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Recommendation ITU-R SA.2169-0

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SA Series: Space applications and meteorology

Technical and operational characteristics of the space operation service (SOS) systems that use the 2 025-2 110 MHz (Earth-to-space) (space-to-space) and 2 200-2 290 MHz (space-to-Earth) (space-to-space) frequency bands for use in assessing of interference and for conducting sharing studies

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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.2169-0

Technical and operational characteristics of the space operation service (SOS) systems that use the 2 025-2 110 MHz (Earth-to-space) (space-to-space) and 2 200-2 290 MHz (space-to-Earth) (space-to-space) frequency bands for use in assessing of interference and for conducting sharing studies

(2025)

Scope

This Recommendation provides technical and operational characteristics for use in sharing studies for the space operation service (SOS) systems that use the 2 025-2 110 MHz (Earth-to-space) (space-to-space) and 2 200-2 290 MHz (space-to-Earth) (space-to-space) frequency bands.

Keywords

Tracking, Telemetry, Command, Space Operation, TT&C, SOS, DRS, POCS

Abbreviations/Glossary

CP	Circular polarization
DRS	Data relay satellite
GSO	Geostationary-satellite orbit
HEO	Highly-elliptical orbit
LEO	Low-Earth orbit
MEO	Medium-Earth orbit
ND	Non-directional
non-GSO	Non-geostationary-satellite orbit
POCS	Proximity operations communication system
SOS	Space operation service
TT&C	Telemetry, tracking and command

Related ITU-R Recommendations and Reports

Recommendation ITU-R SA.363 – Space operation systems

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

Recommendation ITU-R SA.1020 – Hypothetical reference system for the Earth exploration-satellite and meteorological satellite services

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

The ITU Radiocommunication Assembly,

considering

a) that the frequency band 2 025-2 110 MHz is allocated to the SOS on a primary basis among other services in the Earth-to-space and space-to-space directions;

b) that the frequency band 2 200-2 290 MHz is allocated to the SOS on a primary basis among other services in the space-to-Earth and space-to-space directions,

recommends

that the technical and operational characteristics for the SOS systems operating in the 2 025-2 110 MHz (Earth-to-space) (space-to-space) and 2 200-2 290 MHz (space-to-Earth) (space-to-space) frequency bands detailed in the Annex should be used in sharing studies.

Annex

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1 Introduction

This Annex provides the technical and operational characteristics of telemetry, tracking and command (TT&C) systems operating in the space operation service in the 2 025-2 110 MHz and 2 200-2 290 MHz frequency bands.

The TT&C system performs the following functions for ensuring the successful operation of a satellite:

1 Telemetry to enable ground controllers to monitor the operational health and status of the satellite, and the measured values are transmitted from satellite to the ground control centre.

2 Tracking/ranging to enable ground controllers to determine the satellite’s location and orientation.

3 Telecommand to enable ground controllers to command the various electronic units aboard the satellite, sending commands from the ground to the satellite.

The frequency band 2 025-2 110 MHz is allocated to space operation service (SOS) (Earth-to-space) (space-to-space) and the frequency band 2 200-2 290 MHz is allocated to SOS (space-to-Earth) (space-to-space). These frequency bands are used by geostationary and non-geostationary satellites and the inter-satellite links.

2 Technical and operational characteristics of the geostationary satellites

Representative characteristics of the TT&C systems for GSO SOS systems are listed in Tables 1 and 2.

2.1 Telemetry in the 2 200-2 290 MHz frequency band

Table 1 lists the system parameters for telemetry downlinks in the frequency band 2 200-2 290 MHz for the GSO SOS systems.

