International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R SA.1414-2

(07/2017)

Characteristics of data relay satellite systems

SA Series

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

Electronic Publication
Geneva, 2017

RECOMMENDATION ITU-R SA.1414-2

Characteristics of data relay satellite systems

(Question ITU-R 118/7)

(1999-2013-2017)

Scope

This Recommendation provides parameters for data relay satellite (DRS) systems worldwide to be used as guidance for deriving sharing criteria and coordination thresholds.

Keywords

DRS, space-to-Earth, Earth-to-space, space-to-space, forward feeder link, return feeder link

Related ITU-R Recommendations

Recommendations ITU-R SA.510, ITU-R SA.1018, ITU-R SA.1019, ITU-R SA.1155, ITU-R SA.1274, ITU-R SA.1275, ITU-R SA.1276

The ITU Radiocommunication Assembly,

considering

a) that data relay satellite (DRS) systems operate as described in Recommendation ITU-R SA.1018 – Hypothetical reference system for systems comprising data relay satellites in the geostationary orbit and user spacecraft in low-Earth orbits;

b) that there is an increase in mission requirements and in space research activity conducted particularly in low-Earth orbit;

c) that DRS provide support to many programmes/missions in the space research service and are vital to supporting both manned and unmanned space research telecommunications;

d) that it is necessary to establish relevant criteria for sharing between DRS systems and other services operating in co-frequency bands;

e) that the technical characteristics of representative DRS systems need to be considered in order to derive relevant sharing criteria,

recommends

1 that the characteristics of DRS systems, as described in Annex, may be used in interference sharing studies;

2 that the information provided in Annex should also be used as guidance for deriving sharing criteria and coordination thresholds as appropriate for DRS systems.

Annex

Characteristics of existing Data Relay Satellite (DRS) systems

TABLE 1

Forward Earth-to-DRS feeder link characteristics

Transmitting earth station					
Network	Russian Federation	United States of America	Europe	Japan	China
Location	Russian Federation(1)	United States of America(1)	Europe	Japan	China
Frequency range (GHz)	Ku=14.5-15.34 Ka=27.5-28.6 selectable	14.6-15.25 selectable	Selectable 27.5-27.51	29.5-31 selectable	29.4-30.2 selectable
Link description	Forward feeder-links Ku/Ka-bands(5)	Composite(2)	Decentralized(3)	Decentralized (3), (4)	Composite(7)
Transmission rate	≤ 90 Mbit/s	≤ 25 Mbit/s	1 Mbit/s	≤ 50 Mbit/s	≤ 100 Mbit/s
Modulation	QPSK/SSM(6), QPSK	PSK	PSK	PSK	PSK
Polarization	Left-hand circular	Linear	Circular	Circular	Linear
Antenna size (m)	13.1(Ku)/9 (Ka)	18.3	6.8	5, 9.2 and 13	3, 12 and 15
Tx antenna gain (dBi)	63.3 (Ku)/66.4 (Ka)	66.4	59.3	63, 68.2 and 71.4	56.9, 68.2 and 70.1
Tx antenna radiation pattern	Rec. ITU-R S.580	RR Appendix 8, Annex III			
Necessary bandwidth (MHz)	≤ 80 per channel	650 (composite)	1	≤ 978 (composite)	≤ 800 (composite)
Maximum power spectral density (dB(W/Hz))	–52.8 (Ku)/-52 (Ka)	–58	–36	–32.5	–47
Maximum e.i.r.p. spectral density (dB(W/Hz))	10.5 (Ku)/14.4 (Ka)	8.8	23.3	38.9	23.1
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 (Ku)/1.2 (Ka)	1.8	2.2(8)	2.0	1.5
Rx antenna gain (dBi)	36 (Ku)/49.6 (Ka)	47.0	34(8)	53	49.5
Rx antenna radiation pattern	Rec. ITU-R S.672				
System noise temperature (K)	550	977	438	890 and 579	1 318
Link availability (%)	99.9	99.9	99.6	99.9	99.9
Interference criterion	Rec. ITU-R SA.1155				

Notes to Table 1:

(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 seven channels: One DRS command and ranging channel, one DRS pilot tone signal, one S-band (2 GHz) multiple access (S-MA) link, two S-band single access (S-SA) links and two Ku-band (14/11 GHz and 30/20 GHz) single access (K-SA) links.

(3) The European DRS ground system consists currently of 4 earth stations, including the TT&C earth station, located in different countries within Europe. The earth station communicates with the DRS through its European coverage antenna.

(4) The Japanese network employs a decentralized link concept that permits independent forward feeder links from different earth stations.

