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| U.S. Radiocommunication Sector  Fact Sheet | |
| **Working Party:** ITU-R WP-5B | **Document No:** USWP5B-33-12 |
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| **Purpose/Objective:** To collect relevant technical and operational characteristics to develop a framework document for compatibility and sharing studies performed under WRC-27 Agenda Item 1.8 in accordance with Resolution **663 (WRC-23).** | |
| **Abstract:** Pursuant to Resolution **663 (Rev.WRC-23)**, Working Party (WP) 5B is the responsible group for WRC-27 Agenda Item 1.8 request to consider possible additional spectrum allocations to the radiolocation service on a primary basis in the frequency range 231.5-275 GHz and possible new identifications for radiolocation service applications in frequency bands within the frequency range 275-700 GHz for millimetric and sub-millimetric wave imaging systems. This document will serve as a place to collect relevant technical and operational characteristics from affected services and have sections for the future sharing and compatibility studies and their associated results. | |
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| **Radiocommunication Study Groups** |  |
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| United States of America | |
| Draft framework of working document for sharing studies under WRC-27 Agenda Item 1.8 | |
| Studies on possible new additional allocations to the radiolocation service on a primary basis in the frequency range 231.5-275 GHz, and possible new identifications for radiolocation service applications in frequency bands within the frequency range 275-700 GHz | |
| Pursuant to Resolution **663 (Rev.WRC-23)**, Working Party (WP) 5B is the responsible group for WRC-27 Agenda Item 1.8 request to consider possible additional spectrum allocations to the radiolocation service on a primary basis in the frequency range 231.5-275 GHz and possible new identifications for radiolocation service applications in frequency bands within the frequency range 275-700 GHz for millimetric and sub-millimetric wave imaging systems. This document will serve as a place to collect relevant technical and operational characteristics from affected services and have sections for the future sharing and compatibility studies and their associated results.  The US has concerns about the impacts of Agenda Item 1.8 to incumbent services in the frequency range 231.5-275 GHz and within the frequency range 275-700 GHz. | |

**Attachment:** 1

Attachment 1

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| --- |
| Draft framework of working document for sharing studies under WRC-27 Agenda Item 1.8 |
| Studies on possible new additional allocations to the radiolocation service on a primary basis in the frequency range 231.5-275 GHz, and possible new identifications for radiolocation service applications in frequency bands within the frequency range 275-700 GHz |

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Simulation study matrix TOC

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Active service type** | | | | | | | |
| **EESS (passive) Band (GHz)** | **MS** | **RLS** | **FSS** | **MSS** | **ISS** | **RNS** | **RNSS** | **FS** |
| **231.5-275** | section [TBD] | section [TBD] | section [TBD] | section [TBD] | section [TBD] | section [TBD] | section [TBD] | section [TBD] |
| **275-700** | section [TBD] | section [TBD] | section [TBD] | section [TBD] | section [TBD] | section [TBD] | section [TBD] | section [TBD] |

# Introduction

In *resolves* 1.8of Resolution **663 (WRC-23)**, the 2023 World Radiocommunication Conference (WRC-23) resolves “to invite the ITU Radiocommunication Sector to complete in time for the 2027 world radiocommunication conference:

the description of the technical and operational characteristics, including required protection criteria, for those receive-only and active millimetric and sub-millimetric wave RLS systems and applications in the categories listed in recognizing a)[[1]](#footnote-2);

2 studies on globally harmonized spectrum for the RLS, in particular for those millimetric and sub-millimetric wave RLS systems and applications above 231.5 GHz;

3 sharing and compatibility studies (in-band and adjacent bands) for active millimetric and sub-millimetric wave RLS systems and applications with other services in the frequency range 231.5-275 GHz, while ensuring protection for the current use and further development of the incumbent services allocated to this frequency range;

4 sharing and compatibility studies (in-band and adjacent bands) for RLS applications with EESS (passive), space research service (passive) and RAS applications in the frequency range 275-700 GHz, while maintaining protection for the passive service applications identified in No. **5.565**;

5 sharing and compatibility studies (in-band and adjacent bands) for RLS applications with fixed service and land mobile service applications in the frequency range 275-450 GHz, as identified in No. **5.564A**

## 1.1 Table of incumbent bands under consideration

TABLE 1.1

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

|  |
| --- |
| EESS (passive)  frequency band |
| 235-238 GHz |
| 239.2-242.2 |
| 244.2-247.2 GHz |
| Above 275 GHz |