TABLE 1

GSO SOS system parameters for telemetry downlinks in the frequency band 2 200-2 290 MHz

Function	**Telemetry**
System	**System A**
Maximum necessary bandwidth (MHz)	4.930
Transmitting Satellite parameters	
Satellite antenna input power (dBW) (1)	1.8
Satellite antenna type	Bicone/Crossed-dipole
Satellite maximum antenna gain (dBi)	1.0
Satellite antenna polarization	CP
Satellite antenna radiation pattern	Cardioid −13 dB at 170 degrees
Receiving Earth station parameters	
Earth station antenna type	Parabolic
Earth station antenna radiation pattern	Rec. ITU-R S.465-6
Earth station maximum antenna gain (dBi)	50
Earth station antenna polarization	CP
Earth station receiver noise temperature (K)	130
Minimum elevation angle (degree)	5

(1) "satellite antenna input power" includes the antenna feeder loss.

2.2 Command in the 2 025-2 110 MHz frequency band

Table 2 lists the system parameters for command uplinks in the 2 025-2 110 MHz frequency band for GSO SOS systems.

TABLE 2

GSO SOS system parameters for command uplinks in the frequency band 2 025-2 110 MHz

Function	Command
System	**System A**
Maximum necessary bandwidth (MHz)	0.084
Transmitting Earth station parameters	
Earth station antenna input power (dBW)	21.9
Earth station antenna type	Parabolic
Earth station antenna radiation pattern	34.6 dB at 0.95 degrees Rec. ITU-R S.465-6
Earth station maximum antenna gain (dBi)	49.5
Earth station antenna polarization	CP
Minimum elevation angle (degree)	5
Receiving satellite parameters	
Satellite antenna type	Crossed-dipole
Satellite maximum antenna gain (dBi)	1
Satellite antenna polarization	CP
Satellite antenna radiation pattern	−11 dB at 165 degrees
Satellite receiver noise temperature (K)	650

3 Technical and operational characteristics of the non-geostationary satellites

Representative characteristics of the TT&C systems for non-geostationary-satellite orbit (non-GSO) SOS systems are listed below in Tables 3 and 4.

Non-GSO satellites operate in a variety of orbits depending on their mission objectives, and characteristics of the TT&C systems are designed according to orbital features such as shape of orbit, orbital altitude, so the characteristics of the TT&C systems are provided for representative orbits of the LEO sun-synchronous orbit, LEO low latitude orbit, MEO, HEO, and Lagrange L1/L2 orbit.

3.1 Telemetry/ranging in the 2 200-2 290 MHz frequency band

Table 3 lists the system parameters for telemetry/ranging downlinks in the frequency band 2 200-2 290 MHz for the non-GSO SOS systems. Ranging is used on non-GSO satellites to locate the satellite’s position. Ranging is accomplished alone or together with the telemetry transmission.

TABLE 3

Non-GSO SOS system parameters for telemetry/ranging downlinks in the frequency band 2 200-2 290 MHz

Function	**Command/ranging**						
Orbit type	**LEO, Sun synchronous**						
System	**System B**	**System C**	**System D**	**System E**	**System F**	**System G**	**System H**
Maximum necessary bandwidth (MHz)	3.2	6	2.2 (2) / 2.5 (3)	0.8	3	3.32	0.5
Orbit information							
Shape of orbit	Circular	Circular	Circular	Circular	Circular	Circular	Circular
Orbital altitude (km)	824	510	628	600	773	550	500-800
Inclination angle (degree)	98.7	97	97.9	97.8	98.3	97.6	97-98.5
Satellite parameters							
Satellite antenna input power (1) (dBW)	7	−0.2	−22.2 (2) / −5.2 (3)	−3	1	0.3	-4
Satellite antenna type	Helix	Crossed dipole with a reflector	Crossed dipoles with a reflector	Quadrifilar helix	Quadrifilar helix	Broadband patch panel	Quadrifilar Helix / Patch
Satellite maximum antenna gain (dBi)	3	2	7.5	3	3.5	5.6	0
Satellite antenna polarization	CP	CP	CP	CP	CP	CP	CP
Satellite antenna radiation pattern	ND by multiple antenna	ND by multiple antenna	ND by multiple antenna	ND by multiple antenna	ND by multiple antenna	Constant gain over ¼ of the sphere	ND
Receiving Earth station parameters							
Earth station antenna type	Parabolic	Parabolic	Parabolic	Parabolic	Parabolic	Parabolic	Parabolic
Earth station antenna radiation pattern	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.580-6
Earth station maximum antenna gain (dBi)	42 / 44.8 / 46.8	34.9 / 39	44.2	42 / 45 / 47	42 / 45 / 47	42 / 45 / 47	44
Earth station antenna polarization	CP	CP	CP	CP	CP	CP	CP
Earth station receiver noise temperature (K)	130 / 190 / 245	75 / 100	148	139 / 145 / 152	139 / 145 / 152	139 / 145 / 152	200
Minimum elevation angle (degree)	5	5	5	3	3	3	3

