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Radiocommunication Sector of ITU

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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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 – Preferred frequencies and bandwidths for manned and unmanned near-Earth satellites of the space research service

Recommendation ITU-R SA.510-3 – 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 – Protection criteria for radiocommunication links for manned and unmanned near-Earth research satellites

Recommendation ITU-R SA.1018-1 – 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 – Frequency bands and transmission directions for data relay satellite networks/systems

Recommendation ITU-R SA.1155-2 – Protection criteria related to the operation of data relay satellite systems

Recommendation ITU-R SA.1414-2 – Characteristics of data relay satellite systems

Recommendation ITU-R SA.1626-1 – 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.

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 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. Sharing feasibility was assessed on the basis of the protection criteria given in Recommendation ITU-R SA.609.

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/m^2 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/m^2 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

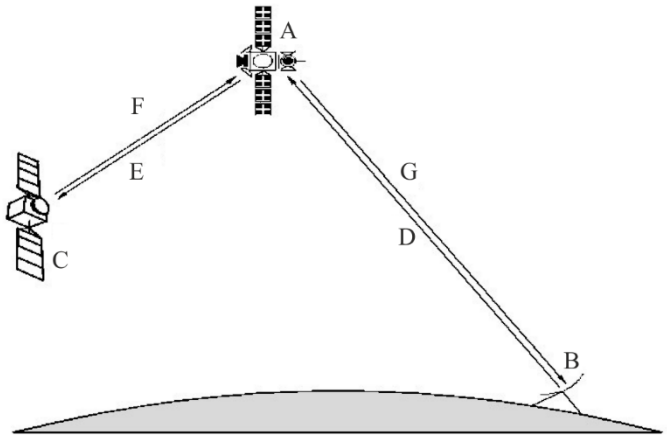
Note: For the SRS S/C in HEO orbit, the PFD margin is calculated at an assumed minimum transmit altitude of 20,000 km and the link margin is calculated at a maximum range of 300 000 km.

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)



A: DRS
B: DRS earth station
C: DRS user spacecraft
D: Forward feeder link
E: Forward inter-orbit link (IOL)
F: Return IOL
G: Return feeder link

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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	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 or Rec. ITU-R SA.1276 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	Rec. ITU-R S.672
System noise temperature (K)	550	977
Link availability (%)	99.9	99.9
Interference criterion	Rec. ITU-R SA.1155	

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	≤ 43
Tx antenna radiation pattern	Rec. ITU-R S.672	
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 or Rec. ITU-R SA.1276	
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	
System noise temperature (K)	550	661
Link reliability (%)	99.9	99.9
Interference criterion	Rec. ITU-R SA.1155	