|  |  |
| --- | --- |
| U.S. Radiocommunication Sector  Fact Sheet | |
| **Working Party:** ITU-R WP 7D | **Document No:** 24USWP7D\_09\_NC |
| **Ref.** Res. **712 (WRC-23)** | **Date:** 01/31/2024 |
| **Document Title:** New Working Document towards a Preliminary Draft New Report on Sharing and Compatibility between RAS and Active Satellite Services in the 71-235 GHz range | |
| **Author(s)/Contributors(s):**  Frank Schinzel (NRAO) | Email: fschinze@nrao.edu Phone: 575-322-3182 |
| **Purpose/Objective:** This report provides results from sharing and compatibility studies to be performed under Resolution **712 (WRC-23)**. | |
| **Abstract:** Pursuant to Resolution **712 (WRC-23)**, which resolves to invite compatibility studies between the RAS and the active satellite services in certain adjacent and nearby frequency bands in the range 71 – 235 GHz. Under this resolution, studies are invited to inform possible regulatory measures regarding the protection of the RAS in the frequency bands listed.  This document will provide a summary of results from sharing and compatibility studies performed in support of Res. **712 (WRC-23)**. | |

|  |  |
| --- | --- |
| **Radiocommunication Study Groups** | Logo  Description automatically generated |
|  |  |
|  |  |
| Source: | **Document 7D/XXX-E** |
| **XX March 2024** |
| **English only** |
| United States of America | |
| Working Document towards A PRELIMINARY DRAFT NEW REPORT  SHARING AND COMPATIBILITY between Ras and active satellite services in the 71-235 GHz range | |

**Introduction**

This new working document towards a preliminary draft new report provides an outline for work to summarize results from compatibility studies between the RAS and the active satellite services as called for in Resolution **712 (WRC-23)**, as follows:

compatibility studies between the RAS and the active satellite services in certain adjacent and nearby frequency bands listed in Table 2 below with a view to setting the relevant threshold levels for unwanted emissions from any GSO and non-GSO space stations …:

TABLE 2

RAS frequency bands to be studied and corresponding active services to be included

|  |  |  |
| --- | --- | --- |
| Radio astronomy frequency band | Active satellite service frequency band | Active satellite service  (space-to-Earth) |
| 76-81 GHz | 71-76 GHz | Fixed-satellite service (FSS), mobile-satellite service (MSS), broadcasting-satellite service (BSS) |
| 130-134 GHz | 123-130 GHz | FSS, MSS, radionavigation-satellite service (RNSS) |
| 164-167 GHz | 167-174.5 GHz | FSS |
| 226-231.5 GHz | 232-235 GHz | FSS |

**Attachment**

ATTACHMENT

Working Document towards A PRELIMINARY DRAFT NEW REPORT

**Sharing and Compatibility between RAS and Active Satellite Services in the 71-235 GHz range**

# 1 Introduction

Radio astronomy at mm-wavelengths is rapidly evolving and has become a key means for investigating the universe. It has been crucial in detecting numerous interstellar molecules, such as water and carbon monoxide in space. It has been used in the detection of more than a thousand molecules, many unknown on Earth. The millimeter radiation of molecules is not absorbed by interstellar clouds of dust, which has allowed for these numerous discoveries made to date. Other topics of interest for which mm-wave observations yield key scientific insights include the observation of star and planet formation processes, study of emission from the vicinity of compact objects such as black holes, and study of the earliest galaxies.

To detect such faint, naturally occurring, signals of cosmic emissions at mm-wavelengths, parabolic reflectors are typically used, which can be combined interferometrically to achieve the highest possible spatial resolutions. The most productive facility currently in operation at the frequency bands covering 71 – 235 GHz is the Atacama Large Millimeter Array (ALMA), situated in Chile and which is expected to continue to receive technical upgrades well beyond 2030. Single dish telescopes and smaller interferometric facilities are also in operation around the world, all of which provide unique observational capabilities in these frequency bands. Most recently, a new facility that will include radio telescopes located across North America, the next generation Very Large Array (ngVLA) was rated among the top two projects in the U.S. National Academy of Sciences’ Astro2020 decadal survey (“Pathways to Discovery in Astronomy and Astrophysics for the 2020s”). The ngVLA will vastly improve the observational capabilities in the 67 – 116 GHz range in the northern hemisphere and is expected to start construction in the 2020-2030 decade. In addition to interferometers, single-dish telescopes operate within this frequency range across the globe, including the Arizona Radio Observatory in the U.S.A., the Large Millimeter Telescope in Mexico, the Atacama Pathfinder Experiment in Chile, or the Pico Veleta Telescope in Spain.