TABLE 3 (*end*)

Function	**Command/ranging**					
Orbit type	**LEO, low latitude**			**MEO**	**HEO**	**L1/L2**
System	**System I**	**System J**	**System K**	**System L**	**System M**	**System N**
Maximum necessary bandwidth (MHz)	0.064	2.4 [2] / 3 [3]	2.3	2.5 [2] / 2.0 [3]	0.075	1.15
Orbit information						
Shape of orbit	Circular	Circular	Circular	elliptical	Highly elliptical	Heliocentric (L1)
Orbital altitude (km)	550	550	200-500	32 700 (apogee) 300 (perigee)	41885 (apogee) 9710 (perigee)	1 500 000
Inclination angle (degree)	24	31	51.6	31	63.435	N/A
Satellite parameters						
Satellite antenna input power [1] (dBW)	−12.0	−23.5 [2] / −3 [3]	−1.5 / 1.5	5.1 (apogee) −14.9 [2] / 5.1 [3] (perigee)	5.5	5
Satellite antenna type	Quadrifilar helix	Crossed dipoles with a reflector	Helix	Crossed dipoles with a reflector / dipole	Quadrifilar helix	2 omni antennas
Satellite maximum antenna gain (dBi)	2.5	7	5	6	8	−4.5
Satellite antenna polarization	CP	CP	CP	CP / Vertical polarization	CP	CP
Satellite antenna radiation pattern	ND by multiple antenna	ND by multiple antenna	ND by multiple antenna	ND by multiple antenna	ND by multiple antenna	ND by multiple antenna
Receiving Earth station parameters						
Earth station antenna type	Parabolic	Parabolic	Parabolic	Parabolic	Parabolic	Parabolic
Earth station antenna radiation pattern	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.465	RR App. **8**
Earth station maximum antenna gain (dBi)	34.2 / 46.6	56.3	47.1	47.1	46.7	50.5 / 51.8
Earth station antenna polarization	CP	CP	CP	CP	CP	CP
Earth station receiver noise temperature (K)	70 / 157	70	147	147	247	251
Minimum elevation angle (degree)	5	5	5	5	5	5

[1] "satellite antenna input power" includes the antenna feeder loss.

[2] For PCM-PSK/PM.

[3] For QPSK.

3.2 Command/ranging in the 2 025-2 110 MHz frequency band

Table 4 lists the system parameters for command/ranging uplinks in the 2 025-2 110 MHz frequency band for non-GSO SOS systems. Ranging is used on non-GSO satellites to locate the satellite's position. Ranging is accomplished alone or together with the command transmission.

TABLE 4

Non-GSO SOS system parameters for command/ranging uplinks in the frequency band 2 025-2 110 MHz