(5) The Russian Federation DRS employs several independent forward feeder-link channels in Ku-Band, as well as S-band (2 GHz) multiple access (S-MA) links, S-band single access (S-SA) links, Ku-band single access (Ku-SA) links and differential correction and monitoring system links that are augmented for the GLONASS system (GLONASS/SDCM), as well as single forward feeder-link channel in Ka band, containing Ka-band single access (Ka-SA) link.

(6) SSM: Spread-spectrum modulation.

(7) The Chinese networks implement a composite link concept that permits forward feeder links from different earth stations.

(8) The antenna is a shaped antenna.

TABLE 2

Forward DRS-to-spacecraft link characteristics

Transmitting DRS															
Network	Russian Federation	China	United States of America	Europe	Japan	United States of America	China	Russian Federation	Russian Federation	United States of America	Europe	Japan	United States of America	China	Russian Federation
Orbital locations	Rec. ITU-R SA.1275 or Rec. ITU-R SA.1276														
Frequency range (GHz)	2.025-2.110[3]	2.090-2.098	2.103-2.110	2.025-2.110[1]					13.4-13.8	13.750-13.800	22.55-23.55				
Link description	Multiple access (S-MA) links			Single access (S-SA) links					Single Access (Ku-SA) links		Single Access (Ka-SA) links				
Transmission rate (bit/s)	≤ 1 kbit/s	≤ 300 kbit/s 3 Mcps		≤ 1 Mbit/s	≤ 6 Mbit/s	≤ 300 kbit/s 3 Mcps	≤ 300 kbit/s 3 Mcps	≤ 64 kbit/s	≤ 40 Mbit/s	≤ 25 Mbit/s	≤ 10 Mbit/s	≤ 50 Mbit/s	≤ 25 Mbit/s	≤ 100 Mbit/s	≤ 10 Mbit/s
Modulation	QPSK/SSM[2]	PSK	SQPN/PSK[2]				PSK	QPSK/SSM[2]	QPSK	PSK	OQPSK	PSK	PSK	PSK	PSK
Polarization	RHC	LHC	LHC	Circular				RHC	RHC	Circular					
Antenna size (m)	Phased array		Phased array	2.8	3.6	4.9	4.2	4	4	4.9	1.3	3.6	4.9	4.2	4
Tx antenna gain (dBi)	14.3	26	26.0	34	36.4	36.0	35	35.0	51.8	51.2	48.0	57.4	54.7	56.5	56.4
Tx antenna radiation pattern	Rec. ITU-R S.672														
Necessary bandwidth (MHz)	≤ 6	≤ 8	≤ 6	≤ 6	30	6	20	6	40	50	2	≤ 150	50	≤ 100	≤ 50
Maximum power spectral density (dB(W/Hz))	–52.5	–46	–51.8	–54.7	–44.5	–55.3	–49.9	–56.4	–66.6	–79.7	–60.0	–49.5	–68.7	–64	-64.2
Maximum e.i.r.p. spectral density (dB(W/Hz))	–38.2	–20	–25.8	–20.7	–8.1	–19.3	–14.9	–21.4	–14.8	–28.5	–12.0	–7.9	–14.0	–7.5	-7.8

LHC – Left-hand circular; RHC – right-hand circular.

TABLE 2 (*end*)

Receiving spacecraft															
Network	Russian Federation	China	United States of America	Europe	Japan	United States of America	Russian Federation	China	Russian Federation	United States of America	Europe	Japan	United States of America	China	Russian Federation
Orbital locations	Mainly low-Earth orbit														
Frequency range (GHz)	2.025-2.110[3]	2.090-2.098	2.103-2.110	2.025-2.110[1]					13.4-13.8	13.750-13.800	22.55-23.55				
Antenna size (m)	Omnidirectional, arrays			Omnidirectional, arrays, parabolic = ≤ 1.5				Omnidirectional, arrays, parabolic = ≤ 0.8	≤ 1.2	≤ 1.5	(4)		≤ 1.3	≤ 0.8	≤ 1
Rx antenna gain (dBi)	≤ 1.5 / ≤ 7.2	≤ 11	≤ 1.5	≤ 27.3	≤ 27.1	≤ 27.3	≤ 11	≤ 15	≤ 40.8	≤ 44	≤ 50	≤ 48.9	≤ 47	≤ 43	≤ 45.2
Rx antenna radiation pattern	Rec. ITU-R S.672 for high gain antenna								Rec. ITU-R S.672						
System noise temperature (K)	450	600	600	600	680	600	450	600	550	1 000	800	850	1 400	1 400	550
Required E_b/N_0 (dB)	10.6	9.5	–9.5	9.5	10.5	9.5	10.6	9.5	10.6	9.5	2.8	10.8	9.5	9.5	9.5
Required BER	1×10^{-6}	1×10^{-6}	1×10^{-5}	1×10^{-6}	1×10^{-6}	1×10^{-5}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-5}	1×10^{-9}		1×10^{-5}	1×10^{-6}	1×10^{-6}
Link reliability (%)	99.9	99.9	99.99	99.9	99.9	99.99	99.9	99.9	99.9	99.9	99.6		99.9	99.9	99.9
Interference criterion	Rec. ITU-R SA.1155														

SQPN: Staggered quadriphase pseudo-random noise; SSM: Spread-spectrum modulation.