Relevant characteristics of RAS systems are provided in a number of ITU-R reports. A detailed description of technical and operational characteristics of radio astronomy facilities operating in the mm-wavelength range is provided in Rep. ITU-R RA.2510-0. Of widely-distributed astronomy arrays operating above 200 GHz is provided in Rep. ITU-R RA.2508-0. Technical and operational characteristics of broadband, background-limited detectors operating in the mm-wave regime is provided in RA.2512-0.

The frequency bands allocated to RAS enable observations of a multitude of physical phenomena, including thermal and non-thermal continuum emission and spectral line emission from atoms and molecules. Radio telescopes require sensitive receivers and a low noise environment in order to detect this extremely faint naturally occurring radio emission. Many of the RAS allocations in the International Table of Frequency Allocations are also listed in Footnote No. **5.149**, where Administrations are urged to take all practicable steps to protect the Radio Astronomy Service, or Footnote No. **5.340**, where all emissions are prohibited (see Table 2). The feasibility of sharing must recognize the need to protect the passive services. The threshold emission levels detrimental to the Radio Astronomy Service are listed in Recommendation ITU-R RA.769-2.

This report specifically addresses compatibility between the Radio Astronomy Service (RAS) and the active satellite services in the 71 – 235 GHz range and especially adjacent and nearby frequency bands listed in Table 1.

TABLE 1

RAS frequency bands studied and corresponding active services to be included in this report.

|  |  |  |
| --- | --- | --- |
| Radio astronomy frequency band | Active satellite service frequency band | Active satellite service  (space-to-Earth) |
| 76-81 GHz | 71-76 GHz | Fixed-satellite service (FSS), mobile-satellite service (MSS), broadcasting-satellite service (BSS) |
| 130-134 GHz | 123-130 GHz | FSS, MSS, radionavigation-satellite service (RNSS) |
| 164-167 GHz | 167-174.5 GHz | FSS |
| 226-231.5 GHz | 232-235 GHz | FSS |

## 1.2 Sharing and protection requirements for RAS in the 76 – 235 GHz range

Between 76 and 235 GHz, the radio astronomy service currently shares 45% (43 GHz) of the band with active satellite services, which include amateur-satellite, broadcasting-satellite, EESS (active), fixed-satellite (FSS), inter-satellite, mobile-satellite (MSS), radionavigation-satellite (RNSS), and space research (active). A complete summary is provided in ITU-R Report RA.2510, while here we provide an excerpt focusing on FSS, MSS, BSS, and RNSS. Table 2 provides a summary of the applicable bands, highlighting both the relevant active services and RAS bands, including specific bands to be included in this report, as listed in Table 1. This provides the context within which studies are performed.

In most cases where sharing of RAS with active services is indicated, footnote RR. No. **5. 149** applies, which encourages administrations to take all practicable steps to protect the radio astronomy service from harmful interference. This footnote includes caution that emissions from spaceborne or airborne stations can be particularly serious sources of interference to RAS, which is also the case for active satellite services. RR. No **5.340**, also referenced for certain bands in Table 2, notes that all emissions are prohibited. These bands are used simultaneously for both continuum and spectral line observations. The interference threshold levels detrimental to the RAS are given in Recommendation ITU-R RA.769 for the lower and upper part for the frequency range respectively as -129 to -119 dB(W/m2) and -228 to -218 dB(W/(m2 Hz)) for continuum observations, and -148 to -139 dB(W/m2) and -208 to -199 dB(W/(m2 Hz)).

TABLE 2

Overview of RAS frequency bands and bands of the active satellite services FSS, MSS, BSS and RNSS in the 71 – 235 GHz range