TABLE 1.2

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

|  |
| --- |
| EESS (active)  frequency band |
| 237.9-238 GHz |
|  |

## 1.2 References and related ITU-R documents

## 1.3 Propagation models and technical and operational characteristics of other services and systems

[Editor’s note: *This section will be updated and reviewed as more information becomes available from other WPs and contributors.]*

|  |  |  |
| --- | --- | --- |
| Source | Services/Applications/Models | Reference |
| WPs 3J, 3K, 3M | Propagation information to support studies in preparation for WRC-27 agenda item 1.8 | [5B/111](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R23-WP5B-C-0111) |
| WP 7C | Liaison statement to Working Party 5B (copy to Working Parties 3J, 3K, 3M, 4A, 4C, 5A, 5C and 7D for information) - Information on active and passive sensors in the EESS for WRC-27 agenda item 1.8 | [5B/20](https://www.itu.int/md/R23-WP5B-C-0020/en) |
|  |  |  |
|  |  |  |

## 1.4 Information on the services allocated in and adjacent to the frequency bands studied under WRC-27 agenda item 1.8 and related footnotes

Frequency bands

Considering in-band and adjacent frequency bands scenarios, the following frequency bands allocated to EESS (passive) below 275 GHz need to be included in the relevant studies under this agenda item:

‒ 226-231.5 GHz: This frequency band is subject to RR No. **5.340** (all emissions are prohibited) and is adjacent to the lower edge addressed under WRC-27 agenda item 1.8. Only adjacent frequency band compatibility studies are assumed to be performed.

‒ 250-252 GHz: This frequency band is subject to RR No. **5.340** (all emissions are prohibited). Only adjacent frequency band compatibility studies are assumed to be performed.

‒ 235-238 GHz: It is noted that this frequency band is only used by limb sounding instruments.

‒ 239.2-242.2 GHz and 244.2-247.2 GHz: these two frequency bands have been allocated to EESS (passive) by WRC-23 and sharing studies with EESS (passive) should be undertaken once RLS characteristics are known.

The band 237.9-238 GHz is also allocated to EESS (active) through RR No. **5.563B**, and its use is limited to spaceborne cloud radars.

Above 275 GHz, there is currently no frequency allocation in the RR, but RR No. **5.565** identifies several frequency bands that are relevant and are already in use by EESS (passive). When considering sharing and compatibility studies in the range 275-700 GHz, the following EESS (passive) frequency bands are to be taken into account:

‒ 275-286 GHz, 296-306 GHz, 313-356 GHz, 361-365 GHz, 369-392 GHz, 397‑399 GHz, 409-411 GHz, 416‑434 GHz, 439-467 GHz, 477-502 GHz, 523‑527 GHz, 538-581 GHz, 611-630 GHz, 634‑654 GHz, 657-692 GHz.

Table of Frequency Allocations

|  |  |  |
| --- | --- | --- |
| Allocation to services | | |
| Region 1 | Region 2 | Region 3 |
| 200-209 GHz  EARTH EXPLORATION-SATELLITE (passive)  RADIO ASTRONOMY  SPACE RESEARCH (passive)  5.340 5.341 5.563A | | |
| 209-217 GHz  FIXED  FIXED-SATELLITE (Earth-to-space)  MOBILE  RADIO ASTRONOMY  5.149 5.341 | | |
| 217 - 226 GHz  FIXED  FIXED-SATELLITE (Earth-to-space)  MOBILE  RADIO ASTRONOMY  SPACE RESEARCH (passive) 5.562B  5.149 5.341 | | |
| 226 - 231.5 GHz  EARTH EXPLORATION-SATELLITE (passive)  RADIO ASTRONOMY  SPACE RESEARCH (passive)  5.340 | | |
| 231.5 - 232 GHz  FIXED  MOBILE  Radiolocation | | |
| 232 - 235 GHz  FIXED  FIXED-SATELLITE (space-to-Earth)  MOBILE  Radiolocation | | |
| 235 - 238 GHz  EARTH EXPLORATION-SATELLITE (passive)  FIXED-SATELLITE (space-to-Earth)  SPACE RESEARCH (passive)  5.563A 5.563B | | |
| 238 - 240 GHz  FIXED  FIXED-SATELLITE (space-to-Earth)  MOBILE  RADIOLOCATION  RADIONAVIGATION  RADIONAVIGATION-SATELLITE | | |
| 240 - 241 GHz  FIXED  MOBILE  RADIOLOCATION | | |
| 241 - 248 GHz  RADIO ASTRONOMY  RADIOLOCATION  Amateur  Amateur-satellite  5.138, 5.149 | | |
| 248 - 250 GHz  AMATEUR  AMATEUR-SATELLITE  Radio astronomy  5.149 | | |
| 250 - 252 GHz  EARTH EXPLORATION-SATELLITE (passive)  RADIO ASTRONOMY  SPACE RESEARCH (passive)  5.340 5.563A | | |
| 252 - 265 GHz  FIXED  MOBILE  MOBILE-SATELLITE (Earth-to-space)  RADIO ASTRONOMY  RADIONAVIGATION  RADIONAVIGATION-SATELLITE  5.149 5.554 | | |
| 265 - 275 GHz  FIXED  FIXED-SATELLITE (Earth-to-space)  MOBILE  RADIO ASTRONOMY  5.149 5.563A | | |
| 275 - 3 000 GHz  (Not allocated)  5.564A 5.565 | | |