(1) Transmit frequency is selectable in 5 MHz steps, 500 × 221/240 kHz steps for the Russian Federation DRS, 1 MHz steps for Chinese DRS.

(2) Signals with low data rate transmissions will be spread by a pseudo-random noise code so as to meet pfd limits.

(3) For the Russian Federation DRS transmit frequency is selectable in 500 × 221/240 kHz steps.

(4) Since a single antenna is used on the non-geostationary spacecraft for both the forward and return link, the antenna size is driven by the required bit rate on the return link and may therefore vary according to the spacecraft.

TABLE 3

Return spacecraft-to-DRS link characteristics

Transmitting spacecraft															
Network	Russian Federation	China	United States of America	Europe	Japan	United States of America	China	Russian Federation	Russian Federation	United States of America	Europe	Japan	United States of America	China	Russian Federation
Orbital locations	Mainly low-Earth orbit														
Frequency range (GHz)	2.200-2.290[3]	2.270-2.278	2.284-2.291	2.200-2.290[1]					14.76-15.34	14.891-15.116	25.25-27.50				
Link description	Multiple access (S-MA) links			Single access (S-SA) links					Single access (Ku-SA) links		Single access (Ka-SA) links				
Transmission rate	≤ 1 kbit/s	≤ 300 kbit/s 3 Mcps	≤ 3 Mbit/s	≤ 1 Mbit/s	≤ 12 Mbit/s	≤ 6 Mbit/s	≤ 2 Mbit/s	≤ 64 kbit/s	≤ 90 Mbit/s	≤ 300 Mbit/s	≤ 300 Mbit/s	≤ 300 Mbit/s	≤ 800 Mbit/s	≤ 600 Mbit/s	≤ 600 Mbit/s
Modulation	QPSK/SSM	PSK	SQPN/PSK[2]				PSK	QPSK/SSM	QPSK	PSK	OQPSK	PSK	PSK	PSK	MPSK
Polarization	RHC	LHC	LHC	Circular				RHC	RHC	Circular					
Antenna size (m)	Omnidirectional, arrays			Omnidirectional, arrays, parabolic = ≤ 1.5			Omnidi-rectional, arrays, parabolic = ≤ 0.8	Omnidi-rectional, arrays, parabolic = ≤ 1.5	≤ 1.2	≤ 1.5	(3)	≤ 1.9	≤ 1.5	≤ 0.8	≤ 1
Tx antenna gain (dBi)	≤ 1.5 / 7.2	≤ 11	≤ 15	≤ 27.3	≤ 27.6	≤ 27.3	≤ 15	≤ 11	≤ 42.2	≤ 43	≤ 50	≤ 49.7	≤ 47	≤ 44.5	≤ 46.1
Tx antenna radiation pattern	Rec. ITU-R S.672 for high gain antenna								Rec. ITU-R S.672						
Necessary bandwidth (MHz)	6	8	6	≤ 6	20	6	20	6	≤ 80 per channel	≤ 225	≤ 405 per channel	≤ 300	≤ 650	≤ 600	≤ 300[4]
Maximum power spectral density (dB(W/Hz))	–55.8	–46	–60.8	–51	–55.7	–60.8	–46	55.8	–71.5	–73.5	–58.5	–58.8	–67.5	–50	-68.3
Maximum e.i.r.p. spectral density (dB(W/Hz))	Compliant with pfd limits								–29.3	–30.5	–8.5	–9.1	–20.5	–5.5	-22.2

TABLE 3 (*end*)