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range (GHz) | FSS/MSS/BSS/RNSS Service Allocation | RAS Status | Footnote Referencing RAS |
| 71-74 | FSS (space-to-Earth) MSS (space-to-Earth) | None | None |
| 74-76 | FSS (space-to-Earth) BSS | None | None |
| 76-81 | None | Co-primary with other active services | 5.149 |
| 81-84 | FSS (Earth-to-space) MSS (Earth-to-space) | Co-primary with other active services | 5.149 |
| 84-86 | FSS (Earth-to-space) | Co-primary with other active services | 5.149 |
| 86-92 | None | Co-primary with other passive services | 5.340 |
| 92-94 | None | Co-primary with other active services | 5.149 |
| 94.1-95 | None | Co-primary with other active services | 5.149 |
| 95-100 | RNSS | Co-primary with other active services | 5.149 |
| 100-102 | None | Co-primary with other passive services | 5.340 |
| 102-105 | None | Co-primary with other active services | 5.149 |
| 105-109.5 | None | Co-primary with other active and passive services | 5.149 |
| 109.5-111.8 | None | Co-primary with other passive services | 5.340 |
| 111.8-114.25 | None | Co-primary with other active and passive services | 5.149 |
| 114.25-116 | None | Co-primary with other passive services | 5.340 |
| 123-130 | FSS (space-to-Earth) MSS (space-to-Earth) RNSS | Secondary | 5.562D, 5.149 |
| 130-134 | None | Co-primary with other active services | 5.149 |
| 134-136 | None | Co-primary with other active services |  |
| 136-148.5 | None | Co-primary with other active services | 5.149 |
| 148.5-151.5 | None | Co-primary with other passive services | 5.340 |
| 151-158.5 | None | Co-primary with other active services | 5.149 |
| 158.5-164 | FSS (space-to-Earth) MSS (space-to-Earth) | None | None |
| 164-167 | None | Co-primary with other passive services | 5.340 |
| 167-174.5 | FSS (space-to-Earth) | None | 5.149 |
| 182-185 | None | Co-primary with other passive services | 5.340 |
| 191.8-200 | MSS, RNSS | None | 5.149 |
| 200-209 | None | Co-primary with passive services | 5.340 |
| 209-226 | FSS (Earth-to-space) | Co-primary with active and passive services | 5.149 |
| 226-231.5 | None | Co-primary with passive services | 5.340 |
| 232-235 | FSS (space-to-Earth) | None | None |

# 2 Satellite System Characteristics

[To be liaised from WP 4A/4C]

# 3 Propagation Characteristics

[EDITOR’s NOTE: Confirmation of the information in this section should be done by relevant Study Group3 Working parties. Additional information would be helpful on the 10th percentile issue.]

Above 71 GHz, atmospheric absorption is a key factor in sharing studies, but also varies widely depending on the particular atmospheric characteristics considered, e.g., the presence of oxygen and water vapor. Overall propagation loss can vary greatly with respect to, e.g., frequency, altitude, water vapor content, and elevation angle. Thus, care must be taken to understand the entirety of the particular propagation loss scenario and to limit active emissions to levels that do not cause harmful interference to RAS and EESS (passive) systems. Sharing studies must be carried out using the most transparent atmospheric conditions relevant to the site in question, usually the 10th percentile lowest attenuation weather conditions.

The three most important elements for sharing include (1) site elevation (and atmospheric conditions); (2) site location for any ground-based terrain shielding, attenuation due to clutter, etc.; (3) transmitter characteristics, including power level, beam size/shape, and whether the transmitter is ground-based, air borne, or in space. For active satellite service compatibility, ground-based terrain shielding does not play a role, where interference is primarily driven through line-of-sight effects and beam-sidelobe coupling.

Section 3 of Rep. ITU-R RA.2510-0 provides a summary of atmospheric attenuation characteristics in the frequency range of concern and thus will not be repeated in this report.

While Earth curvature, scattering and terrain shielding can add attenuation and decrease the separation distance to meet the ITU-R RA.769-2 power limits, this is primarily for ground-based transmitters. For airborne and space-based transmitters, as described in RR 5.149, much larger separation distances are needed to avoid levels of harmful interference.

[Atmospheric Considerations for Sharing, Attenuation levels etc. and other considerations; factors as provided by WP 3J, 3M]

# 4 Compatibility of Active Satellite Services with RAS

[Unwanted emission threshold levels; additional characteristics and protection criteria for RAS; summary of studies and subsections describing conducted studies]

# 5 Sharing Criteria

[Mitigations to Enhance Sharing; Description of possible sharing strategies such as geographic exclusion zones, or time duplexing]

# 6 References and related ITU-R Documents

Report ITU-R RA.2131 Supplementary information on the detrimental threshold levels of interference to radio astronomy observations in Recommendation ITU-R RA.769    
  
Report ITU-R RA.2508 Widely-distributed radio astronomy array systems operating above 200 GHz  
  
Report ITU-R RA.2510 Technical and operational characteristics of radio astronomy systems in the 67-116 GHz (3-4 mm) range  
  
Report ITU-R RA.2512 Technical and operational characteristics of broadband, background-limited detectors operating in the millimetre-wave regime  
  
Recommendation ITU-R RA.769-2 Protection criteria used for radio astronomical measurements  
  
Recommendation ITU-R RA.1750 Mutual planning between the Earth exploration-satellite service (active) and the radio astronomy service in the 94 GHz and 130 GHz bands

# 7 List of Acronyms and Abbreviations