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| **Recommendation ITU-R SA.2141-0**  **(12/2021)** |
| **Characteristics of space research service systems in the frequency  range 14.8-15.35 GHz** |
| **SA Series**  **Space applications and meteorology** |

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| **V** | Vocabulary and related subjects |

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| ***Note***: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.* |

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RECOMMENDATION ITU-R SA.2141-0

Characteristics of space research service systems   
in the frequency range 14.8-15.35 GHz

(2021)

Scope

This Recommendation provides technical and operational system characteristics for the space research service in the 14.8-15.35 GHz band. These characteristics should be considered in sharing and compatibility studies.

Keywords

System characteristics, Space Research Service (SRS), space-to-Earth, Earth-to-space, space-to-space, forward feeder link, Data Relay Satellites (DRS)

Related ITU-R Recommendations and Reports

Recommendation [ITU-R SA.364-6](https://www.itu.int/rec/R-REC-SA.364/en) – Preferred frequencies and bandwidths for manned and unmanned near-Earth satellites of the space research service

Recommendation [ITU-R SA.510-3](https://www.itu.int/rec/R-REC-SA.510/en) – Feasibility of frequency sharing between the space research service and other services in bands near 14 and 15 GHz Potential interference from data relay satellite systems

Recommendation [ITU-R SA.609-2](https://www.itu.int/rec/R-REC-SA.609/en) – Protection criteria for radiocommunication links for manned and unmanned near-Earth research satellites

Recommendation [ITU-R SA.1018-1](https://www.itu.int/rec/R-REC-SA.1018/en) – Hypothetical reference system for systems comprising data relay satellites in the geostationary orbit and user spacecraft in low Earth-orbits

Recommendation [ITU-R SA.1019-1](https://www.itu.int/rec/R-REC-SA.1019-1-201707-I/en) – Frequency bands and transmission directions for data relay satellite networks/systems

Recommendation ITU-R [SA.1155-2](https://www.itu.int/rec/R-REC-SA.1155-2-201707-I/en) – Protection criteria related to the operation of data relay satellite systems

Recommendation ITU-R [SA.1414-2](https://www.itu.int/rec/R-REC-SA.1414-2-201707-I/en) – Characteristics of data relay satellite systems

Recommendation ITU-R [SA.1626-1](https://www.itu.int/rec/R-REC-SA.1626-1-201312-I/en) – Feasibility of sharing between the space research service (space-to-Earth) and the fixed and mobile services in the band 14.8-15.35 GHz.

The ITU Radiocommunication Assembly,

considering

*a)* that the frequency band 14.8-15.35 GHz is allocated on a primary basis to the fixed and mobile services, and on a secondary basis to the SRS without qualification as to the direction of transmission;

*b)* that the SRS (passive) and Earth exploration-satellite service (EESS) (passive) are allocated on a secondary basis by No. **5.339** of the Radio Regulations (RR) in the 15.20-15.35 GHz band;

*c)* that the SRS (passive), EESS (passive), and radio astronomy services are allocated on a primary basis in the 15.35-15.4 GHz band subject to No. **5.340** and No. **5.511** of the RR;

*d)* that data relay satellite systems operated by multiple administrations make use of the 14.8‑15.35 GHz band both for inter-orbit user links (space-to-space) and feeder uplinks (Earth-to-space);

*e)* that requirements exist for wideband SRS downlinks to transmit future high data rate scientific data;

*f)* that WRC-23 agenda item 1.13 proposes to consider the upgrade of the SRS allocation in this band from secondary to primary status,

recognizing

*a)* that the frequency band 14.8-15.35 GHz is currently used by data relay satellites for inter-satellite links, which permits the establishment of communications with satellites in non-geostationary orbits (non-GSO), including crewed flights in the SRS;

*b)* that the frequency band 14.8-15.35 GHz is also used for existing high-speed data links from non-GSO satellites within the SRS, and is planned for use in future systems;

*c)* that these satellites are needed for the operation of telescopes and other passive instruments used for measuring such phenomena as the Earth’s magnetosphere and solar flares,

recommends

that the technical and operational system characteristics for the space research service in the 14.8‑15.35 GHz band detailed in Annex 1 should be considered in sharing and compatibility studies.

