| **U.S. Radiocommunication Sector**  **FACT SHEET** | | | |
| --- | --- | --- | --- |
| **Study Group:** WP7B | | **Document No:** US7B\_27\_022\_NC | |
| **Reference:** Annex 2 to the September 2024 WP7B Chairman’s Report,  Resolution **680 (WRC-23),**  WRC-27 Agenda Item **1.15** | | **Date:** 11 February 2025 | |
| **Document Title:**  Working document towards PDN Report ITU-R SA.[LUNAR\_1.15\_STUDIES] | | | |
| **Authors** | **Telephone** | | **E-Mail** |
| Dennis Lee, NASA/JPL  Cathy Sham, NASA/JSC  Scott Kotler, Lockheed Martin  Steve Baruch, NWSP for Lockheed Martin Corporation | 818-354-6908  281-222-1117  703-789-3923  240-476-2600 | | [dennis.k.lee@jpl.nasa.gov](mailto:dennis.k.lee@jpl.nasa.gov)  [catherine.c.sham@nasa.gov](mailto:catherine.c.sham@nasa.gov)  [scott.kotler@LMCO.com](mailto:scott.kotler@LMCO.com)  [sbaruch@newwavespectrum.com](mailto:sbaruch@newwavespectrum.com) |
| **Purpose/Objective**:  The purpose of this contribution is to further progress the working document in WP7B with sharing and compatibility studies per Res. **680 (WRC-23)** *resolves to invite… in time for 2027 World Radio Conference* 1, 2 and 4 | | | |
| **Abstract**:  Under Agenda item **1.15** **(WRC-27)**, possible new or modified space research service (space-to-space) allocations, in the frequency ranges identified in Resolution **680 (WRC-23)** *resolves to invite* 1, are under study to ensure sharing and compatibility between SRS links on the lunar surface/between lunar orbit and lunar surface and incumbent services in Res **680 (WRC-23)** *recognizings* g) to n) and RAS in adjacent and nearby bands.  At the September 2024 meeting, an initial framework for the sharing and compatibility studies report was introduced. This contribution is to further progress the working document towards a Preliminary Draft New Report SA.[LUNAR 1.15 STUDIES]. | | | |
| **Fact Sheet Preparer:** Dennis Lee, NASA/JPL | | | |

|  |  |
| --- | --- |
| **Radiocommunication Study Groups** |  |
|  |  |
|  |  |
| Source: Document 7B/TEMP/30  Subject: WRC-27 agenda item 1.15 | Annex 2 to Document 7B/97-E |
| 27 September 2024 |
| English only |
| Annex 2 to Working Party 7B Chair’s Report | |
| Working document towards a preliminary draft  new Report ITU-R SA.[LUNAR 1.15 STUDIES] | |
| |  | | --- | | Sharing studies of space research systems for lunar operations  under WRC-27 agenda item 1.15 | | |

(202X)

Scope

Keywords

Glossary / Abbreviations

Related ITU Recommendations and Reports

# 1 Introduction

This document provides the sharing studies and spectrum needs related to systems in the space research service planned for operations on the lunar surface, or systems in lunar orbit communicating with systems on the lunar surface, in the following frequency ranges or portions thereof:

• 390-406.1 MHz, 420-430 MHz and 440-450 MHz, limited to outside the SZM;

• 2 400-2 690 MHz, 3 500-3 800 MHz, 5 150-5 570 MHz, 5 570-5 725 MHz, 5 775-5 925 MHz, 7 190-7 235 MHz, 8 450-8 500 MHz and 25.25-28.35 GHz.

and taking into account protection of incumbent services in Resolution **680 (WRC-23)** *recognizing g)* to *n)* and RAS on the Earth and in the shielded zone of the Moon (SZM) in the same, adjacent or nearby bands.

The objective of this document is to respond to *resolves to invite the ITU Radiocommunication Sector to complete in time for the 2027 world radiocommunication conference 1) and 4)* of Resolution **680 (WRC-23)** under WRC-27 agenda item 1.15.

# 2 Spectrum needs

Figure 1 shows a conceptual diagram of the envisioned elements [1] used for space research operations on the lunar surface, and the associated communication network architecture in the vicinity of the Moon. The communication links between the lunar elements will be used to support scientific discovery and human/robotic exploration of the Moon, and may leverage technology and frequency ranges originally developed for wireless communication networks on Earth. A detailed description of the technical and operating characteristics of systems in the space research service planned for operations on the lunar surface, or systems in lunar orbit communicating with systems on the lunar surface, are provided in PDN Report ITU-R SA.[LUNAR.SRS STATIONS CHAR]. This section provides a description of the amount of spectrum needed within each frequency range needed to support the envisioned concept of operations as described in the aforementioned Report and summarized below.

Figure 1

Envisioned Lunar Surface Communication Architecture

A computer generated image of a space mission

Description automatically generated with medium confidence

In this lunar communication network architecture, it is assumed that the initial human exploration activities will centered around the lunar landers, and eventually around permanent habitation modules. The lunar landers will be considered as a stationary surface platform for the duration of the landed mission phase, which may last up to several months. There will likely be multiple landers present on the lunar surface at any one time, some which may be crewed and others which are for robotic exploration only. There may also be multiple habitation modules, each with their own local area communication networks and high rate point-to-point links between habitation modules.

The lander and the habitation module are expected to provide a wireless local area network (WLAN) service for crew and rovers in the near vicinity of the lander (< 300 meters). The data rate for each device is expected to be between 1-30 Mbps including file transfers and high definition video, with up to 15-20 connected devices per WLAN. The frequency ranges for this application are expected to in the 2 400-2 483.5 MHz and 5 150-5 725 MHz bands using Wi-Fi technology. In addition, lunar terrain vehicles and pressurized rovers may also provide WLAN coverage in their immediate vicinity for crewed exploration of the Moon away from the lander/habitation modules.

For longer range connectivity around the lander and habitation modules, it is expected that network coverage will be provided by technology similar to 3GPP developed for terrestrial networks. The data rates per lunar device is expected to between 3-12 Mbps for voice, data, and video. Initial deployments on the Moon will likely involve a base station installed on the lunar lander supporting EVA communications for up to 6 lunar elements (crew and/or rovers) in a 2 km radius around the lander. This can be supported using a FDD network in the 2 500-2 690 MHz band, assuming a 50 MHz guard band between the FDD uplink and downlink bands. For crew contingency walk-back scenarios where coverage is limited or the range is large (up to 10 km), the data rate using this network may limited to 100 kbps.

Eventual deployment around the habitation module will involve multiple base stations for a larger coverage area and more lunar elements (up to approximately 30-50 devices). These networks may utilize the 3 500-3 800 MHz frequency range in order to provide a higher data rates (up to 100 Mbps per device) and increased network capacity. The lunar terrain vehicle and pressurized rover may also carry a base station to provide connectivity during long range crewed exploration missions away from the lander/habitation module.

During crewed exploration missions, short range crew suit-to-suit communications up to 200 meters distance is need for voice and data. The data rate for this application is expected to be around 100 kbps and will use the 420-430 MHz frequency range. For higher rate suit-to-suit communications involving high definition video (~12 Mbps), technology based on the Sidelink device-to-device communications in the 5 855-5 925 frequency band may also be used. Furthermore, the astronauts will carry a distress beacon in the 406-406.1 MHz band. This beacon will be used to notify a lunar orbiting satellite in the event of an emergency. The crew EVA suits and rovers will also carry devices to receive signals transmitted by lunar orbiting satellites for position determination and time synchronization in the 2 483.5-2 500 MHz band. Outside of the SZM, relay communications between elements on the lunar surface and lunar orbiting satellites may also take place in the 390-405 MHz and 440-450 MHz bands.

For high rate point-to-point links between the habitation module and remote experimental platforms involving science observations and/or data collection, the 27.5-28.35 GHz frequency range is expected be used. These links may involve data rates up to 1 Gbps using highly directional antennas. This frequency band may also be used for high rate communications between two habitation modules, or for relay communications between a lander and a habitation module.

Table 1 shows a calculation of the spectrum needs for different envisioned lunar SRS applications.

Table 1

Envisaged Concept of Operations of Spectrum Use for SRS Systems in the Lunar Environment

| Frequency Band | Lunar Surface to Lunar Surface | Lunar Orbit to Lunar Surface | Lunar Surface to Lunar Orbit |
| --- | --- | --- | --- |
| 390-405 MHz \* |  | X |  |
| 406-406.1 MHz \* |  |  | X |
| 420-430 MHz \* | X |  |  |
| 440-450 MHz \* |  |  | X |
| 2400-2483.5 MHz | X |  |  |
| 2483.5-2500 MHz |  | X |  |
| 2500-2690 MHz | X |  |  |
| 3500-3800 MHz | X |  |  |
| 5150-5570 MHz | X |  |  |
| 5570-5725 MHz | X |  |  |
| 5725-5855 MHz | X |  |  |
| 5855-5925 MHz | X |  |  |
| 7190-7235 MHz |  | X |  |
| 8450-8500 MHz |  |  | X |
| 27.5-28.35 GHz | X |  |  |
| \* Outside of the Shielded Zone of the Moon. | | | |

Table 2

Lunar SRS Spectrum Needs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | EVA Comms | HAB module | Point-to-point Surface Comms | Orbiter relay comms (proximity link) | Remote Science Instruments | Exploration Vehicle (LTV, pressurized rover) |
| Data Type | Voice, Data, Video | High rate data transfer, file upload, high definition video | Backhaul data | Relay data | Scientific measurement data | Voice, Data, Video |
| Data Rate (Mbps) | 12 | 30 | 1000 | 100 | 30 | 30 |
| # of Devices/ Links per Site | 6-12 | TBD | TBD | 6  (forward and return) | 20 | 4 |
| Total capacity (Mbps) | 144 | TBD | TBD | 600 | 600 | 120 |
| Spectral efficiency (bits/s/Hz) | 1 | TBD | TBD | 2 | 2 | 1 |
| Spectrum needs (MHz) | 144 | TBD | TBD | 300 | 300 | 120 |
| Total Spectrum needs (MHz)(1) | TBD | | | | | |
| (1) Not including bandwidth for backup communications and guard bands | | | | | | |

# 3 Services identified for sharing and compatibility studies with space research systems for lunar communications

This section provides a summary of the services identified for sharing and compatibility studies with lunar surface SRS systems, or systems in lunar orbit communicating with systems on the lunar surface, in the frequencies ranges listed for study in Resolution **680 (WRC-23)**. The following tables provide a summary of the services identified for sharing and compatibility studies in each frequency range, along with the regions and relevant footnotes from Article 5 in the Radio Regulations.

The technical and operating characteristics of systems in the space research service planned for operations on the lunar surface, or systems in lunar orbit communicating with systems on the lunar surface, are provided in PDN Report ITU-R SA.[LUNAR.SRS STATIONS CHAR]. All the lunar communications described in this report are between or among types of space stations on the lunar surface or in lunar orbit.