Receiving DRS															
Network	Russian Federation	China	United States of America	Europe	Japan	United States of America	China	Russian Federation	Russian Federation	United States of America	Europe	Japan	United States of America	China	Russian Federation
Orbital locations	Rec. ITU-R SA.1275 or Rec. ITU-R SA.1276														
Frequency range (GHz)	2.200-2.290[(1)]	2.270-2.278	2.284-2.291	2.200-2.290[(1)]					14.76-15.34	14.891-15.116	25.25-27.50				
Antenna size (m)	Horn	Phased array		2.8	3.6	4.9	4.2	4	4	4.9	1.3	3.6	4.9	4.2	4
Rx antenna gain (dBi)	14.8	27	30.0	34.7	37.2	36.8	36.5	35.7	52.6	52.6	49.0	58.8	55.9	57.5	57.4
Rx antenna radiation pattern	Rec. ITU-R S.672														
System noise temperature (K)	450	741	478	590	404	537	741	550	550	661	800	475	870	1 000	550
Link reliability (%)	99.9	99.9	99.99		99.9	99.99	99.9	99.9	99.9	99.9	99.6		99.9	99.9	99.9
Interference criterion	Rec. ITU-R SA.1155														

(1) Transmit frequency is selectable in 5 MHz steps for United States of America DRS, 100 kHz steps for Japanese DRS, 500 kHz for the Russian Federation DRS, 1 MHz steps for Chinese DRS.

(2) Signals with low data rate transmissions will be spread by a pseudo-random noise code so as to meet pfd limits.

(3) Since a single antenna is used on the non-geostationary spacecraft for both the forward and return link, the antenna size is driven by the required bit rate on the return link and may therefore vary according to the spacecraft.

(4) Return spacecraft-to-DRS composite link consists of several sub-channels 150 MHz wide.

TABLE 4

Return DRS-to-Earth feeder link characteristics

Transmitting DRS							
Network	Russian Federation	United States of America	Europe		Japan	China	Russian Federation
Orbital locations	Rec. ITU-R SA.1275 or Rec. ITU-R SA.1276 and 31° E (for Europe)						
Frequency range (GHz)	10.7--11.7, 12.5-12.75	13.4-14.05	18.1-21.2	25.5-27[5]	19.7-21.2	18.9-21.2	17.7-21.2
Link description	Ku-band (14/11 GHz) return feeder	Ku-band (14/11 GHz) return feeder	Ka-band (30/20 GHz) return feeder				
Transmission rate (Mbit/s)	≤ 150[3]	[1]	[2]		[2]	[4]	≤ 600
Modulation	QPSK, QPSK/SSM	PSK	NRZ-L/BPSK/PM	OQPSK	SQPN/PSK	PSK	MPSK
Polarization	RHC	Linear	Circular		Circular	Linear	Circular
Antenna size (m)	0.6	2	2.2[6]	2.2[6]	2.0	1.5	1.2
Tx antenna gain (dBi)	34.3	44.8	39[6]	39[6]	49.5	46.4	45.9
Tx antenna radiation pattern	Rec. ITU-R S.672						
Necessary bandwidth (MHz)	≤ 150 per channel	650 (composite), 225 (dedicated)	1	450 per channel	839	≤ 2 300 (composite)	≤ 300[7] (composite)
Maximum power spectral density (dB(W/Hz))	–57.5	–58.6	–63	–71.3	–40.9	–57.1	–69.6
Maximum e.i.r.p. density (dB(W/Hz))	–23.2	–13.8	–24	–31.6	8.6	–10.7	–23.7
Receiving earth station							
Location	Russian Federation	United States of America	Europe		Japan	China	Russian Federation
Antenna size (m)	13.1	18.3	6.8	6.8	5, 9.2 and 13	3, 12 and 15	9
Rx antenna gain (dBi)	61.3	65.5	62.2	62.8, 64.2	59.5, 67.7	53.4, 65.5 and 67.1	62.7
Rx antenna radiation pattern	Rec. ITU-R S.580	RR Appendix 8, Annex III					Rec. ITU-R S.580
System noise temperature (K)	320	300	320	300	200	330	320
Link availability (%)	99.9	99.9	99.89	99.89	99.9		99.9
Interference criterion	Rec. ITU-R SA.1155, Rec. ITU-R S.741	Rec. ITU-R SA.1155					

Notes to Table 4:

(1) The United States of America DRS transmits a dedicated and a composite link. Transmission rate for the dedicated link is 300 Mbit/s, for the composite link the transmission rate is on the order of 800 Mbit/s.

(2) The European and Japanese networks employ a decentralized link concept that permits independent return feeder links to different earth station.

(3) The Russian Federation DRS transmits several independent return feeder links within the indicated frequency range with transmission rates ≤ 150 Mbits/s.

(4) The Chinese networks implement a composite link concept that permits return feeder links to different earth stations.

(5) In the frequency band 25.5-27 GHz, the return DRS-to-Earth feeder link carries signals in the space research and Earth exploration-satellite services.

(6) The antenna is a shaped antenna.

(7) The Russian Federation DRS Return DRS-to-Earth Feeder composite link consists of several sub-channels 150 MHz wide.