5.138 The following bands:

6 765-6 795 kHz (centre frequency 6 780 kHz),

433.05-434.79 MHz (centre frequency 433.92 MHz) in Region 1 except in the countries mentioned in No. 5.280,

61-61.5 GHz (centre frequency 61.25 GHz),

122-123 GHz (centre frequency 122.5 GHz),

and 244-246 GHz (centre frequency 245 GHz)

are designated for industrial, scientific and medical (ISM) applications. The use of these frequency bands for ISM applications shall be subject to special authorization by the administration concerned, in agreement with other administrations whose radiocommunication services might be affected. In applying this provision, administrations shall have due regard to the latest relevant ITU-R Recommendations.

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)

5.340 All emissions are prohibited in the following bands:

|  |  |  |
| --- | --- | --- |
| 1 400-1 427 MHz | 2 690-2 700 MHz, except those provided for by No. 5.422 | 10.68-10.7 GHz, except those provided for by No. 5.483 |
| 15.35-15.4 GHz, except those provided for by No. 5.511 | 23.6-24 GHz | 31.3-31.5 GHz |
| 31.5-31.8 GHz, in Region 2 | 48.94-49.04 GHz, from airborne stations | 52.6-54.25 GHz |
| 86-92 GHz 100-102 GHz | 109.5-111.8 GHz | 114.25-116 GHz |
| 148.5-151.5 GHz | 164-167 GHz | 182-185 GHz |
| 190-191.8 GHz | 200-209 GHz | 226-231.5 GHz |
| 250-252 GHz. (WRC-03) |  |  |

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.

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)

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-2019)

5.563A In the bands 200-209 GHz, 235-238 GHz, 250-252 GHz and 265-275 GHz, ground-based passive atmospheric sensing is carried out to monitor atmospheric constituents. (WRC-2000)

5.563B The band 237.9-238 GHz is also allocated to the Earth exploration-satellite service (active) and the space research service (active) for spaceborne cloud radars only. (WRC-2000)

5.565 The following frequency bands in the range 275-1 000 GHz are identified for use by administrations for passive service applications:

– radio astronomy service: 275-323 GHz, 327-371 GHz, 388-424 GHz, 426-442 GHz,453-510 GHz, 623-711 GHz, 795-909 GHz and 926-945 GHz;

– Earth exploration-satellite service (passive) and space research service (passive): 275-286 GHz, 296-306 GHz, 313-356 GHz, 361-365 GHz, 369-392 GHz, 397-399 GHz, 409-411 GHz, 416-434 GHz, 439-467 GHz, 477-502 GHz, 523-527 GHz, 538-581 GHz, 611-630 GHz, 634-654 GHz, 657-692 GHz, 713-718 GHz, 729-733 GHz, 750-754 GHz, 771-776 GHz, 823-846 GHz, 850-854 GHz, 857-862 GHz, 866-882 GHz, 905-928 GHz, 951-956 GHz, 968-973 GHz and 985-990 GHz.

The use of the range 275-1 000 GHz by the passive services does not preclude use of this range by active services. Administrations wishing to make frequencies in the 275-1 000 GHz range available for active service applications are urged to take all practicable steps to protect these passive services from harmful interference until the date when the Table of Frequency Allocations is established in the above-mentioned 275-1 000 GHz frequency range.

All frequencies in the range 1 000-3 000 GHz may be used by both active and passive services. (WRC-12)

Relevant ITU-R Recommendations and Reports

*Recommendations*

ITU-R [RS.1813](https://www.itu.int/rec/R-REC-RS.1813/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 1.4-450 GHz*

ITU-R [RS.1815](https://www.itu.int/rec/R-REC-RS.1815/en) *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](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 [RS.2105](https://www.itu.int/rec/R-REC-RS.2105/en) *Typical technical and operational characteristics of Earth exploration-satellite service (active) systems using allocations between 432 MHz and 238 GHz*

ITU-R [RS.2431](https://www.itu.int/pub/R-REP-RS.2431) *Technical and operational characteristics of EESS (passive) systems in the range 275-450 GHz*

*Contributed Recommendations*

# Technical and operational characteristics from affected services (EESS passive services)

## General Notes

Antenna patterns for EESS (passive) are provided in Recommendation [ITU-R RS.1813](https://www.itu.int/rec/R-REC-RS.1813/en).