## 3.1 390-406.1 MHz

TABLE 3

Services identified for sharing studies with lunar communications (390-406.1 MHz)

| **Service** | **Frequencies** | **Footnotes** |
| --- | --- | --- |
| FIXED | 390.0-399.9 MHz |  |
| 400.15-401 MHz | **5.262** |
| MOBILE | 390.0-399.9 MHz |  |
| 400.15-401 MHz | **5.262** |
| MOBILE-SATELLITE  (Earth-to-space) | 399.9-400.05 MHz | **5.209**, **5.220**, **5.260A**, **5.260B** |
| 406.00-406.10 MHz | **5.265**, **5.266**, **5.267** |
| MOBILE-SATELLITE  (space-to-Earth) | 400.15-401.00 MHz | **5.208A**, **5.208B**, **5.209** |
| Fixed(1) | 401-406 MHz |  |
| (1) Service allocated on a secondary basis as per Radio Regulations, but identified for study by WP 5C. | | |

## 3.2 420-430 MHz

TABLE 4

**Services identified for sharing studies with lunar communications (420-430 MHz)**

|  |  |  |
| --- | --- | --- |
| Service | Frequencies | Footnotes |
| FIXED | 420-430 MHz |  |
| MOBILE except aeronautical mobile | 420-430 MHz |  |
| RADIOLOCATION | 420-430 MHz | **5.269** |

## 3.3 440-450 MHz

TABLE 5

**Services identified for sharing studies with lunar communications (440-450 MHz)**

|  |  |  |
| --- | --- | --- |
| Service | Frequencies | Footnotes |
| FIXED | 440-450 MHz |  |
| MOBILE except aeronautical mobile | 440-450 MHz |  |
| RADIOLOCATION | 440-450 MHz | **5.269**, **5.285** |

## 3.4 2 400-2 690 MHz

TABLE 6

**Services identified for sharing studies with lunar communications (2 400-2 690 MHz)**

| Service | Frequencies | Footnotes |
| --- | --- | --- |
| FIXED | 2 400-2 690 MHz |  |
| MOBILE | 2 400-2500 MHz |  |
| RADIOLOCATION | 2 450-2 500 MHz |  |
| RADIODETERMINATION-SATELLITE (space-to-Earth) | 2 483.5-2 500 MHz | **5.398**, **5.399** (Region 1), **5.401** (Regions 1&3), **5.402** |
| MOBILE-SATELLITE (space‑to‑Earth) | 2 483.5-2 500 MHz | **5.351A**, **5.401** (Regions 1&3), **5.402** |
| 2 500-2 520 MHz |  |
| MOBILE-SATELLITE  (Earth-to-space) | 2 655-2 670 MHz | **5.420** |
| 2 670-2 690 MHz | **5.351A** |
| FIXED-SATELLITE  (space-to-Earth) | 2 500-2 535 MHz | **5.415** |
| 2 535-2 655 MHz | **5.415** |
| 2 655-2 690 MHz | **5.415** |
| FIXED-SATELLITE  (Earth-to-space) | 2 655-2 690 MHz | **5.415** |
| MOBILE except aeronautical mobile | 2 500-2 690 MHz | **5.384A**, **5.409A** (Regions 1&2) |
| MOBILE (identified for IMT) | 2 500-2 690 MHz | **5.384A** |
| MOBILE (identified for HIBS) | 2 500-2 690 MHz | **5.409A** |
| BROADCASTING-SATELLITE | 2 520-2 655 MHz | **5.413**, **5.416**, **5.418B**, **5.418C** |
| 2 520-2 535 MHz | **5.413**, **5.416** |
| 2 535-2 655 MHz | **5.413**, **5.416**, **5.418**, **5.418A**, **5.418B**, **5.418C** |
| 2 655-2 670 MHz | **5.413**, **5.416** |
| AERONAUTICAL RADIONAVIGATION (1) | 2 700-2 900 MHz | **5.423** |
| NOTE: The frequency range from 2 400 to 2 500 MHz is also designated for industrial, scientific and medical (ISM) applications according RR No. **5.150**. Radiocommunication services operating within these bands must accept harmful interference which may be caused by these applications. ISM equipment operating in these bands is subject to the provisions of No. **15.13**.  (1) Service identified for compatibility analysis by WP 5B. | | |

## 3.5 3 500-3 800 MHz

TABLE 7

**Services identified for sharing studies with lunar communications (3 500-3 800 MHz)**

|  |  |  |
| --- | --- | --- |
| **Service** | **Frequencies** | **Footnotes** |
| FIXED | 3 500-3 800 MHz |  |
| FIXED SATELLITE  (space-to-Earth) | 3 500-3 800 MHz |  |
| MOBILE except aeronautical mobile | 3 500-3 600 MHz | **5.430A** (Region 1), **5.431B** (Region 2), **5.433A** (Region 3) |
| 3 600-3 800 MHz | **5.434A** (Region 1), **5.435A** (Region 1), **5.433B** (Region 1), **5.434B** (Region 1), **5.434** (Region 2) |
| MOBILE (identified for IMT) | 3 500-3 600 MHz | **5.430A**, **5.431B**, **5.433A** |
| 3 600-3 700 MHz | **5.434** |
| 3 700-3 800 MHz | **5.434B** |
| 3 700-3 800 MHz | **5.435B** |

## 3.6 5 150-5 570 MHz

TABLE 8

**Services identified for sharing studies with lunar communications (5 150-5 570 MHz)**

|  |  |  |
| --- | --- | --- |
| **Service** | **Frequencies** | **Footnotes** |
| FIXED SATELLITE  (Earth-to-space) | 5 150-5 250 MHz | **5.447A**, **5.447C** |
| FIXED SATELLITE (1)  (space-to-Earth) | 5 150-5 216 MHz | **5.447B** |
| MOBILE except aeronautical mobile | 5 150-5 250 MHz | **5.446A**, **5.446B**, **5.447** |
| 5 250-5 350 MHz | **5.446A**, **5.447F** |
| 5 470-5 570 MHz | **5.446A**, **5.450A** |
| AERONAUTICAL MOBILE | 5 150 -5 250 MHz | **5.446C**, **5.446D** |
| AERONAUTICAL RADIONAVIGATION | 5 150-5 250 MHz |  |
| 5 350-5 460 MHz | **5.449** |
| 5 470-5 650 MHz | **5.450** |
| FIXED | 5 250-5 350 MHz | **5.447E** |
| RADIOLOCATION | 5 250-5 350 MHz | **5.448A** |
| 5 350-5 470 MHz | **5.448D** |
| 5 470-5 570 MHz | **5.450B** |
| SPACE RESEARCH (active) | 5 250-5 255 MHz | **5.447D** |
| 5 255-5 350 MHz | **5.448A** |
| 5 350-5 460 MHz | **5.448C** |
| 5 460-5 570 MHz | **5.448B** |
| RADIONAVIGATION | 5 250-5 350 MHz | **5.448** |
| 5 460-5 470 MHz | **5.448B**, **5.449** |
| MARITIME RADIONAVIGATION | 5 470-5 570 MHz | **5.448B** |
| (1) This allocation is limited to feeder links of non-geostationary-satellite systems in the mobile satellite service and is subject to provisions of No. **9.11A**. | | |

## 3.7 5 570-5 725 MHz

TABLE 9

**Services identified for sharing studies with lunar communications (5 570-5 725 MHz)**

|  |  |  |
| --- | --- | --- |
| **Service** | **Frequencies** | **Footnotes** |
| RADIOLOCATION | 5 570-5 650 MHz | **5.450B** |
| 5 650-5 725 MHz |  |
| FIXED | 5 650-5 725 MHz | **5.453**, **5.455** |
| MOBILE | 5 650-5 725 MHz | **5.453** |
| MOBILE except aeronautical mobile | 5 570-5 725 MHz | **5.450A** |

## 3.8 5 775-5 925 MHz

TABLE 10

**Services identified for sharing studies with lunar communications (5 775-5 925 MHz)**

|  |  |  |
| --- | --- | --- |
| **Service** | **Frequencies** | **Footnotes** |
| FIXED SATELLITE  (Earth-to-space) | 5 775-5 850 MHz |  |
| 5 850-5 925 MHz |  |
| RADIOLOCATION | 5 775-5 850 MHz |  |
| FIXED | 5 775-5 850 MHz | **5.453** |
| 5 850-5 925 MHz |  |
| MOBILE | 5 775-5 850 MHz | **5.453** |
| NOTE: The frequency range from 5 725 to 5 875 MHz is also designated for industrial, scientific and medical (ISM) applications according RR No. **5.415A**. Radiocommunication services operating within these bands must accept harmful interference which may be caused by these applications. ISM equipment operating in these bands is subject to the provisions of No. **15.13**. | | |

## 3.9 7 190-7 235 MHz

TABLE 11

**Services identified for sharing studies with lunar communications (7 190-7 235 MHz)**

|  |  |  |
| --- | --- | --- |
| **Service** | **Frequencies** | **Footnotes** |
| FIXED | 7 190-7 235 MHz |  |
| MOBILE | 7 190-7 235 MHz |  |
| SPACE RESEARCH  (Earth-to-space) | 7 190-7 235 MHz | **5.460**, **5.459** |

## 3.10 8 400-8 500 MHz

TABLE 12

**Services identified for sharing studies with lunar communications (8 450-8 500 MHz)**

|  |  |  |
| --- | --- | --- |
| **Service** | **Frequencies** | **Footnotes** |
| FIXED | 8 450-8 500 MHz |  |
| MOBILE except aeronautical mobile | 8 450-8 500 MHz |  |
| SPACE RESEARCH  (space-to-Earth) | 8 450-8 500 MHz |  |

## 3.11 25.25-28.35 GHz

TABLE 13

**Services identified for sharing studies with lunar communications (25.25-28.35 GHz)**

|  |  |  |
| --- | --- | --- |
| **Service** | **Frequencies** | **Footnotes** |
| FIXED | 25.25-27 GHz | **5.534A** |
| 27-27.5 GHz | **5.534A** (Regions 2&3) |
| 27.5-28.35 GHz | **5.537A** |
| FIXED (identified for HAPS) | 25.25-27.5 GHz | **5.534A** |
| INTER SATELLITE | 25.25-27.5 GHz | **5.536**, **5.537** (Regions 2&3) |
| 27.5-28.35 GHz (1) | **5.521A** |
| MOBILE | 25.25-27.5 GHz | **5.532AB** |
| 27.5-28.35 GHz |  |
| FIXED SATELLITE  (Earth-to-space) | 27-27.5 GHz |  |
| 27.5-28.35 GHz | **5.484A**, **5.516B**, **5.517A**, **5.539**, **5.538**, **5.540**, **5.517B** |
| (1) New intersatellite service allocation from WRC-23. | | |

# 4 Technical and operational characteristics for sharing and compatibility studies

Technical and operational characteristics to be considered in the sharing and compatibility studies are presented in the table below, as provided by WP 7B and the contributing groups to WRC-27 agenda item 1.15.

|  |  |  |
| --- | --- | --- |
| **Working Party 7B/** | **Contributing Group** | **Services/Parameters** |
| [35/Annex 2](https://www.itu.int/md/R23-WP7B-C-0035/en) | WP 7B | Lunar SRS |
| [58](https://www.itu.int/md/R23-WP7B-C-0058/en) | WP 3J | Propagation models |
| - | WP 4A | Fixed-satellite service  Broadcasting-satellite service |
| [41](https://www.itu.int/md/R23-WP7B-C-0041/en), [106](https://www.itu.int/md/R23-WP7B-C-0106/en) | WP 4C | Mobile-satellite service |
| - | WP 5A | Land mobile service |
| [49](https://www.itu.int/md/R23-WP7B-C-0049/en), [114](https://www.itu.int/md/R23-WP7B-C-0114/en) | WP 5B | Aeronautical mobile service  Radiodetermination service |
| [56](https://www.itu.int/md/R23-WP7B-C-0056/en) | WP 5C | Fixed service |
| [64](https://www.itu.int/md/R23-WP7B-C-0064/en) , [105](https://www.itu.int/md/R23-WP7B-C-0105/en) | WP 5D | International Mobile Telecommunications (IMT) |
| [95](https://www.itu.int/md/R23-WP7B-C-0095/en) | WP 7A | Standard Frequency and Time Signal |
| - | WP 7B | Space research service  Earth exploration-satellite service |
| [103](https://www.itu.int/md/R23-WP7B-C-0103/en) | WP 7C | Space research service (active)  Earth exploration-satellite service (passive) |
| [101](https://www.itu.int/md/R23-WP7B-C-0101/en) | WP 7D | Radio astronomy service |

# 5 Sharing and compatibility studies

The sharing and compatibility studies are presented in the Annexes to this document.