Annex 1  
  
Technical and operational system characteristics   
for the space research service in the 14.8-15.35 GHz band

# 1 Introduction

Space Research Service (SRS) systems use the 14.8-15.35 GHz band for the following applications:

– direct data downlinks from SRS missions (using a variety of orbit types) to earth stations located globally,

– Earth-to-space feeder uplinks from Data Relay Satellite (DRS) system earth stations to GSO data relay system satellites,

– space-to-space inter-orbit links from the user spacecraft to the GSO DRS satellites.

The characteristics of each of these are discussed below.

# 2 Characteristics of SRS direct data downlinks in the 14.8-15.35 GHz band

It is expected that SRS missions employing direct data downlinks in this band will be limited in number, with an estimated three to five satellites per year worldwide. These will generally be deployed in low-Earth orbit, with either polar or equatorial inclination with some at geostationary altitudes and others at HEO orbits or at the L1 or L2 libration points, as well as in Lunar Orbits or at the Lunar Surface. For most of these SRS mission orbit types, the characteristics of the SRS satellites transmitting direct data downlinks are reflected in the link budgets given in Table 1. For the SRS S/C in Lunar orbits or at the Lunar Surface, link budget parameters will vary depending on operational needs and available advanced modulation and coding techniques; however, the PFD on the Earth’s surface would not exceed levels specified in Recommendation ITU-R [SA.1626](https://www.itu.int/rec/R-REC-SA.1626/en).

In most cases, the links were assumed to support a data rate of 400 Mbit/s on the space‑to‑Earth link, although some links support up to 1.2 Gbit/s. The e.i.r.p. spectral density was adjusted so that the pfd limits of Recommendation ITU‑R [SA.1626](https://www.itu.int/rec/R-REC-SA.1626/en) would be satisfied at all elevation angles. The radiation pattern of the receiving antenna of the SRS earth station was assumed to conform to Recommendation ITU‑R [SA.509](https://www.itu.int/rec/R-REC-SA.509/en). Sharing feasibility was assessed on the basis of the protection criteria given in Recommendation ITU-R [SA.609](https://www.itu.int/rec/R-REC-SA.609/en).

TABLE 1

Example high-rate direct data downlink SRS mission link budgets

| Case | NGSO 800 km alt @ 5 deg  ES ant elev | NGSO 800 km alt @ 10 deg ES ant elev | NGSO 800 km alt @ 90 deg ES ant elev | GSO  @ 10 deg elev | HEO | HEO | L1/L2 | L1/L2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Frequency (GHz) | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15, 15.2 |
| Wavelength (m) | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 |  | 0.020 |  |
| Polarization | RHCP or LHCP | | | | | | | |
| Satellite apogee (km) | 800 | 800 | 800 | 35 785 | 300 000 | 300 000 | 1 500 000 | 1 500 000 |
| Satellite perigee (km) | 800 | 800 | 800 | 35 785 | 500 | 500 | 1 500 000 | 1 500 000 |
| Data rate (Mbit/s) | 400 | 400 | 400 | 400 | 400 | 320 | 100 | 600 per channel |
| Modulation method | QPSK Uncoded | | | | |  | QPSK Uncoded | 8PSK |
| S/C transmit power (dBW) | 5 | 5 | 5 | 13 | 13 | 11.8 | 13 | 23 |
| S/C transmit filter, cable loss (dBW) | −0.5 | −0.5 | −0.5 | −0.5 | −0.5 | −0.5 | −0.5 | −0.5 |
| S/C transmit antenna diameter (m) | 0.38 | 0.38 | 0.38 | 0.86 | 1.5 | 1.5 | 1.5 | 2.3 |
| S/C transmit antenna efficiency | 0.55 | 0.55 | 0.55 | 0.55 | 0.6 | 0.6 | 0.6 | 0.6 |
| S/C transmit antenna gain (dBi) | 32.9 | 32.9 | 32.9 | 40.0 | 45.2 | 45 | 45.2 | 49 |
| S/C transmit EIRP (dBW) | 37.4 | 37.4 | 37.4 | 52.5 | 57.7 | 55.8 | 57.7 | 71.5 |
| S/C peak EIRP density (dBW/MHz) | 14.4 | 14.4 | 14.4 | 29.5 | 34.7 | 35.8 | 40.7 | 48.5 |
| Path length (km) | 2 784 | 2 367 | 800 | 40 585 | 20 000 | 20 000 | 1 505 257 | 1 505 257 |
| Free space path loss (dB) | 184.9 | 183.5 | 174.0 | 208.1 | 225.5 | 225.5 | 239.5 | 239.5 |
| 10\*log(4\*pi\*d^2) | 139.9 | 138.5 | 129.1 | 163.2 | 157.0 | 157.0 | 194.5 | 194.5 |
| ES receive elevation angle (degree) | 5.0 | 10.0 | 90.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| PFD limit (dBW/m2 MHz) | −124 | −121.5 | −114 | −123.5 | −121.5 | −121.5 | −121.5 | −121.5 |