Function	**Command/ranging**						
Orbit type	**LEO, Sun synchronous**						
System	**System B**	**System C**	**System D**	**System E**	**System F**	**System G**	**System H**
Maximum necessary bandwidth (MHz)	Command 0.032 Configuration Data 0.256	6	1.1	0.38	0.3	0.2	0.5
Orbit information							
Shape of orbit	Circular	Circular	Circular	Circular	Circular	Circular	Circular
Orbital altitude (km)	824	510	628	600	773	550	500-800
Inclination angle (degree)	98.7	97	97.9	97.8	98.3	97.6	97-98.5
Transmitting Earth station parameters							
Earth station antenna input power (dBW)	9.8	22	20	11.7	11.7	11.7	30
Earth station antenna type	Parabolic	Parabolic	Parabolic	Parabolic	Parabolic	Parabolic	Parabolic
Earth station antenna radiation pattern	Rec. ITU-R S.465-6	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.580-6
Earth station maximum antenna gain (dBi)	41.4 / 42 / 46.2	34.2/38	43.2	41 / 44 / 46	41 / 44 / 46	41 / 44 / 46	43
Earth station antenna polarization	CP	CP	CP	CP	CP	CP	CP
Minimum elevation angle (degree)	5	5	5	5	5	5	5
Satellite parameters							
Satellite antenna type	Helix	Crossed dipoles with a reflector	Crossed dipoles with a reflector	Quadrifilar helix	Quadrifilar helix	Broadband patch panel	Quadrifilar Helix / Patch
Satellite maximum antenna gain (dBi)	3	2	7.5	3	3.5	5.6	0
Satellite antenna polarization	CP	CP	CP	CP	CP	CP	CP
Satellite antenna radiation pattern	ND by multiple antenna	ND by multiple antenna	ND by multiple antenna	ND by multiple antenna	ND by multiple antenna	Constant gain over ¼ of the sphere	ND
Satellite receiver noise temperature (K)	263	450	515	999	1892	8300	1200

TABLE 4 (*end*)

Function	**Command/ranging**						
Orbit type	**LEO, low latitude**				**MEO**	**HEO**	**L1/L2**
System	**System I**	**System J**	**System K**	**System O**	**System L**	**System M**	**System N**
Maximum necessary bandwidth (MHz)	0.064	2	0.044	0.095	2	0.1	1.0
Orbit information							
Shape of orbit	Circular	Circular	Circular	Circular	elliptical	Highly elliptical	Heliocentric (L1)
Orbital altitude (km)	550	550	200-500	1336	32 700 (apogee) 300 (perigee)	41885 (apogee) 9710 (perigee)	1 500 000
Inclination angle (degree)	24	31	51.6	66	31	63.435	N/A
Transmitting Earth station parameters							
Earth station antenna input power (dBW)	11	20	20	8	30	13.9	22.8 / 31
Earth station antenna type	Parabolic	Parabolic	Parabolic	Omni	Parabolic	Parabolic	Parabolic
Earth station antenna radiation pattern	Rec. ITU-R S.465-6	Rec. ITU-R S.465	Rec. ITU-R S.465	ND	Rec. ITU-R S.465	Rec. ITU-R S.465	RR App. **8**
Earth station maximum antenna gain (dBi)	36.5 / 46.8	55.6	47	6	47	46.3	49.8 / 51.1
Earth station antenna polarization	CP	CP	CP	Linear	CP	CP	CP
Minimum elevation angle	5	5	5	3	5	5	5
Satellite parameters							
Satellite antenna type	Quadrifilar helix	Crossed dipoles with a reflector	Helix	Omni	Crossed dipoles with a reflector / dipole	Quadrifilar helix	2 omni antennas
Satellite maximum antenna gain (dBi)	2.5	7	5	5.2	6	8	−4.5
Satellite antenna polarization	CP	CP	CP	CP	CP	CP	CP
Satellite antenna radiation pattern	ND by multiple antenna	ND by multiple antenna	ND by multiple antenna	ND	ND by multiple antenna	ND by multiple antenna	ND by multiple antenna
Satellite receiver noise temperature (K)	1697	2674	537	170	789	840	603

4 Technical and operational characteristics of the SOS space-to-space links

The SOS space-to-space links typically include the use of a Data Relay Satellite (DRS) system and a Proximity Operations Communication System (POCS).