**Annex 1:** Sharing and compatibility studies of SRS for lunar operations in the frequency band 390-406.1 MHz

**Annex 2:** Sharing and compatibility studies of SRS or lunar operations in the frequency band 420‑430 MHz

**Annex 3:** Sharing and compatibility studies of SRS for lunar operations in the frequency band 440-450 MHz

**Annex 4:** Sharing and compatibility studies of SRS for lunar operations in the frequency band 2 400-2 690 MHz

**Annex 5:** Sharing and compatibility studies of SRS for lunar operations in the frequency band 3 500-3 800 MHz

**Annex 6:** Sharing and compatibility studies of SRS for lunar operations in the frequency band 5 150-5 570 MHz

**Annex 7:** Sharing and compatibility studies of SRS for lunar operations in the frequency band 5 570-5 725 MHz

**Annex 8:** Sharing and compatibility studies of SRS for lunar operations in the frequency band 5 775-5 925 MHz

**Annex 9:** Sharing and compatibility studies of SRS for lunar operations in the frequency band 7 190-7 235 MHz

**Annex 10:** Sharing and compatibility studies of SRS for lunar operations in the frequency band 8 450-8 500 MHz

**Annex 11:** Sharing and compatibility studies of SRS for lunar operations in the frequency band 25.25-28.35 GHz

ANNEX 1

Sharing and compatibility studies of SRS for lunar operations   
in the frequency band 390-406.1 MHz

### A1.1 Sharing and compatibility of fixed service and SRS for lunar operations in the frequency band 390-406.1 MHz

### A1.1.1 Study A [USA]

#### A.1.1.1.1 Technical and operational characteristics of SRS operating in the 390-406.1 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including tables 3.3-2 and 3.3-4, as summarized in Table A.1.1.1.1.

Table A.1.1.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Orbit Space Station Transmitter | Lunar Surface Transmitter |
| --- | --- | --- |
| Frequency range | 390 – 406 MHz | 406 – 406.1 MHz |
| Beam Type | Fixed | Fixed |
| Polarization | CP | CP |
| Peak Gain (dBi) | 0 | 0.0 |
| Max. EIRP Density (dBW/Hz) | ‒63 | ‒27.5 |
| Max. EIRP (dBW) | 0 | 2.5 |
| Orbital Characteristics or Antenna Height | Apolune: 7 000-11 000 km  Perilune: 600-2 700 km | <5 m |
| Channel BW (MHz) | 2 | 0.05 |

#### A.1.1.1.2 Technical and operational characteristics of fixed service operating in the 390-406.1 MHz frequency range

The document [7B/56](https://www.itu.int/md/R23-WP7B-C-0056/en) provides relevant technical information to support studies between SRS and Fixed Services (FS) under Agenda Item 1.15. The characteristics for FS for point-to-point (PP) systems are based on the information contained in the [Report ITU-R F.](https://www.itu.int/pub/R-REP-F.2108)2108, Table 1, as summarized in Table A.1.1.1.2.

Table A.1.1.1.2

Characteristics of the FS (PP) systems

| Parameter | Value |
| --- | --- |
| Frequency range | 340- 470 MHz |
| Modulation format | GMSK |
| Receiver noise bandwidth | 0.6 MHz |
| Antenna gain | 12 dBi |
| Feeder loss | 4.4 dB |
| Receiver thermal noise | -146.5 dBW |
| Protection criteria (I/N) | ‒6 dB |

#### A.1.1.1.3 Propagation model

This sharing study includes the lunar SRS system in orbit and on the surface of the Moon, and fixed services operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.1.1.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.1.1.1.5 Study results

The study was conducted in accordance with the scenario outlined in Figure A.1.1.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the FS victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km), while atmospheric, depolarization and clutter losses are not considered
* In the present study, it is assumed that both systems operate at the same central frequency. A bandwidth correction factor (CF) is applied when the bandwidth of the potential interferer exceeds the bandwidth of the victim receiver under analysis. If the bandwidth of the interferer is equal to or smaller than that of the victim receiver, the bandwidth correction factor is 0
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the FS victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the FS feeder loss; is the FS victim receiver maximum antenna gain; and is the thermal noise power in the FS victim receiver bandwidth; FDR is the frequency-dependent rejection based on the transmit and receiver bandwidths

* The single and aggregate I/N results are compared to the FS protection criteria (I/N ≤ 6 dB) to verify whether the FS protection is met

Figure A.1.1.1.1

SRS–FS Scenario

Table

Description automatically generated with medium confidence

Table A.1.1.1.3

SRS - FS co-channel results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Analysis | I/N result | Margin to the FS protection criteria |
| Lunar Surface Transmitter | 391 MHz | Single Entry | -46.3 dB | 40.3 dB |
| Lunar Orbit Space Station Transmitter | 406.0025 MHz | Single Entry | -38.8 dB | 32.8 dB |

#### A.1.1.1.6 Summary and analysis of the results of Study A

The interference-to-noise ratio metric shows that even in the single entry static worst-case analysis, there is a margin of at least 32.8 dB to satisfy the FS protection criteria. That also implies that aggregating over 1900 simultaneously transmitting worst case towards the Earth interfering transmitters would still meet the FS protection criteria, which far exceeds the expected active number of lunar transmitters in this band. Thus the results of this static worst case study suggest that sharing between SRS and terrestrial FS operating in the 390-406.1 MHz band (co-channel) is feasible.

### A1.1.2 Study B

### A1.1.3 Study C

## A1.2 Sharing studies between mobile satellite service (MSS) and SRS operating in the frequency band 390-406.1 MHz

### A1.2.1 Study A [USA]

#### A.1.2.1.1 Technical and operational characteristics of SRS operating in the 390-406.1 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.3-4, as summarized in Table A.1.2.1.1.

Table A.1.2.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Orbit Space Station Transmitter |
| --- | --- |
| Frequency range | 390 – 406 MHz |
| Beam Type | Fixed |
| Polarization | CP |
| Peak Gain (dBi) | 0 |
| Max. EIRP Density (dBW/Hz) | ‒63 |
| Max. EIRP (dBW) | 0 |
| Orbital Characteristics | Apolune: 7 000-11 000 km  Perilune: 600-2 700 km |
| Channel BW (MHz) | 2 |

#### A.1.2.1.2 Technical and operational characteristics of mobile satellite service (MSS) operating in the 390-406.1 MHz frequency range

The document [7B/41](https://www.itu.int/md/R23-WP7B-C-0041/en) provides relevant technical information to support studies between SRS and mobile satellite service (MSS) under Agenda Item 1.15. The technical characteristics and protection criteria used in this study were extracted from [Recommendation ITU-R M.2046](https://www.itu.int/rec/R-REC-M.2046/en) for non-geostationary (non-GSO) MSS systems (Earth-to-space) operating in the 399.9–400.05 MHz band, and from [Recommendation ITU-R M.1184](https://www.itu.int/rec/R-REC-M.1184/en) for MSS (space-to-Earth) systems operating in the 400.15–401 MHz band, as summarized in Table A.1.2.1.2.

In the absence of protection criteria defined in ITU-R Recommendations, document [7B/41](https://www.itu.int/md/R23-WP7B-C-0041/en) recommends using a ΔT/T criterion of 6%. This criterion is currently found in Table 5-1 of RR Appendix 5 and serves as the coordination criterion between GSO MSS networks. Additionally, according to document [7B/106](https://www.itu.int/md/R23-WP7B-C-0106/en), there is no available characteristics or protection criteria available for MSS systems in the 406 – 406.1 MHz band, so no particular study for this frequency range was conducted.

Table A.1.2.1.2

Characteristics of the MSS Systems

| Parameter | MSS (Earth-to-space) | MSS (space-to-Earth) |
| --- | --- | --- |
| Frequency range | 399 – 400.05 MHz | 400.6 – 400.9 MHz |
| System | non-GSO (ARGOS 4) | non-GSO |
| System noise temperature (K) / Receiver noise figure (dB) | 1214 K | 3.8 dB\* |
| Antenna gain | 3.85 dBi | 7 dBi |
| Receiver bandwidth | 1.6 kHz | 300 kHz |
| Protection criteria | spfd ≤ –197.9 dB(W/(m2 · Hz)) | I/N ≤ -12.2 dB |

\*Assumed parameter (no available receiver noise figure value)

#### A.1.2.1.3 Propagation model

This sharing study includes the lunar SRS system both in orbit and on the surface of the Moon, as well as MSS systems orbiting the Earth and operating on its surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for those scenarios.

#### A.1.2.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.1.2.1.5 Study results

The study was conducted in accordance with the scenarios outlined in Figure A.1.2.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the MSS victim receiver
* For the MSS (space-to-Earth), the free space propagation loss assumes a minimum distance of 355,000 km between the stations on Earth and the Moon, as presented in Figure A.1.2.1.1 (b). Atmospheric, depolarization, and clutter losses are not considered
* In the present study, it is assumed that both systems operate at the same central frequency. A bandwidth correction factor (CF) is applied when the bandwidth of the potential interferer exceeds the bandwidth of the victim receiver under analysis. If the bandwidth of the interferer is equal to or smaller than that of the victim receiver, the bandwidth correction factor is 0
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the MSS victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the MSS victim receiver maximum antenna gain; and is the thermal noise power in the MSS victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* For the MSS (Earth-to-space), considering a satellite orbiting the Earth, the free space propagation loss assumes a non-GSO altitude of 650 km. This results in a minimum distance of 354,350 km between the stations on Earth and the Moon, as presented in Figure A.1.2.1.1(a)
* For the MSS (Earth-to-space), the aggregate interference spectral flux density (SFD) to the MSS space receiver is calculated as shown below, considering Lunar SRS potential interferers
* The single and aggregate interference results are compared to the MSS protection criteria to verify whether the service protection criteria is met

Figure A.1.2.1.1

SRS–MSS Scenarios: (a) MSS (Earth-to-space); (b) MSS (space-to-Earth).

|  |
| --- |
| **(a)** |
| **(b)** |

Table A.1.2.1.3

SRS – MSS (Earth-to-space) co-channel results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Analysis | SFD result  dB(W/m2\*Hz) | Margin to the MSS protection criteria |
| Lunar Orbit Space Station Transmitter | 400 MHz | Single Entry | -244.9 | 47.0 dB |

Table A.1.2.1.4

SRS – MSS (space-to-Earth) co-channel results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Analysis | I/N result | Margin to the MSS protection criteria |
| Lunar Orbit Space Station Transmitter | 400.8 MHz | Single Entry | -51.2 | 39.0 dB |

#### A.1.2.1.6 Summary and analysis of the results of Study A

The interference metrics show that even in the single entry static worst-case analysis, there is a margin of at least 39 dB to satisfy the MSS protection criteria. That also implies that aggregating over 7900 worst case interfering transmitters would still meet the MSS protection criteria, which far exceeds the expected number of lunar transmitters in this band. Thus the results of this study suggest that sharing between SRS Lunar orbit transmitters and MSS systems operating in the 390–406.1 MHz band (co-channel) is feasible.

## A1.3 …

## A1.[X] Summary and analysis of the results of studies

*[Note: The summary should offer an objective overview, encompassing the results of sharing and compatibility studies, alongside any pertinent information applicable for future comparisons among studies. Additionally, it should address any mitigation techniques or proposals employed to safeguard services operating within the same band or adjacent bands, where applicable, to SRS lunar systems.]*

ANNEX 2

Sharing and compatibility studies of SRS for lunar operations  
in the frequency band 420-430 MHz

## A2.1 Sharing studies between fixed service and SRS for lunar operations in the frequency band 420-430 MHz

### A2.1.1 Study A [USA]

#### A.2.1.1.1 Technical and operational characteristics of SRS operating in the 420-430 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.2.1.1.1.

Table A.2.1.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 420 – 430 MHz |
| Polarization | Vertical |
| Peak Gain (dBi) | 0.0 |
| EIRP Density (dBW/MHz) | ‒0.4 |
| Max. EIRP (dBW) | 2.6 |
| Channel BW (MHz) | 2 |

#### A.2.1.1.2 Technical and operational characteristics of fixed service operating in the 420– 430 MHz frequency range

The document [7B/56](https://www.itu.int/md/R23-WP7B-C-0056/en) provides relevant technical information to support studies between SRS and Fixed Services (FS) under Agenda Item 1.15. The characteristics for fixed service (FS) for point-to-point (PP) systems are based on the information contained in the draft revision of [Recommendation ITU-R F.758-7](https://www.itu.int/md/R23-WP7B-C-0056/en), Table 17, as summarized in Table A.2.1.1.2.