## 2.1 231-275 GHz systems

Typical parameters of passive sensors operating in the 231-275 GHz frequency band

The 231-275 GHz frequency band is essential for the measurement of atmospheric trace gases using passive remote sensing satellite limb sounders. Specifically, at the 240 GHz part of the spectrum, data products include measurements of carbon monoxide, nitric acid in the upper and lower stratosphere, cloud ice water content (IWC), ice water path (IWP), ozone, volcanic sulfur dioxide, and improve the quality of upper tropospheric water vapor measurements. Table 2.2.1 summarizes the parameters of passive sensors that are or will be operating within the 231 and 275 GHz frequency band.

The technical and operational characteristics of EESS (passive) systems in the range 231.5-275 GHz are given in section 6.20 of Recommendation [ITU-R RS.1861](https://www.itu.int/rec/R-REC-RS.1861/en).

Finally, the characteristics of EESS (active) systems in the band 237.9-238 GHz are given in section 7.14 of Recommendation [ITU-R RS.2105](https://www.itu.int/rec/R-REC-RS.2105/en).

## 2.2 275-700 GHz systems

Typical parameters of passive sensors operating in the 275-700 GHz frequency band

The 275-700 GHz frequency band is essential for the measurement of atmospheric trace gases using passive remote sensing satellite limb sounders. Specifically, at the 640 GHz band data products include measurements of bromine monoxide, methyl chloride, methyl cyanide, methanol, chlorine monoxide, hydrogen chloride, hydroperoxyl, hypochlorous acid, volcanic sulfur dioxide, methyl cyanide, nitric acid, cloud ice water content (IWC), ice water path (IWP), nitrous oxide, ozone and improve the quality of upper tropospheric water vapor measurements. Table 2.3.1 summarizes the parameters of passive sensors that are or will be operating within the 275 and 700 GHz frequency band.

The technical and operational characteristics of EESS (passive) systems in the range 275-450 GHz are given in Report [ITU-R RS.2431](https://www.itu.int/pub/R-REP-RS.2431).

The characteristics of EESS (passive) systems in the range 450-700 GHz are currently not fully documented. WP 7C will provide this information at a later stage.

## 2.3 Protection criteria for EESS (passive)

For EESS (passive), the interference criteria are given in Table 2 of Recommendation [ITU-R RS.2017](https://www.itu.int/rec/R-REC-RS.2017/en). The interference criteria in Recommendation ITU-R RS.2017 are aggregate criteria for all sources of interference.

It should also be noted that this Recommendation does not yet include the protection criteria for the newly allocated bands 239.2-242.2 GHz and 244.2-247.2 GHz. The corresponding work will be undertaken within WP 7C but, at the current stage, interference criteria given in Report [ITU-R RS.2535](https://www.itu.int/pub/R-REP-RS.2535) should be used (i.e. the same protection criteria as specified in Recommendation ITU-R RS.2017 for the band 226-231.5 GHz).

Table 2.3.1 Protection criteria for EESS (passive) from RS.2017

| 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) |
| --- | --- | --- | --- | --- |
| 231.5-275 | 100 | −169 | 0.01 | N, C |
| 275-700 | 10 | −189 | 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.

# Sharing and compatibility studies

## 3.1 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 is 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 are 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 is generated where the directional vectors from each active source to the EESS (passive) sensor is computed along with the apparent gain of the transmit and receive antennas using their respective antenna patterns.

The interfering signal power level, (W), received by a spaceborne sensor at the simulation step from the active station is calculated from:

(A3-1)

where:

: active station out of band transmitter power in the EESS (passive) band, accounting for frequency dependent rejection;

: active station antenna gain towards spaceborne sensor;

: spaceborne receive antenna gain towards terrestrial source;

 : losses due to atmospheric absorption (Rec. ITU-R P.676 via Rec. ITU-R P.619);

: Free Space Path Loss;

The aggregate interference from radiolocation systems at the simulation step, (W), is calculated by the summation of the received interference from all active stations within line of sight of EESS (passive) satellite:

(A3-2)

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

(A3-3)

Using the resulting data containing received interfering power levels, a CCDF curve is generated to assess interference received by the sensor undergoing observations over the MAI.

## 3.2 Simulation #1

[TBD]

## 3.3 Simulation #2

[TBD]

# Results

[TBD]

# Summary

[TBD]

# Glossary and abbreviations

*EESS* Earth Exploration Satellite Services

*IWC* Ice Water Content

*IWP* Ice Water Path

*RAS* Radio Astronomy Services

*RLS* Radiolocation Services

*SRS* Space Research Services

1. that the frequency ranges 231.5-275 GHz and 275-700 GHz are also allocated to other radiocommunication services and that those allocations are used by a variety of incumbent systems in many administrations, and that the protection of these services, including adjacent services, should be studied; [↑](#footnote-ref-2)