TABLE 1 (*end*)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Case | NGSO 800 km alt @ 5 deg ES ant elev | NGSO 800 km alt @ 10 deg ES ant elev | NGSO 800 km alt @ 90 deg ES ant elev | GSO @ 10 deg elev | HEO | HEO | L1/L2 | L1/L2 |
| PFD on Earth's surface (dBW/m2 MHz) | −125.5 | −124.1 | −114.7 | −133.7 | −122.3 | −161.7 | −153.8 | −147.3 |
| ES receive antenna diameter | 1.35 | 1.35 | 1.35 | 4.25 | 17.0 | 12.0 | 34.0 | 32.0 |
| ES receive antenna efficiency | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| ES receive antenna gain (dBi) | 45.0 | 45.0 | 45.0 | 54.9 | 67.0 | 64.0 | 73.0 | 72.5 |
| Beam-edge allowance, rain and atmospheric loss (dB) | −3.0 | −3.0 | −3.0 | −3.0 | −4.0 | −4.0 | −4.0 | −4.0 |
| ES receiver system noise temperature (deg K) | 150.0 | 150.0 | 150.0 | 150.0 | 150.0 | 150 | 150.0 | 150 |
| No (dBW/Hz) | −206.8 | −206.8 | −206.8 | −206.8 | −206.8 | −206.8 | −206.8 | −206.8 |
| Receiver losses (dB) | −1.0 | −1.0 | −1.0 | −1.0 | −1.0 | −1.0 | −1.0 | −1.0 |
| Received Eb/No (dB) | 13.9 | 15.3 | 24.7 | 15.6 | 14.5 | 17.7 | 12.5 | 18.5 |
| Theoretical Eb/No (1E-6 BER) (dB) | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 15 |
| Required Eb/No (1E-6 BER) (dB) | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 16 |
| Eb/No margin (dB) | 2.4 | 3.8 | 13.2 | 4.1 | 3.0 | 6.2 | 1.0 | 2.5 |
| Note: For the SRS S/C in HEO orbit, the PFD margin is calculated at an assumed minimum transmit altitude of 20,000 km and the link margin is calculated at a maximum range of 300 000 km. | | | | | | | | |

# 3 Data Relay Satellite Systems

As shown in Fig. 1 below, the DRS network consists of several GSO-satellites used to relay signals between centrally located earth stations and low-Earth orbiting user satellites. In some existing DRS networks, the 14.8-15.35 GHz band segment is used both for the ‘forward feeder link’ (from the DRS earth station to the DRS GSO satellite) which is shown as Link D in Fig. 1, and the DRS ‘return inter-orbit link’ (from the user satellite to the DRS GSO satellite) which is shown as link F in Fig. 1.

FIGURE 1

Architecture of a DRS network (Recommendation ITU-R [SA.1626](https://www.itu.int/rec/R-REC-SA.1626/en))

Diagram

Description automatically generated

## 3.1 Characteristics of SRS data relay satellite forward feeder links

Characteristics of DRS forward feeder links (see link D in Fig. 1) operating in the 14.8‑15.35 GHz band are given in Table 2 below.