Table A.2.1.1.2

Characteristics of the FS (PP) systems

| Parameter | Value |
| --- | --- |
| Frequency range | 406.1- 450 MHz |
| Reference | Recommendation ITU-R F.1567 |
| Modulation format | 32-QAM |
| Receiver noise bandwidth | 3.5 MHz |
| Antenna height | 30 m |
| Antenna pattern | Recommendation ITU-R F.699 |
| Antenna gain | 25 dBi |
| Feeder loss | 2 dB |
| Receiver noise figure | 3.5 dB |
| Protection criteria (I/N) | ‒6 dB |

#### A.2.1.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon, and fixed services operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.2.1.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.2.1.1.5 Study results

The study was conducted in accordance with the scenario outlined in Figure A.2.1.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the FS victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km), while atmospheric, depolarization and clutter losses are not considered
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the FS victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the FS feeder loss; is the FS victim receiver maximum antenna gain; and is the thermal noise power in the FS victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the FS protection criteria (I/N ≤ 6 dB) to verify whether the FS protection is met

Figure A.2.1.1.1

SRS–FS Scenario

Table

Description automatically generated with low confidence

Table A.2.1.1.3

SRS - FS co-channel results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Analysis | I/N result | Margin to the FS protection criteria |
| Lunar Surface Transmitter | 425 MHz | Single Entry | -35.3 dB | 29.3 dB |

#### A.2.1.1.6 Summary and analysis of the results of Study A

The interference-to-noise ratio metric shows that in the single entry static worst-case analysis, there is a margin of at least 29.3 dB to satisfy the FS protection criteria. That also implies that aggregating over 850 worst case interfering transmitters would still meet the FS protection criteria, which far exceeds the expected number of lunar transmitters in this band. The results of this study suggest that sharing between SRS and ground-based FS operating in the 420-430 MHz band (co-channel) is feasible.

### A2.1.2 Study B

### A2.1.3 Study C

## A2.2 Sharing studies between radiolocation service and SRS operating in the frequency band 420-430 MHz

#### A.2.2.1.1 Technical and operational characteristics of SRS operating in the 440-450 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.2.2.1.1.

Table A.2.2.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 420 – 430 MHz |
| Polarization | Vertical |
| Peak Gain (dBi) | 0.0 |
| EIRP Density (dBW/MHz) | ‒0.4 |
| Max. EIRP (dBW) | 2.6 |
| Channel BW (MHz) | 2 |

#### A.2.2.1.2 Technical and operational characteristics of radiolocation service operating in the 420– 430 MHz frequency range

The document [7B/114](https://www.itu.int/md/R23-WP7B-C-0114/en) provides relevant technical information to support studies between SRS and radars operating in the radiolocation service under Agenda Item 1.15. The characteristics for radars systems are based on the Recommendation [ITU-R M.1462](https://www.itu.int/rec/R-REC-M.1462/en), Tables 1, 3 and 4, as summarized in Table A.2.2.1.2.

Table A.2.2.1.2

Characteristics of the radar systems

| Parameter | Ground | Airborne | Shipborne |
| --- | --- | --- | --- |
| Frequency range | 420- 450 MHz | | |
| Polarization | Circular | Horizontal | - |
| Platform height/altitude | 15 m | Ascent, descent and operational operations. Ceiling is around 9 km | - |
| Antenna gain | 40 dBi | 22 dBi | 30 dBi |
| Antenna scan | Sector ±60° azimuth  scan, with rotating or  random modes  3-85° elevation | ±60° elevation (mechanically  positioned or electronically  scanned);  3600 azimuth at 3-7 rpm | 3600 azimuth |
| Receiver noise figure | 4 dB | 5 dB | 4 dB |
| Receiver IF bandwidth | 2 MHz | 1 MHz | 2 MHz |
| Protection criteria (I/N) | ‒6 dB | | |

#### A.2.2.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon, and radiolocation service operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.2.2.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.2.2.1.5 Study results

The study was conducted in accordance with the scenarios outlined in Figure A.2.2.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the radar victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km for ground and shipborne radars and 354,991 km for airborne), while atmospheric, depolarization and clutter losses are not considered
* In the present study, it is assumed that both systems operate at the same central frequency. A bandwidth correction factor (CF) is applied when the bandwidth of the potential interferer exceeds the bandwidth of the victim receiver under analysis. If the bandwidth of the interferer is equal to or smaller than that of the victim receiver, the bandwidth correction factor is 0
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the radar victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the radar victim receiver maximum antenna gain; and is the thermal noise power in the radar victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the radar protection criteria (I/N ≤ 6 dB) to verify whether the radiolocation service protection is met

Figure A.2.2.1.1

SRS–RLS Scenarios: (a) Ground and shipborne; (b) Airborne.

A black line with numbers

Description automatically generated with medium confidence

**(a)**

A picture containing table

Description automatically generated

**(b)**

Table A.2.2.1.3

SRS – RLS co-channel results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Radar | Analysis | I/N result | Margin to the radar protection criteria |
| Lunar Surface Transmitter | 425 MHz | Ground | Single Entry | TBD | TBD |
| Lunar Surface Transmitter | 425 MHz | Airborne | Single Entry | -35.4 dB | 29.4 dB |
| Lunar Surface Transmitter | 425 MHz | Shipborne | Single Entry | -26.4 dB | 20.4 dB |

#### A.2.2.1.6 Summary and analysis of the results of Study A

## A2.3 …

## A2.[X] Summary and analysis of the results of studies

*[Note: The summary should offer an objective overview, encompassing the results of sharing and compatibility studies, alongside any pertinent information applicable for future comparisons among studies. Additionally, it should address any mitigation techniques or proposals employed to safeguard services operating within the same band or adjacent bands, where applicable, to SRS lunar systems.]*

ANNEX 3

Sharing and compatibility studies of SRS for lunar operations  
in the frequency band 440-450 MHz

## A3.1 Sharing studies between fixed services and SRS operating in the frequency band 440-450 MHz

### A3.1.1 Study A [USA]

#### A.3.1.1.1 Technical and operational characteristics of SRS operating in the 440-450 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.2.1.1.1.

Table A.3.1.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 440 – 450 MHz |
| Beam Type | Fixed |
| Polarization | Vertical |
| Peak Gain (dBi) | 0.0 |
| Max. EIRP Density (dBW/Hz) | ‒61 |
| Max. EIRP (dBW) | 2 |
| Antenna Height | < 5 m |
| Channel BW (MHz) | 2 |

#### A.3.1.1.2 Technical and operational characteristics of fixed service operating in the 440– 450 MHz frequency range

The document [7B/56](https://www.itu.int/md/R23-WP7B-C-0056/en) provides relevant technical information to support studies between SRS and Fixed Services (FS) under Agenda Item 1.15. The characteristics for fixed service (FS) for point-to-point (PP) systems are based on the information contained in the draft revision of [Recommendation ITU-R F.758-7](https://www.itu.int/md/R23-WP7B-C-0056/en), Table 17, as summarized in Table A.3.1.1.2.

Table A.3.1.1.2

Characteristics of the FS (PP) systems

| Parameter | Value |
| --- | --- |
| Frequency range | 406.1- 450 MHz |
| Reference | Recommendation ITU-R F.1567 |
| Modulation format | 32-QAM |
| Receiver noise bandwidth | 3.5 MHz |
| Antenna height | 30 m |
| Antenna pattern | Recommendation ITU-R F.699 |
| Antenna gain | 25 dBi |
| Feeder loss | 2 dB |
| Receiver noise figure | 3.5 dB |
| Protection criteria (I/N) | ‒6 dB |

#### A.3.1.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon and fixed services operating on Earth's surface. Therefore, Working Party 3J in the Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on [Recommendation ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.3.1.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.3.1.1.5 Study Results

The study was conducted in accordance with the scenario outlined in Figure A.2.1.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the FS victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km), while atmospheric, depolarization and clutter losses are not considered
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the FS victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the FS feeder loss; is the FS victim receiver maximum antenna gain; and is the thermal noise power in the FS victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the FS protection criteria (I/N ≤ 6 dB) to verify whether the FS protection is met

Figure A.2.1.1.1

SRS–FS Scenario

Table

Description automatically generated with low confidence

Table A.2.1.1.3

SRS - FS co-channel results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Analysis | I/N result | Margin to the FS protection criteria |
| Lunar Surface Transmitter | 425 MHz | Single Entry | -36.3 dB | 30.6 dB |

#### A.3.1.1.6 Summary and analysis of the results of Study A

The results of this study suggest that sharing between SRS and ground-based FS operating in the 440-450 MHz band (co-channel) is feasible. The interference-to-noise ratio metric shows that even in the single entry static worst-case analysis, there is a margin of at least 30.6 dB to satisfy the FS protection criteria. That also implies that aggregating over 1100 worst case interfering transmitters would still meet the FS protection criteria, which far exceeds the expected number of lunar transmitters in this band.

### A3.1.2 Study B

### A3.1.3 Study C

## A3.2 Sharing studies between radiolocation service and SRS operating in the frequency band 440-450 MHz

### A2.2.1 Study A [USA]

#### A.2.2.1.1 Technical and operational characteristics of SRS operating in the 440-450 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.2.2.1.1.

Table A.2.2.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 440 – 450 MHz |
| Beam Type | Fixed |
| Polarization | Vertical |
| Peak Gain (dBi) | 0.0 |
| Max. EIRP Density (dBW/Hz) | ‒61 |
| Max. EIRP (dBW) | 2 |
| Antenna Height | < 5 m |
| Channel BW (MHz) | 2 |

#### A.2.2.1.2 Technical and operational characteristics of radiolocation service operating in the 440– 450 MHz frequency range

The document [7B/114](https://www.itu.int/md/R23-WP7B-C-0114/en) provides relevant technical information to support studies between SRS and radars operating in the radiolocation service (RLS) under Agenda Item 1.15. The characteristics for radars systems are based on the [Recommendation ITU-R F.1462](https://www.itu.int/md/R23-WP7B-C-0056/en)-1, Tables 1, 3 and 4, as summarized in Table A.3.2.1.2.

Table A.3.2.1.2

Characteristics of the radar systems

| Parameter | Ground | Airborne | Shipborne |
| --- | --- | --- | --- |
| Frequency range | 420- 450 MHz | | |
| Polarization | Circular | Horizontal | - |
| Platform height/altitude | 15 m | Ascent, descent and operational operations. Ceiling is around 9 km | - |
| Antenna gain | 40 dBi | 22 dBi | 30 dBi |
| Antenna scan | Sector ±60° azimuth  scan, with rotating or  random modes  3-85° elevation | ±60° elevation (mechanically  positioned or electronically  scanned);  3600 azimuth at 3-7 rpm | 3600 azimuth |
| Receiver noise figure | 4 dB | 5 dB | 4 dB |
| Receiver IF bandwidth | 2 MHz | 1 MHz | 2 MHz |
| Protection criteria (I/N) | ‒6 dB | | |

#### A.3.2.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon, and radiolocation service operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.3.2.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.3.2.1.5 Study results

The study was conducted in accordance with the scenarios outlined in Figure A.3.2.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the radar victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km for ground and shipborne radars and 354,991 km for airborne), while atmospheric, depolarization and clutter losses are not considered
* In the present study, it is assumed that both systems operate at the same central frequency. A bandwidth correction factor (CF) is applied when the bandwidth of the potential interferer exceeds the bandwidth of the victim receiver under analysis. If the bandwidth of the interferer is equal to or smaller than that of the victim receiver, the bandwidth correction factor is 0
* The aggregate interference-to-noise ratio (I/N) is calculated considering three Lunar SRS transmitters pointing towards the radar victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the radar victim receiver maximum antenna gain; and is the thermal noise power in the radar victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the radar protection criteria (I/N ≤ 6 dB) to verify whether the radiolocation service protection is met

Figure A.3.2.1.1

SRS–RLS Scenarios: (a) Ground and shipborne; (b) Airborne.