4.1 Data Relay Satellite (DRS) systems

The hypothetical reference system of the DRS systems is described in Recommendations ITU-R SA.1018 and ITU-R SA.1020. The DRS spacecraft is typically located on the geostationary orbit, and the space-to-space links of the DRS system are established between the DRS spacecraft and low-Earth orbiting user spacecraft.

The 2 025-2 110 MHz frequency band is used for SOS Earth-to-space links. This frequency band is also used for SOS forward space-to-space links, typically for radiocommunications from DRS spacecraft to low-Earth orbiting spacecraft. The characteristics of DRS-to-spacecraft links can be found in Table 2 of Recommendation ITU-R SA.1414.

The 2 200-2 290 MHz frequency band is used for SOS space-to-Earth links. This frequency band is also used for SOS return space-to-space links, typically for radiocommunications from low-Earth orbiting spacecraft to DRS spacecraft. The characteristics of spacecraft-to-DRS links can be found in Table 3 of Recommendation ITU-R SA.1414.

4.2 Proximity Operations Communication System (POCS)

The proximity space links are short-range, bi-directional, fixed or mobile radio links, generally used to communicate among probes, landers, rovers, orbiting constellations, and orbiting relays. The POCS supports several communications needs between such a variety of network elements for manned and unmanned missions.

The 2 025-2 110 MHz frequency band is used for the POCS forward space-to-space radiocommunications links and the 2 200-2 290 MHz frequency band is used for the POCS return space-to-space radiocommunications links.

Table 5 lists typical POCS operation scenarios.

TABLE 5

Examples of POCS operation scenario

System	Example 1
Location to operate	Near-Earth circular orbit of about 400 km altitude
Communication system 1	Visiting spacecraft
Communication system 2	Manned spacecraft
Objectives of operations	Inter-orbit communication when visiting spacecraft approaches manned spacecraft
Maximum distance between POCS systems	23 km

4.2.1 Telemetry/ranging in the 2 200-2 290 MHz frequency band

Table 6 lists the system parameters of telemetry/ranging return links in the frequency band 2 200-2 290 MHz for both transmitting and receiving sides of the POCS systems. Ranging is used on the POCS links to measure distance between two POCS systems.

TABLE 6

POCS system parameters for telemetry/ranging return links in the frequency band 2 200-2 290 MHz

Function	**Telemetry/ranging**
System	**System P**
Maximum necessary bandwidth (MHz)	6 (2)
Communication system 1 parameters (transmitting side)	
Antenna input power (1) (dBW)	−0.02
Antenna type	Helix
Maximum antenna gain (dBi)	5
Antenna polarization	CP
Antenna radiation pattern	ND by multiple antenna
Communication system 2 parameters (receiving side)	
Antenna type	Micro-strip
Antenna radiation pattern	ND by multiple antenna
Maximum antenna gain (dBi)	7.5
Antenna polarization	CP
Receiver noise temperature (K)	525

(1) "antenna input power" includes the antenna feeder loss.

(2) Spread spectrum.

4.2.2 Command/ranging in the 2 025-2 110 MHz frequency band

Table 7 lists the system parameters for command links in the 2 025-2 110 MHz frequency band for both transmitting and receiving sides of the POCS systems. Ranging is used on the POCS links to measure distance between two POCS systems.

TABLE 7

POCS system parameters for command/ranging forward links in the frequency band 2 025-2 110 MHz

Function	**Command/ranging**
System	**System P**
Maximum necessary bandwidth (MHz)	10 [2]
Communication system 2 parameters (transmitting side)	
Antenna input power [1] (dBW)	−7.6
Antenna type	Micro-strip
Antenna radiation pattern	ND by multiple antenna
Maximum antenna gain (dBi)	7.5
Antenna polarization	CP
Communication system 1 parameters (receiving side)	
Antenna type	Helix
Maximum antenna gain (dBi)	5.0
Antenna polarization	CP
Antenna radiation pattern	ND by multiple antenna
Receiver noise temperature (K)	455

[1] "antenna input power" includes the antenna feeder loss.

[2] Spread spectrum.