TABLE 2

Earth-to-DRS Ku-band forward feeder link characteristics

|  |  |  |
| --- | --- | --- |
| Transmitting earth station | | |
| Network | Russian Federation | United States of America |
| Location | Russian Federation(1) | United States of America(1) |
| Frequency range (GHz) | 14.5-15.34  selectable | 14.6-15.25  selectable |
| Link description | Forward feeder‑links (3) | Composite(2) |
| Transmission rate | ≤ 105 Mbit/s | ≤ 25 Mbit/s |
| Modulation | QPSK/SSM(4), QPSK | PSK |
| Polarization | Left-hand circular | Linear |
| Antenna size (m) | 13.1, 3.7, 3.0, 0.9 | 18.3 |
| Tx antenna gain (dBi) | 63.3, 50.8, 49.8, 40.5 | 66.4 |
| Tx antenna radiation pattern | Rec. ITU-R [S.580](https://www.itu.int/rec/R-REC-S.580/en) | RR Appendix **8**, Annex III |
| Necessary bandwidth (MHz) | ≤ 80 per channel | 650 (composite) |
| Maximum power spectral density (dB(W/Hz)) | −47 | –58 |
| Maximum e.i.r.p. spectral density (dB(W/Hz)) | 10.5 | 8.8 |
| **Receiving DRS** | | |
| Orbital locations | Rec. ITU-R [SA.1275](https://www.itu.int/rec/R-REC-SA.1275/en) or Rec. ITU-R [SA.1276](https://www.itu.int/rec/R-REC-SA.1276/en) and 31° E (for Europe) | |
| Antenna size (m) | 0.6 | 1.8 |
| Rx antenna gain (dBi) | 36 | 47.0 |
| Rx antenna radiation pattern | Rec. ITU-R [S.672](https://www.itu.int/rec/R-REC-S.672/en) | Rec. ITU-R [S.672](https://www.itu.int/rec/R-REC-S.672/en) |
| System noise temperature (K) | 550 | 977 |
| Link availability (%) | 99.9 | 99.9 |
| Interference criterion | Rec. ITU-R [SA.1155](https://www.itu.int/rec/R-REC-SA.1155/en) | |
| *Notes to Table 2:*  (1) The earth stations for the Russian Federation network are located within the territory of the Russian Federation. The earth stations for the United States of America network are located in White Sands (New Mexico), Blossom Point (Maryland) and Guam. The coordinates of the stations are: 32.5° N, 106.60° W for White Sands; 38.43° N, 77.08° W for Blossom Point; and 13.62° N, 144.86° E for Guam.  (2) The composite link for the United States of America network is composed of a Ku-band (14/11 GHz) single access link.  (3) The Russian Federation DRS employs several independent forward feeder-link channels in Ku-Band, Ku-band single access (Ku-SA) links and differential correction and monitoring system links that are augmented for the GLONASS system (GLONASS/SDCM).  (4) SSM: Spread-spectrum modulation. | | |

## 3.2 Characteristics of SRS Data Relay Satellite System Inter-Orbit Return Links

Characteristics of DRS inter-orbit return links (see Link F in Fig. 1) operating in the 14.8‑15.35 GHz band are given in Table 3 below.

TABLE 3

Return spacecraft-to-DRS link characteristics

|  |  |  |
| --- | --- | --- |
| Transmitting spacecraft | | |
| Network | Russian Federation | United States of America |
| Orbital locations | Mainly low-Earth orbit | |
| Frequency range (GHz) | 14.76-15.34 | 14.891-15.116 |
| Link description | Single access (Ku-SA) links |  |
| Transmission rate | ≤ 105 Mbit/s | ≤ 300 Mbit/s |
| Modulation | 8PSK, QPSK | PSK |
| Polarization | RHC | Circular |
| Antenna size (m) | ≤ 1.2 | ≤ 1.5 |
| Tx antenna gain (dBi) | ≤ 42.2 | ≤  |
| Tx antenna radiation pattern | Rec. ITU-R [S.672](https://www.itu.int/rec/R-REC-S.672/en) | |
| Necessary bandwidth (MHz) | ≤ 80 per channel | ≤ 225 |
| Maximum power spectral density (dB(W/Hz)) | −71.5 | −73.5 |
| Maximum e.i.r.p. spectral density (dB(W/Hz)) | −29.3 | −30.5 |
| Receiving DRS | | |
| Network | Russian Federation | United States of America |
| Orbital locations | Rec. ITU-R [SA.1275](https://www.itu.int/rec/R-REC-SA.1275/en) or Rec. ITU-R [SA.1276](https://www.itu.int/rec/R-REC-SA.1276/en) | |
| Frequency range (GHz) | 14.76-15.34 | 14.891-15.116 |
| Antenna size (m) | 4 | 4.9 |
| Rx antenna gain (dBi) | 52.6 | 52.6 |
| Rx antenna radiation pattern | Rec. ITU-R [S.672](https://www.itu.int/rec/R-REC-S.672/en) | |
| System noise temperature (K) | 550 | 661 |
| Link reliability (%) | 99.9 | 99.9 |
| Interference criterion | Rec. ITU-R [SA.1155](https://www.itu.int/rec/R-REC-SA.1155/en) | |