A picture containing table

Description automatically generated

**(a)**

A black and white image of a number

Description automatically generated with medium confidence

**(b)**

Table A.3.2.1.3

SRS – RLS co-channel results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Radar | Analysis | I/N result | Margin to the radar protection criteria |
| Lunar Surface Transmitter | 445 MHz | Ground | Single Entry | TBD | TBD |
| Lunar Surface Transmitter | 445 MHz | Airborne | Single Entry | -36.3 dB | 30.3 dB |
| Lunar Surface Transmitter | 445 MHz | Shipborne | Single Entry | -27.4 dB | 21.5 dB |

#### A.3.2.1.6 Summary and analysis of the results of Study A

## A3.3 …

## A3.[X] Summary and analysis of the results of studies

*[Note: The summary should offer an objective overview, encompassing the results of sharing and compatibility studies, alongside any pertinent information applicable for future comparisons among studies. Additionally, it should address any mitigation techniques or proposals employed to safeguard services operating within the same band or adjacent bands, where applicable, to SRS lunar systems.]*

ANNEX 4

Sharing and compatibility studies of SRS for lunar operations  
 in the frequency band 2 400-2 690 MHz

*[Note: Insert relevant sharing and compatibility studies for each of the identified service.]*

## A4.1 Sharing studies between fixed services and SRS for lunar operations in the frequency band 2 400-2 690 MHz

### A4.1.1 Study A [USA]

#### A.4.1.1.1 Technical and operational characteristics of SRS operating in the 2 400-2 690 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.4.1.1.1.

Table A.4.1.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter | |
| --- | --- | --- |
| Frequency range | 2400 – 2483.5 MHz | 2500 – 2690 MHz |
| Polarization | Vertical | Linear ±45º CP |
| Peak Gain (dBi) | 6 | 16 |
| EIRP Density (dBW/MHz) | 19 | 19 |
| Max. EIRP (dBW) | 6 | 29 |
| Channel BW (MHz) | 20 | 10 |

#### A.4.1.1.2 Technical and operational characteristics of fixed service operating in the 2 400-2 690 MHz frequency range

The document [7B/56](https://www.itu.int/md/R23-WP7B-C-0056/en) provides relevant technical information to support studies between SRS and Fixed Services (FS) under Agenda Item 1.15. The characteristics for fixed service (FS) for point-to-point (PP) and point-to-multipoint (PmP) systems are based on the information contained in the draft revision of [Recommendation ITU-R F.758-7](https://www.itu.int/md/R23-WP7B-C-0056/en), Tables 17 and 20, as summarized in Table A.4.1.1.2.

Table A.4.1.1.2

Characteristics of the FS systems

| Parameter | Point-to-point (PP) | Point-to-multipoint (PmP) |
| --- | --- | --- |
| Frequency range | 2290-2670 MHz | 1350-2690 MHz |
| Reference | Recommendation ITU-R F.1243 | Recommendation ITU-R F.701 |
| Modulation format | MSK | QPSK |
| Receiver noise bandwidth | 14 MHz | 3.5 MHz |
| Antenna height | 50 m | 30 m |
| Antenna pattern | Recommendation ITU-R F.699 | Recommendation ITU-R F.699 |
| Antenna gain | 25 dBi | 27 dBi |
| Feeder loss | 4 dB | 0 dB |
| Receiver noise figure | 4 dB | 3.5 dB |
| Protection criteria (I/N) | -6 dB | |

#### A.4.1.1.3 Propagation model

This study includes the lunar SRS system orbiting the Moon and fixed services operating on Earth's surface. Therefore, Working Party 3J in the document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on [Recommendation ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.4.1.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.4.1.1.5 Study Results

The study was conducted in accordance with the scenario outlined in Figure A.4.1.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the FS victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km), while atmospheric, depolarization and clutter losses are not considered
* In the present study, it is assumed that both systems operate at the same central frequency. A bandwidth correction factor (CF) is applied when the bandwidth of the potential interferer exceeds the bandwidth of the victim receiver under analysis. If the bandwidth of the interferer is equal to or smaller than that of the victim receiver, the bandwidth correction factor is 0
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the FS victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the FS feeder loss; is the FS victim receiver maximum antenna gain; and is the thermal noise power in the FS victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the FS protection criteria (I/N ≤ 6 dB) to verify whether the FS protection is met

Figure A.4.1.1.1

SRS–FS Scenario

A black line with numbers

Description automatically generated with medium confidence

Table A.4.1.1.3

SRS – FS (PP) co-channel results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Analysis | I/N result | Margin to the FS protection criteria |
| Lunar Surface Transmitter | 2410 MHz | Single Entry | -57.0 dB | 51.0 dB |
| Lunar Surface Transmitter | 2510 MHz | Single Entry | -32.8 dB | 26.8 dB |

Table A.4.1.1.4

SRS – FS (PmP) co-channel results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Analysis | I/N result | Margin to the FS protection criteria |
| Lunar Surface Transmitter | 2410 MHz | Single Entry | -50.5 dB | 44.5 dB |
| Lunar Surface Transmitter | 2510 MHz | Single Entry | -24.9 dB | 18.9 dB |

#### A.4.1.1.6 Conclusion of Study A

The interference-to-noise ratio metric shows that in the single entry static worst-case analysis, there is a margin of at least 18.9 dB to satisfy the FS protection criteria.

### A4.1.2 Study B

### A4.1.3 Study C

## A4.2 Sharing studies between mobile service operating as a terrestrial component of IMT and SRS operating in the frequency band 2 400-2 690 MHz

### A4.2.1 Study A [USA]

#### A.4.2.1.1 Technical and operational characteristics of SRS operating in the 2500-2690 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.4.2.1.1.

Table A.4.2.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 2500 – 2690 MHz |
| Polarization | Linear ±45º |
| Peak Gain (dBi) | 16 |
| EIRP Density (dBW/MHz) | 19 |
| Max. EIRP (dBW) | 29 |
| Channel BW (MHz) | 10 |

#### A.4.2.1.2 Technical and operational characteristics of mobile service operating as a terrestrial component of IMT in the 2500-2690 MHz frequency range

The document [7B/105](https://www.itu.int/md/R23-WP7B-C-0105/en) provides relevant technical information to support studies between SRS and mobile services operating as a terrestrial component of IMT, under Agenda Item 1.15. The characteristics and protection criteria for terrestrial component of IMT are based on the information contained in the Annex 4.4 to Document [5D/716](https://www.itu.int/md/R19-WP5D-C-0716/en), as summarized in Tables A.4.2.1.2 and A.4.2.1.3.

Table A.4.2.1.2

**IMT Base Station (BS) parameters for bands between 2 and 3 GHz**

|  | **Rural/ Urban/suburban macro** |
| --- | --- |
| Antenna height | 30 m rural /20 m urban /25 m suburban |
| AAS Antenna gain | 26.2 dBi |
| AAS BS antenna polarization | Linear ±45 degrees |
| Channel bandwidth | 10 MHz |
| AAS BS Noise Figure | 5 dB |

Table A.4.2.1.3

**IMT User Equipment (UE) parameters for bands between 2 and 3 GHz**

|  | **Rural/Urban/suburban macro** |
| --- | --- |
| UE height | 1.5 m |
| Typical antenna gain | −3 dBi |
| Body loss | 4 dB |
| UE Noise Figure | 9 dB |

For this study, the AAS rural/urban/suburban macro scenario represents the worst case, as the base station antenna gain is higher than in non-AAS case.

#### A.4.2.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon, and mobile services operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.4.2.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization, body, building and clutter, the interference levels comply with the established ITU-R service protection criteria.

The study also considered the IMT network in TDD to examine the lower frequencies for both base stations and user equipment. However, no TDD factor was applied in this analysis to compute the interference received by the base station and user equipment 100% of the time, in order to verify compliance with the established ITU-R service protection criteria, even in the worst-case scenario.

#### A.4.2.1.5 Study results

The study was conducted in accordance with the scenario outlined in Figure A.4.2.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the IMT victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km), while atmospheric, depolarization and clutter losses are not considered
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the IMT victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the IMT victim receiver maximum antenna gain; and is the thermal noise power in the IMT victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the IMT protection criteria (I/N ≤ -6 dB) to verify whether the IMT protection is met

Figure A.4.2.1.1

SRS–IMT Scenario

Diagram

Description automatically generated

Table A.4.2.1.4

SRS – IMT co-channel results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | IMT Station | Analysis | I/N result | Margin to the IMT protection criteria |
| Lunar Surface Transmitter | 2510 MHz | Base Station | Single Entry | -27.2 dB | 21.2 dB |
| Lunar Surface Transmitter | 2510 MHz | User Equipment | Single Entry | -60.4 dB | 54.4 dB |

#### A.4.2.1.6 Summary and analysis of the results of Study A

The interference-to-noise ratio metric shows that in the single entry static worst-case analysis, there is a margin of at least 21.2 dB to satisfy the IMT Base Station protection criteria.

## A4.3 Sharing studies between mobile satellite service (MSS) and SRS operating in the frequency band 2 483.5-2 500 MHz

### A4.3.1 Study A [USA]

#### A.4.3.1.1 Technical and operational characteristics of SRS operating in the 2483.5-2500 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.3-4, as summarized in Table A.4.3.1.1.

Table A.4.3.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Orbit Space Station Transmitter |
| --- | --- |
| Frequency range | 2483.5 – 2500 MHz |
| Polarization | CP |
| Peak Gain (dBi) | 16 |
| Max EIRP Density (dBW/Hz) | -48 |
| Max. EIRP (dBW) | 24 |
| Orbital Characteristics  Apolune (km)  Perilune (km) | 7 000-11 000  600-2 700 |
| Channel BW (MHz) | 16 |

#### A.4.3.1.2 Technical and operational characteristics of Mobile Satellite Service (MSS) operating in the 2483.5-2500 MHz frequency range

The document [7B/106](https://www.itu.int/md/R23-WP7B-C-0106/en) provides relevant technical information to support studies between SRS and Mobile Satellite Service (MSS) (space-to-Earth) under Agenda Item 1.15, with the characteristics and protection criteria summarized in Table A.4.3.1.2.

Table A.4.3.1.2

MSS (space-to-Earth) receiver characteristics in 2 483.5-2 500 MHz

|  |  |  |
| --- | --- | --- |
|  | System 1  (HIBLEO-X) | System 2 |
| Height of receivers | 1.5 m | 1.5 m |
| Centre frequency | 2 484.39 MHz | 2 485.75 MHz |
| Bandwidth | 1.23 MHz | 4.5 MHz |
| Terminal noise temperature | *N* = −113.9 dBm/MHz | *N* = −100.9 dBm/MHz |
| Antenna gain | 2.4 dBi | −1 dBi |
| Protection criteria (I/N) | −10 dB | −10 dB |
| Location | Suburban / Rural | Suburban / Rural |

#### A.4.3.1.3 Propagation model

This sharing study includes the lunar SRS system in orbit of the Moon, and MSS operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.4.3.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.4.3.1.5 Study results

The study was conducted in accordance with the scenario outlined in Figure A.4.3.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the MSS victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km), while atmospheric, depolarization and clutter losses are not considered
* In the present study, it is assumed that both systems operate at the same central frequency. A bandwidth correction factor (CF) is applied when the bandwidth of the potential interferer exceeds the bandwidth of the victim receiver under analysis. If the bandwidth of the interferer is equal to or smaller than that of the victim receiver, the bandwidth correction factor is 0
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the MSS victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the MSS victim receiver maximum antenna gain; and is the thermal noise power in the MSS victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the MSS protection criteria (I/N ≤ - 10 dB) to verify whether the MSS protection is met

Figure A.4.3.1.1

SRS–MSS (space-to-Earth) Scenario

A black line with numbers

Description automatically generated with medium confidence

Table A.4.3.1.3

SRS – MSS (space-to-Earth) co-channel results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | MSS Station | Analysis | I/N result | Margin to the MSS protection criteria |
| Lunar Orbit Space Transmitter | 2491.75 MHz | System 1 | Single Entry | -53.0 dB | 43.0 dB |
| Lunar Orbit Space Transmitter | 2491.75 MHz | System 2 | Single Entry | -69.4 dB | 59.4 dB |

#### A.4.3.1.6 Summary and analysis of the results of Study A

The results of this study suggest that sharing between SRS and MSS (space-to-Earth) operating in the 2483.5-2500 MHz band (co-channel), is feasible. The interference-to-noise ratio metric shows that in the single entry static worst-case analysis, there is a margin of at least 43 dB to satisfy the MSS protection criteria. This implies that the aggregate interference from 19952 lunar transmitters would not exceed the MSS protection criterion in this band.

