 92 … 100  |
| Channel bandwidth (GHz)  | 0.58 … 7.98  |
| Channel plan  | See Fig. 1  |
| Transmit peak power (mW)  | 100-200  |
| Sweep frequency (FMCW) (kHz)  | 1.250  |
| Antenna type  | Cassegrain  |
| Antenna gain (dBi)  | 44  |
| Antenna pattern  | Rec. ITU-R F.699  |
| Antenna height (m)  | 4 … 8  |
| Full width at half maximum antenna gain (3 dB beamwidth) (degrees)  | Elevation: 1.0, Azimuth: 1.0  |
| Antenna rotation speed (rpm)  | 15  |
| Detection distance (m)  | 200 … 500  |
| Radiated rotation angle in azimuth (degree)  | ±60  |
| Radar cross section specification (dB/m2)  | −20  |
| Range resolution (cm)  | 3 … 50  |
| Emission bandwidth (−3 dB) (MHz)  | 1  |
| Emission bandwidth (−20 dB) (MHz)  | 3.5  |
| Adjacent channel leakage ration (dBc)  | < −70  |
| Receiver noise figure (dB)  | 10  |
| *I*/*N* protection criteria (dB)  | −6  |

**Figure 4.5.2.1 Channel plan for foreign object debris detection system radars in the 92-100 GHz**



**4.5.3 Landing assistance airborne millimetre wave radar in 95-100 GHz band**

 Recommendation ITU-R M.2162-0 includes the technical and operational characteristics of the foreign object debris detection radars at 95-100 GHz, which is shown in Table 4.5.3.1.

**Table 4.5.3.1 Characteristics of landing assistance radars in the 95-100 GHz**

|  |  |
| --- | --- |
| **Parameter**  | **Radar A**  |
| Application  | Landing assistance  |
| Deployment area  | Worldwide, airborne  |
| Frequency range (GHz)  | 95.1-99.5  |
| Transmit peak power (W)  | 0.5-1  |
| Polarization  | Linear  |
| Pulse duration (µs)  | 100-200  |
| Frequency modulation  | FMCW  |
| Antenna type  | Active electronically scanned array  |
| Radar height relative to the ground (m)  | 200..0 (Airborne – Final approach segment)  |
| Antenna gain (dBi)  | 34-38  |
| Antenna width (m)  | 0.4  |
| Antenna beam width in azimuth (degree)  | 0.5  |
| Antenna scanning range in azimuth (degree)  | ±15  |
| Antenna beam width in elevation (degree)  | 15  |
| Antenna scanning range in elevation (degree)  | ±30[[1]](#footnote-2)  |
| Receiver noise figure (dB)  | 8-10  |
| RF emission bandwidth (MHz)  | 30-60  |
| Channel bandwidth (MHz)  | 80  |
| Maximum channels number  | 4  |
| *I*/*N*[[2]](#footnote-3) protection criterion[[3]](#footnote-4) (dB)  | –6  |

# 5 Simulations

## 5.1 Simulations 1…END [TBD]

5.1.1 EESS (passive) Dynamic Simulation Methodology

Assessments of the aggregate RFI expected from the specific active services into EESS (passive) operating in the certain bands are achieved by dynamic simulations. The analysis will be conducted in which the orbit of the EESS (passive) spacecraft under investigation is dynamically simulated, retaining only the data points when the EESS (passive) sensor antenna boresight points within a defined Measurement Area of Interest (MAI), as defined in Recommendation ITU-R RS.2017. Calculations will be performed to determine the potential interference from each of the current active stations into the EESS (passive) sensors under study and will consider the aggregate effect from multiple active stations. The simulation will propagate the satellite based on its orbital parameters, and the simulation step size is selected to be an irrational number to ensure that the beam dynamics of the passive sensor do not exhibit periodic behaviour. At each simulation step, a snapshot of the interference scenario will be generated where the directional vectors from each active source to the EESS (passive) sensor will be computed along with the gain of the transmit and receive antennas using their respective antenna patterns.

The interfering signal power level, $ I\\_(i,n)$ (W), received by a spaceborne radiometer at the $n\^th$ simulation step from the $i\^th$ active station is calculated from:

 $I\_{i,n}=\frac{ P\_{TX i,n}G\_{TX i,n} G\_{RX i,n}}{L\_{a i,n} L\_{FSPL i,n} L\_{pol i,n}L\_{clutter i, n}}$ (A1-1)

where:

 $ P\_{TX i,n}$: active station out of band transmitter power in the EESS (passive) band, accounting for frequency dependent rejection;

 $G\_{TX i,n}$: active station antenna gain towards spaceborne sensor;

 $G\_{RX i,n}$: spaceborne receive antenna gain towards terrestrial source;

 $L\_{a i,n}$ : atmospheric losses

 $L\_{FSPL i,n}$: Free Space Path Loss;

 $L\_{pol i,n}$: losses due to polarization mismatch;

 $L\_{clutter i,n}$: losses due to clutter (Rec. ITU-R P.2108);

The aggregate interference at the $n^{th}$ simulation step,$ AggI\_{n}$ (W), is calculated by the summation of the received interference from all active stations within line of sight of EESS (passive):

 $AggI\_{n}=\sum\_{i}^{}I\_{i,n}=\sum\_{i}^{}\frac{P\_{TX i,n} G\_{TX i,n} G\_{RX i,n}}{L\_{a i,n} L\_{FSPL i,n} L\_{pol i,n}L\_{clutter i, n}}$ (A1-2)

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

 $AggI\_{n|dB}=10 log\_{10}\left(\sum\_{i}^{}\frac{ P\_{TX i,n} G\_{TX i,n} G\_{RX i,n}}{L\_{a i,n} L\_{FSPL i,n} L\_{pol i,n}L\_{clutter i, n}}\right) \_{|dB}$ (A1-3)

Using the resulting data containing received interfering power levels, a CCDF curve will be generated to assess interference observed over the MAI.

5.1.2 Definition of Simulation MAI

As given specified within Rec. ITU-R RS.2017, the protection criteria for the passive band applies to any square (unless otherwise justified) measurement area on the Earth of 2 000 000 or 10 000 000 square kilometres based on the specific frequency band.

# 6 Summary

[TBD]

1. The radar has no scanning in elevation, the beam is fixed with a down tilt of −6°, and the aircraft pitch variation is not compensated. [↑](#footnote-ref-2)
2. In the absence of performance requirements. [↑](#footnote-ref-3)
3. The protection criterion does not include aeronautical safety margin. [↑](#footnote-ref-4)