## A4.4 Sharing studies between high-altitude platform stations as IMT base stations (HIBS) and SRS operating in the frequency band 2 500-2 690 MHz

### A4.4.1 Study A [USA]

#### A.4.4.1.1 Technical and operational characteristics of SRS operating in the 2500-2690 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.4.4.1.1.

Table A.4.4.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 2500 – 2690 MHz |
| Polarization | Linear ±45º |
| Peak Gain (dBi) | 16 |
| EIRP Density (dBW/MHz) | 19 |
| Max. EIRP (dBW) | 29 |
| Channel BW (MHz) | 10 |

#### A.4.4.1.2 Technical and operational characteristics of high-altitude platform stations as IMT base stations (HIBS) in the 2500-2690 MHz frequency range

The document [7B/64](https://www.itu.int/md/R23-WP7B-C-0064/en) provides the characteristics and protection criteria to support studies between SRS and HIBS under Agenda Item 1.15. The technical and operational characteristics are summarized in Table A.4.4.1.2.

Table A.4.4.1.2

Specification and deployment related parameters of HIBS

|  |  |
| --- | --- |
| Parameter | Band 3 (2 500-2 690 MHz) |
| Duplex method and transmission direction | FDD/TDD (as per frequency arrangements in  Recommendation ITU-R M.1036) |
| Channel bandwidth (MHz) | 20 MHz |
| HIBS Platform Altitude | 18-25 km |
| Number of cells/HIBS | 7 |
| Antenna gain | 14 dBi (1st layer cell), 17 dBi (2nd layer cell) |
| Noise Figure | 5 dB |
| Protection criteria (I/N) | -6 dB |

#### A.4.4.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon, and HIBS operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.4.4.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and atmospheric, the interference levels comply with the established ITU-R service protection criteria.

#### A.4.4.1.5 Study results

The study was conducted in accordance with the scenario outlined in Figure A.4.4.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the HIBS victim receiver
* For the HIBS victim receiver, the highest antenna gain of 17 dBi was considered, which corresponds to the second-layer cell
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (354,975 km), while atmospheric and depolarization and are not considered
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the HIBS victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the HIBS victim receiver maximum antenna gain; and is the thermal noise power in the HIBS victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the HIBS protection criteria (I/N ≤ - 6 dB) to verify whether the HIBS protection is met

Figure A.4.4.1.1

SRS–HIBS Scenario

A picture containing table

Description automatically generated

Table A.4.4.1.3

SRS – HIBS co-channel results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Analysis | I/N result | Margin to the HIBS protection criteria |
| Lunar Surface Transmitter | 2520 MHz | Single Entry | -39.4 dB | 33.4 dB |

#### A.4.4.1.6 Summary and analysis of the results of Study A

The results of this study suggest that sharing between SRS and HIBS in the 2500-2690 MHz band (co-channel), is feasible. The interference-to-noise ratio metric shows that in the single entry static worst-case analysis, there is a margin of at least 33.4 dB to satisfy the HIBS protection criteria. This implies that the aggregate interference from 2187 worst case lunar transmitters would not exceed the HIBS protection criterion in this band.

## A4.[X] Summary and analysis of the results of studies

[*Note: The summary should offer an objective overview, encompassing the results of sharing and compatibility studies, alongside any pertinent information applicable for future comparisons among studies. Additionally, it should address any mitigation techniques or proposals employed to safeguard services operating within the same band or adjacent bands, where applicable, to SRS lunar systems.]*

ANNEX 5

Sharing and compatibility studies of SRS for lunar operations  
in the frequency band 3 500-3 800 MHz

## A5.1 Sharing and compatibility of fixed service and SRS for lunar operations in the frequency band 3 500-3 800 MHz

[*Note: Insert relevant sharing and compatibility studies for each of the identified service.*]

### A5.1.1 Study A [USA]

#### A.5.1.1.1 Technical and operational characteristics of SRS operating in the 3500-3800 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.5.1.1.1.

Table A.5.1.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 3500 – 3800 MHz |
| Polarization | Linear ±45º / CP |
| Peak Gain (dBi) | 26.2 |
| EIRP Density (dBW/MHz) | 22.3 |
| Max. EIRP (dBW) | 42.3 |
| Channel BW (MHz) | 100 MHz |

#### A.5.1.1.2 Technical and operational characteristics of fixed service operating in the 3500– 3800 MHz frequency range

The document [7B/56](https://www.itu.int/md/R23-WP7B-C-0056/en) provides relevant technical information to support studies between SRS and Fixed Services (FS) under Agenda Item 1.15. The characteristics for fixed service (FS) for point-to-point (PP) systems are based on the information contained in the draft revision of [Recommendation ITU-R F.758-7](https://www.itu.int/md/R23-WP7B-C-0056/en), Table 18, as summarized in Table A.5.1.1.2.

Table A.5.1.1.2

Characteristics of the FS (PP) systems

| Parameter | Value |
| --- | --- |
| Frequency range | 3600 - 4200 MHz |
| Reference | Recommendation ITU-R F.635 |
| Modulation format | 64 QAM |
| Receiver noise bandwidth | 10 MHz |
| Antenna height | 30 m |
| Antenna pattern | Recommendation ITU-R F.699 |
| Antenna gain | 42 dBi |
| Feeder loss | 0 dB |
| Receiver noise figure | 3 dB |
| Protection criteria (I/N) | ‒10 dB |

#### A.5.1.1.3 Propagation model

#### A.5.1.1.4 Methodology

#### A.5.1.1.5 Study results

#### A.5.1.1.6 Summary and analysis of the results of Study A

### A5.1.2 Study B

### A5.1.3 Study C

## A5.2 Sharing studies between mobile service operating as a terrestrial component of IMT and SRS operating in the frequency band 3 500-3 800 MHz

### A5.2.1 Study A [USA]

#### A.5.2.1.1 Technical and operational characteristics of SRS operating in the 3500-3800 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.5.2.1.1.

Table A.5.2.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 3500 – 3800 MHz |
| Polarization | Linear ±45º |
| Peak Gain (dBi) | 26.2 |
| EIRP Density (dBW/MHz) | 22.3 |
| Max. EIRP (dBW) | 42.3 |
| Channel BW (MHz) | 100 MHz |

#### A.5.2.1.2 Technical and operational characteristics of mobile service operating as a terrestrial component of IMT in the 3500-3800 MHz frequency range

The document [7B/105](https://www.itu.int/md/R23-WP7B-C-0105/en) provides relevant technical information to support studies between SRS and mobile services operating as a terrestrial component of IMT, under Agenda Item 1.15. The characteristics and protection criteria for terrestrial component of IMT are based on the information contained in the Annex 4.4 to Document [5D/716](https://www.itu.int/md/R19-WP5D-C-0716/en), as summarized in Tables A.5.2.1.2 and A.5.2.1.3.

Table A.5.2.1.2

**IMT Base Station (BS) parameters for bands between 3 and 6 GHz**

|  | **Rural/Urban/suburban macro** |
| --- | --- |
| Antenna height | 35 m rural /20 m urban /25 m suburban |
| AAS Antenna gain | 26.2 dBi |
| AAS BS antenna polarization | Linear±45 degrees |
| Channel bandwidth | 100 MHz |
| AAS BS Noise Figure | 5 dB |

Table A.5.2.1.3

**IMT User Equipment (UE) parameters for bands between 2 and 3 GHz**

|  | **Rural/Urban/suburban macro** |
| --- | --- |
| UE height | 1.5 m |
| Typical antenna gain | −4 dBi |
| Body loss | 4 dB |
| UE Noise Figure | 9 dB |

For this study, the AAS rural/urban/suburban macro scenario represents the worst case, as the base station antenna gain is higher than in non-AAS case.

#### A.5.2.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon, and mobile services operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.5.2.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization, body, building and clutter, the interference levels comply with the established ITU-R service protection criteria.

The TDD factor was not applied in this analysis to calculate the interference received by the base station and user equipment 100% of the time, in order to verify compliance with the established ITU-R service protection criteria, even in the worst-case scenario.

#### A.5.2.1.5 Study results

The study was conducted in accordance with the scenario outlined in Figure A.5.2.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the IMT victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km), while atmospheric, depolarization and clutter losses are not considered
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the IMT victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the IMT victim receiver maximum antenna gain; and is the thermal noise power in the IMT victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the IMT protection criteria (I/N ≤ -6 dB) to verify whether the IMT protection is met

Figure A.5.2.1.1

SRS–IMT Scenario

Diagram

Description automatically generated

Table A.5.2.1.4

SRS – IMT co-channel results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | IMT Station | Analysis | I/N result | Margin to the IMT protection criteria |
| Lunar Surface Transmitter | 3550 MHz | Base Station | Single Entry | -26.9 dB | 20.9 dB |
| Lunar Surface Transmitter | 3550 MHz | User Equipment | Single Entry | -61.3 dB | 55.3 dB |

#### A.5.2.1.6 Summary and analysis of the results of Study A

The interference-to-noise ratio metric shows that in the single entry static worst-case analysis, there is a margin of at least 20.9 dB to satisfy the IMT base station protection criteria.

## A5.3 …

## A5.[X] Summary and analysis of the results of studies

[*Note: The summary should offer an objective overview, encompassing the results of sharing and compatibility studies, alongside any pertinent information applicable for future comparisons among studies. Additionally, it should address any mitigation techniques or proposals employed to safeguard services operating within the same band or adjacent bands, where applicable, to SRS lunar systems.]*

ANNEX 6

Sharing and compatibility studies of SRS for lunar operations  
 in the frequency band 5 150-5 570 MHz

## A6.1 Sharing and compatibility of [existing service XX] and SRS operating in the frequency band 5 150-5 570 MHz

*[Note: Insert relevant sharing and compatibility studies for each of the identified service.]*

### A6.1.1 Study A [USA]

#### A.6.1.1.1 Technical and operational characteristics of SRS operating in the 5 150-5 570 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.6.1.1.1.

Table A.6.1.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 5 150-5 725 MHz |
| Polarization | Linear ±45º / CP |
| Peak Gain (dBi) | 6 |
| EIRP Density (dBW/MHz) | -10 |
| Max. EIRP (dBW) | 6 |
| Channel BW (MHz) | 40 MHz |

#### A.6.1.1.2 Technical and operational characteristics of radiolocation service (RLS) operating in the 5 250 – 5 570 MHz frequency range

The characteristics and protection criteria for radars operating in the radiolocation service are based on the Recommendation [ITU-R M.1638](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.1638-0-200306-S!!PDF-E.pdf), Table 3, as summarized in Table A.6.1.1.2.

Table A.6.1.1.2

Characteristics of the radar systems

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Ground | Airborne | Shipborne |
| Radar | L | S | Q |
| Frequency range | 5 350 – 5 850 MHz | 5 250 – 5 725 MHz | 5 450 – 5 825 MHz |
| Polarization | Vertical/left-  hand circular | Circular | Horizontal |
| Platform height/altitude | 20 m | 9000 m | 40 m |
| Antenna gain | 54 dBi | 40 dBi | 30 dBi |
| Antenna horizontal scan type | N/A (Tracking) | Continuous | 30-270 Sector |
| Receiver noise figure | 5 dB | 3.5 dB | 10 dB |
| Receiver IF bandwidth | 0.25 MHz | 1 MHz | 1 MHz |
| Protection criteria (I/N) | ‒6 dB | | |

#### A.6.1.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon, and radiolocation service operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.6.1.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.6.1.1.5 Study results

The study was conducted in accordance with the scenarios outlined in Figure A.6.1.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the radar victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km for ground and shipborne radars and 354,991 km for airborne), while atmospheric, depolarization and clutter losses are not considered
* In the present study, it is assumed that both systems operate at the same central frequency. A bandwidth correction factor (CF) is applied when the bandwidth of the potential interferer exceeds the bandwidth of the victim receiver under analysis. If the bandwidth of the interferer is equal to or smaller than that of the victim receiver, the bandwidth correction factor is 0
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the radar victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the radar victim receiver maximum antenna gain; and is the thermal noise power in the radar victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the radar protection criteria (I/N ≤ 6 dB) to verify whether the radiolocation service protection is met

Figure A.6.1.1.1

SRS–RLS Scenarios: (a) Ground and shipborne; (b) Airborne.

A black line with numbers

Description automatically generated with medium confidence

**(a)**

A black and white image of a number

Description automatically generated with medium confidence

**(b)**

Table A.6.1.1.3

SRS – RLS co-channel results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Radar | Analysis | I/N result | Margin to the radar protection criteria |
| Lunar Surface Transmitter | 5370 MHz | Ground | Single Entry | -35.0 dB | 29.0 dB |
| Lunar Surface Transmitter | 5370 MHz | Airborne | Single Entry | -47.5 dB | 41.5 dB |
| Lunar Surface Transmitter | 5470 MHz | Shipborne | Single Entry | -64.2 dB | 58.2 dB |

#### A.6.1.1.6 Summary and analysis of the results of Study A

The results of this study suggest that sharing between lunar SRS and Earth-based radars operating in the radiolocation service in the 5 150 - 5 570 MHz band (co-channel) is feasible. The interference-to-noise ratio metric shows that in the single entry static worst-case analysis, there is a margin of at least 29 dB to satisfy the radiolocation service protection criteria. That implies the aggregate interference from 794 lunar surface transmitters would still meet the RLS protection criteria in this band.

### A6.1.2 Study B

### A6.1.3 Study C

## A6.2 Sharing studies between aeronautical radionavigation service (ARNS) and SRS operating in the frequency band 5 150-5 570 MHz

### A6.2.1 Study A [USA]

#### A.6.2.1.1 Technical and operational characteristics of SRS operating in the 5 150-5 570 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.6.2.1.1.

Table A.6.2.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 5 150-5 725 MHz |
| Polarization | Linear ±45º |
| Peak Gain (dBi) | 6 |
| EIRP Density (dBW/MHz) | -10 |
| Max. EIRP (dBW) | 6 |
| Channel BW (MHz) | 40 MHz |

#### A.6.2.1.2 Technical and operational characteristics of aeronautical radionavigation service (ARNS) operating in the 5 250 – 5 570 MHz frequency range

The characteristics and protection criteria for radars operating in the aeronautical radionavigation service (ARNS) are based on the Recommendation [ITU-R M.1638](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.1638-0-200306-S!!PDF-E.pdf), Table 2, as summarized in Table A.6.2.1.2.

Table A.6.2.1.2

Characteristics of the radar system

|  |  |
| --- | --- |
| Parameter | Airborne |
| Radar | D |
| Frequency range | 5 440 MHz |
| Polarization | Horizontal |
| Platform height/altitude | 9000 m (Aircraft altitude) |
| Antenna gain | 34 dBi |
| Antenna horizontal scan type | Continuous |
| Receiver noise figure | 5 dB |
| Receiver IF bandwidth | 1 MHz |
| Protection criteria (I/N) | ‒6 dB |

#### A.6.2.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon, and radiolocation service operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.6.2.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.6.2.1.5 Study results

The study was conducted in accordance with the scenario outlined in Figure A.6.2.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the radar victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (354,991 km), considering the aircraft altitude, while atmospheric, depolarization and clutter losses are not considered
* In the present study, it is assumed that both systems operate at the same central frequency. A bandwidth correction factor (CF) is applied when the bandwidth of the potential interferer exceeds the bandwidth of the victim receiver under analysis. If the bandwidth of the interferer is equal to or smaller than that of the victim receiver, the bandwidth correction factor is 0
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the radar victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the radar victim receiver maximum antenna gain; and is the thermal noise power in the radar victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the radar protection criteria (I/N ≤ 6 dB) to verify whether the radiolocation service protection is met

Figure A.6.2.1.1

SRS–ARNS Scenario

A picture containing table

Description automatically generated

Table A.6.2.1.3

SRS – ARNS co-channel results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Radar | Analysis | I/N result | Margin to the radar protection criteria |
| Lunar Surface Transmitter | 5440 MHz | Airborne | Single Entry | -55.1 dB | 49.1 dB |

#### A.6.2.1.6 Summary and analysis of the results of Study A

The results of this study suggest that sharing between lunar SRS and radars operating in the aeronautical radionavigation service in the 5 150 - 5 570 MHz band (co-channel) is feasible. The interference-to-noise ratio metric in the single entry static worst-case analysis shows a margin of at least 49.1 dB to satisfy the aeronautical radionavigation service protection criteria. This implies that the worst case aggregate interference from 81283 lunar transmitters would still meet the ARNS protection criteria.

## A6.3 Sharing studies between aeronautical mobile service (AMS) and SRS operating in the frequency band 5 150-5 570 MHz

### A6.3.1 Study A [USA]

#### A.6.3.1.1 Technical and operational characteristics of SRS operating in the 5 150-5 570 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.6.3.1.1.

Table A.6.3.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 5 150-5 725 MHz |
| Polarization | Linear ±45º |
| Peak Gain (dBi) | 6 |
| EIRP Density (dBW/MHz) | -10 |
| Max. EIRP (dBW) | 6 |
| Channel BW (MHz) | 40 MHz |

#### A.6.3.1.2 Technical and operational characteristics of aeronautical mobile service (AMS) operating in the 5 150 – 5 250 MHz frequency range

The characteristics and protection criteria for AMS are based on the Recommendation [ITU-R M.2122](https://www.e-navigation.nl/sites/default/files/r-rec-m.2122-0-201901-ipdf-e.pdf), Table 1, as summarized in Table A.6.3.1.2.

Table A.6.3.1.2

Characteristics of the AMS ground system

|  |  |
| --- | --- |
| Parameter | Aeronautical mobile telemetry system |
| Frequency range | 5 150 – 5 160 MHz |
| Channel bandwidth | 8 MHz |
| Receiver antenna gain | 40 dBi |
| Platform height | 40 m |
| Receiver noise figure | 9 dB |
| Protection criteria (I/N) | ‒6 dB |

#### A.6.3.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon, and radiolocation service operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.6.3.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.6.3.1.5 Study results

The study was conducted in accordance with the scenario outlined in Figure A.6.3.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the AMS victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km), while atmospheric, depolarization and clutter losses are not considered
* In the present study, it is assumed that both systems operate at the same central frequency. A bandwidth correction factor (CF) is applied when the bandwidth of the potential interferer exceeds the bandwidth of the victim receiver under analysis. If the bandwidth of the interferer is equal to or smaller than that of the victim receiver, the bandwidth correction factor is 0
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the radar victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the AMS victim receiver maximum antenna gain; and is the thermal noise power in the AMS victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the radar protection criteria (I/N ≤ 6 dB) to verify whether the AMS protection is met

Figure A.6.3.1.1

SRS–AMS Scenario

A black line with numbers

Description automatically generated with medium confidence

Table A.6.3.1.3

SRS – AMS co-channel results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SRS Station | AMS center frequency | AMS | Analysis | I/N result | Margin to the AMS protection criteria |
| Lunar Surface Transmitter | 5155 MHz | Ground | Single Entry | -52.6 dB | 46.6 dB |

#### A.6.3.1.6 Summary and analysis of the results of Study A

The results of this study suggest that sharing between SRS and aeronautical mobile service (AMS) operating service in the 5 150 - 5 570 MHz band (co-channel) is feasible. The interference-to-noise ratio metric shows that in the single entry static worst-case analysis, there is a margin of at least 46.6 dB to satisfy the AMS protection criteria. This implies that even the worst case aggregate interference from 45708 lunar surface transmitters would not exceed the AMS protection criterion in this band.

## A6.[X] Summary and analysis of the results of studies

*[Note: The summary should offer an objective overview, encompassing the results of sharing and compatibility studies, alongside any pertinent information applicable for future comparisons among studies. Additionally, it should address any mitigation techniques or proposals employed to safeguard services operating within the same band or adjacent bands, where applicable, to SRS lunar systems.]*

ANNEX 7

Sharing and compatibility studies of SRS for lunar operations  
 in the frequency band 5 570-5 725 MHz

## A7.1 Sharing and compatibility of [existing service XX] and SRS operating in the frequency band 5 570-5 725 MHz

*[Note: Insert relevant sharing and compatibility studies for each of the identified service.]*

### A7.1.1 Study A [USA]

#### A.7.1.1.1 Technical and operational characteristics of SRS operating in the 5 570-5 725 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.7.1.1.1.

Table A.7.1.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 5 150-5 725 MHz |
| Polarization | Linear ±45º |
| Peak Gain (dBi) | 6 |
| EIRP Density (dBW/MHz) | -10 |
| Max. EIRP (dBW) | 6 |
| Channel BW (MHz) | 40 MHz |

#### A.7.1.1.2 Technical and operational characteristics of radiolocation service (RLS) operating in the 5 570 – 5 725 MHz frequency range

The characteristics and protection criteria for radars operating in the radiolocation service are based on the Recommendation [ITU-R M.1638](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.1638-0-200306-S!!PDF-E.pdf), Table 3, as summarized in Table A.7.1.1.2.

Table A.7.1.1.2

Characteristics of the radar systems

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Ground | Airborne | Shipborne |
| Radar | L | S | Q |
| Frequency range | 5 350 – 5 850 MHz | 5 250 – 5 725 MHz | 5 450 – 5 825 MHz |
| Polarization | Vertical/left-  hand circular | Circular | Horizontal |
| Platform height/altitude | 20 m | 9000 m | 40 m |
| Antenna gain | 54 dBi | 40 dBi | 30 dBi |
| Antenna horizontal scan type | N/A (Tracking) | Continuous | 30-270 Sector |
| Receiver noise figure | 5 dB | 3.5 dB | 10 dB |
| Receiver IF bandwidth | 0.25 MHz | 1 MHz | 1 MHz |
| Protection criteria (I/N) | ‒6 dB | | |

#### A.7.1.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon, and radiolocation service operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.7.1.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.7.1.1.5 Study results

The study was conducted in accordance with the scenarios outlined in Figures A.7.1.1.1 and A.7.1.1.2. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the radar victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km for ground and shipborne scenarios and 354,991 km for airborne), while atmospheric, depolarization and clutter losses are not considered
* In the present study, it is assumed that both systems operate at the same central frequency. A bandwidth correction factor (CF) is applied when the bandwidth of the potential interferer exceeds the bandwidth of the victim receiver under analysis. If the bandwidth of the interferer is equal to or smaller than that of the victim receiver, the bandwidth correction factor is 0
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the radar victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the radar victim receiver maximum antenna gain; and is the thermal noise power in the radar victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the radar protection criteria (I/N ≤ 6 dB) to verify whether the radiolocation service protection is met

Figure A.7.1.1.1

SRS–RLS Scenarios: (a) Ground and shipborne; (b) Airborne.

A black line with numbers

Description automatically generated with medium confidence

**(a)**

A black and white image of a number

Description automatically generated with medium confidence

**(b)**

Table A.7.1.1.3

SRS – RLS co-channel results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Radar | Analysis | I/N result | Margin to the radar protection criteria |
| Lunar Surface Transmitter | 5590 MHz | Ground | Single Entry | -35.3 dB | 29.3 dB |
| Lunar Surface Transmitter | 5590 MHz | Airborne | Single Entry | -47.8 dB | 41.8 dB |
| Lunar Surface Transmitter | 5590 MHz | Shipborne | Single Entry | -64.3 dB | 58.3 dB |

#### A.7.1.1.6 Summary and analysis of the results of Study A

The results of this study suggest that sharing between SRS and radars operating in the radiolocation service in the 5 570 - 5 725 MHz band (co-channel) is feasible. The interference-to-noise ratio metric shows that in the single entry static worst-case analysis, there is a margin of at least 29.3 dB to satisfy the radiolocation service protection criteria. This implies that the worst case aggregate interference from 851 lunar surface transmitters would still meet the RLS protection criteria in this band.

### A7.1.2 Study B

### A7.1.3 Study C

## A7.2 Sharing and compatibility of [existing service YY] and SRS operating in the frequency band 5 570-5 725 MHz

## A7.3 …

## A7.[X] Summary and analysis of the results of studies

*[Note: The summary should offer an objective overview, encompassing the results of sharing and compatibility studies, alongside any pertinent information applicable for future comparisons among studies. Additionally, it should address any mitigation techniques or proposals employed to safeguard services operating within the same band or adjacent bands, where applicable, to SRS lunar systems.]*

ANNEX 8

Sharing and compatibility studies of SRS for lunar operations  
 in the frequency band 5 775-5 925 MHz

## A8.1 Sharing and compatibility of [existing service XX] and SRS operating in the frequency band 5 775-5 925 MHz

*[Note: Insert relevant sharing and compatibility studies for each of the identified service.]*

### A8.1.1 Study A [USA]

#### A.8.1.1.1 Technical and operational characteristics of SRS operating in the 5 775 – 5 925 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including Table 3.2-4, as summarized in Table A.8.1.1.1.

Table A.8.1.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter | |
| --- | --- | --- |
| Frequency range | 5 775-5 855 MHz | 5 855-5 925 MHz |
| Polarization | Vertical | Linear ±45º |
| Peak Gain (dBi) | 6 | 3 |
| EIRP Density (dBW/MHz) | -10 | -16 |
| Max. EIRP (dBW) | 6 | 0 |
| Channel BW (MHz) | 40 MHz | |

#### A.8.1.1.2 Technical and operational characteristics of radiolocation service (RLS) operating in the 5 775 – 5 925 MHz frequency range

The characteristics and protection criteria for radars operating in the radiolocation service are based on the Recommendation [ITU-R M.1638](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.1638-0-200306-S!!PDF-E.pdf), Table 3, as summarized in Table A.8.1.1.2.

Table A.8.1.1.2

Characteristics of the radar systems

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Ground | Ground | Shipborne |
| Radar | L | N | Q |
| Frequency range | 5 350 – 5 850 MHz | 5 400 – 5900 MHz | 5 450 – 5 825 MHz |
| Polarization | Vertical/left-  hand circular | Vertical/left-  hand circular | Horizontal |
| Platform height/altitude | 20 m | 20 | 40 m |
| Antenna gain | 54 dBi | 45.9 dBi | 30 dBi |
| Antenna horizontal scan type | N/A (Tracking) | N/A (Tracking) | 30-270 Sector |
| Receiver noise figure | 5 dB | 11 dB | 10 dB |
| Receiver IF bandwidth | 0.25 MHz | 2 MHz | 1 MHz |
| Protection criteria (I/N) | ‒6 dB | | |

#### A.8.1.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon, and radiolocation service operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.8.1.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.8.1.1.5 Study results

The study was conducted in accordance with the scenario outlined in Figure A.8.1.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the radar victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km), while atmospheric, depolarization and clutter losses are not considered
* In the present study, it is assumed that both systems operate at the same central frequency. A bandwidth correction factor (CF) is applied when the bandwidth of the potential interferer exceeds the bandwidth of the victim receiver under analysis. If the bandwidth of the interferer is equal to or smaller than that of the victim receiver, the bandwidth correction factor is 0
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the radar victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the radar victim receiver maximum antenna gain; and is the thermal noise power in the radar victim receiver bandwidth

* The receiver thermal noise power is calculated from the receiver noise figure (NF) using the formula provided in Recommendation ITU-R P.372-17
* The single and aggregate I/N results are compared to the radar protection criteria (I/N ≤ 6 dB) to verify whether the radiolocation service protection is met

Figure A.8.1.1.1

SRS–RLS Scenario

A black line with numbers

Description automatically generated with medium confidence

Table A.8.1.1.3

SRS – RLS co-channel results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Radar | Analysis | I/N result | Margin to the radar protection criteria |
| Lunar Surface Transmitter | 5795 MHz | Ground (L) | Single Entry | -35.7 dB | 29.7 dB |
| Lunar Surface Transmitter | 5875 MHz | Ground (N) | Single Entry | TBD | TBD |
| Lunar Surface Transmitter | 5795 MHz | Shipborne (Q) | Single Entry | -64.7 dB | 58.7 dB |

#### A.8.1.1.6 Summary and analysis of the results of Study A

### A8.1.2 Study B

### A8.1.3 Study C

## A8.2 Sharing studies between fixed service and SRS for lunar operations in the frequency band 5 775 - 5 925 MHz

### A8.2.1 Study A [USA]

#### A.8.2.1.1 Technical and operational characteristics of SRS operating in the 5 775 – 5 925 MHz frequency range

The technical and operational characteristics for SRS systems are based on those available in the preliminary draft of the new report ITU-R SA.[LUNAR.SRS STATIONS CHAR], including table 3.2-4, as summarized in Table A.8.2.1.1.

Table A.8.2.1.1

Technical Characteristics of the SRS Systems

| Station | Lunar Surface-to-Surface Transmitter |
| --- | --- |
| Frequency range | 5 855-5 925 MHz |
| Polarization | Linear ±45º |
| Peak Gain (dBi) | 6 |
| EIRP Density (dBW/MHz) | -3 |
| Max. EIRP (dBW) | 13 |
| Channel BW (MHz) | 40 MHz |

#### A.8.2.1.2 Technical and operational characteristics of fixed service operating in the in the 5 775 – 5 925 MHz frequency range

The document [7B/56](https://www.itu.int/md/R23-WP7B-C-0056/en) provides relevant technical information to support studies between SRS and Fixed Services (FS) under Agenda Item 1.15. The characteristics for fixed service (FS) for point-to-point (PP) systems are based on the information contained in the [Report ITU-R F.2108](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-F.2108-2007-PDF-E.pdf), Table 9, as summarized in Table A.8.2.1.2.

Table A.8.2.1.2

Characteristics of the FS (PP) systems

| Parameter | Value |
| --- | --- |
| Frequency range | 5 850 – 7 025 MHz |
| Modulation | 64-QAM |
| Receiver noise bandwidth | 10 MHz |
| Antenna height | 30 m |
| Antenna pattern | Recommendation ITU-R F.699 |
| Antenna gain | 43 dBi |
| Feeder loss | 3 dB |
| Receiver thermal noise () | -130 dBW |
| Protection criteria (I/N) | ‒10 dB |

#### A.8.2.1.3 Propagation model

This sharing study includes the lunar SRS system on the surface of the Moon, and fixed services operating on Earth's surface. Therefore, Working Party 3J in Document [7B/58](https://www.itu.int/md/R23-WP7B-C-0058/en) recommends using the propagation model based on Recommendation [ITU-R P.525](https://www.itu.int/rec/R-REC-P.525/en) for this scenario.

#### A.8.2.1.4 Methodology

The methodology employed in this study is based on a static analysis of both single and aggregated worst-case interference. It evaluates whether, even under conditions of perfect antenna coupling between the systems, at the minimum distance between the stations on Earth and the Moon, and in the absence of antenna pointing errors and losses such as depolarization and clutter, the interference levels comply with the established ITU-R service protection criteria.

#### A.8.2.1.5 Study results

The study was conducted in accordance with the scenario outlined in Figure A.8.2.1.1. For the worst-case analysis, the following assumptions were considered:

* Main beam antenna coupling between the potentially interfering lunar SRS transmitters and the FS victim receiver
* Free space propagation loss assuming the minimum distance between the stations on the Earth and the Moon (355,000 km), while atmospheric, depolarization and clutter losses are not considered
* In the present study, it is assumed that both systems operate at the same central frequency. A bandwidth correction factor (CF) is applied when the bandwidth of the potential interferer exceeds the bandwidth of the victim receiver under analysis. If the bandwidth of the interferer is equal to or smaller than that of the victim receiver, the bandwidth correction factor is 0
* The aggregate interference-to-noise ratio (I/N) is calculated considering Lunar SRS transmitters pointing towards the FS victim receiver using the following equation:

where *n* is the number of lunar surface transmitters; is the equivalent isotropic radiated power of each lunar transmitter; FSPL is the free space path loss calculated using Rec. ITU-R P.525; is the FS feeder loss; is the FS victim receiver maximum antenna gain; and is the thermal noise power in the FS victim receiver bandwidth

* The single and aggregate I/N results are compared to the FS protection criteria (I/N ≤ 10 dB) to verify whether the FS protection is met

Figure A.8.2.1.1

SRS–FS Scenario

A black line with numbers

Description automatically generated with medium confidence

Table A.8.2.1.3

SRS - FS co-channel results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SRS Station | SRS center frequency | Analysis | I/N result | Margin to the FS protection criteria |
| Lunar Surface Transmitter | 5875 MHz | Single Entry | -41.8 dB | 31.8 dB |

#### A.8.2.1.6 Summary and analysis of the results of Study A

The results of this study suggest that sharing between SRS and terrestrial FS operating in the 5 775 – 5 925 MHz band (co-channel) is feasible. The interference-to-noise ratio metric shows that even in the static worst-case analysis, including single and aggregated potential interferers, there is a margin of at least 31.8 dB to satisfy the FS protection criteria. This implies that the worst case aggregate interference from even 1513 lunar surface transmitters would not exceed the FS protection criterion.

## A8.3 …

## A8.[X] Summary and analysis of the results of studies

*[Note: The summary should offer an objective overview, encompassing the results of sharing and compatibility studies, alongside any pertinent information applicable for future comparisons among studies. Additionally, it should address any mitigation techniques or proposals employed to safeguard services operating within the same band or adjacent bands, where applicable, to SRS lunar systems.]*

ANNEX 9

Sharing and compatibility studies of SRS for lunar operations  
in the frequency band 7 190-7 235

## A9.1 Sharing and compatibility of [existing service XX] and SRS operating in the frequency band 7 190-7 235 MHz

*[Note: Insert relevant sharing and compatibility studies for each of the identified service.]*

### A9.1.1 Study A

### A9.1.2 Study B

### A9.1.3 Study C

## A9.2 Sharing and compatibility of [existing service YY] and SRS operating in the frequency band 7 190-7 235 MHz

## A9.3 …

## A9.[X] Summary and analysis of the results of studies

*[Note: The summary should offer an objective overview, encompassing the results of sharing and compatibility studies, alongside any pertinent information applicable for future comparisons among studies. Additionally, it should address any mitigation techniques or proposals employed to safeguard services operating within the same band or adjacent bands, where applicable, to SRS lunar systems.]*

ANNEX 10

Sharing and compatibility studies of SRS for lunar operations  
in the frequency band 8 450-8 500 MHz

## A10.1 Sharing and compatibility of [existing service XX] and SRS operating in the frequency band 8 450-8 500 MHz

*[Note: Insert relevant sharing and compatibility studies for each of the identified service.]*

### A10.1.1 Study A

### A10.1.2 Study B

### A10.1.3 Study C

## A10.2 Sharing and compatibility of [existing service YY] and SRS operating in the frequency band 8 450-8 500 MHz

## A10.3 …

## A10.[X] Summary and analysis of the results of studies

*[Note: The summary should offer an objective overview, encompassing the results of sharing and compatibility studies, alongside any pertinent information applicable for future comparisons among studies. Additionally, it should address any mitigation techniques or proposals employed to safeguard services operating within the same band or adjacent bands, where applicable, to SRS lunar systems.]*

ANNEX 11

Sharing and compatibility studies of SRS for lunar operations  
in the frequency band 25.25-28.35 GHz

## A11.1 Sharing and compatibility of [existing service XX] and SRS operating in the frequency band 25.25-28.35 GHz

*[Note: Insert relevant sharing and compatibility studies for each of the identified service.]*

### A11.1.1 Study A

### A11.1.2 Study B

### A11.1.3 Study C

## A11.2 Sharing and compatibility of [existing service YY] and SRS operating in the frequency band 25.25-28.35 GHz

## A11.3 …

## A11.[X] Summary and analysis of the results of studies

*[Note: The summary should offer an objective overview, encompassing the results of sharing and compatibility studies, alongside any pertinent information applicable for future comparisons among studies. Additionally, it should address any mitigation techniques or proposals employed to safeguard services operating within the same band or adjacent bands, where applicable, to SRS lunar systems.]*

\_\_\_\_\_\_\_\_\_\_\_\_\_\_