Recommendation ITU-R SA.2079-1

(12/2023)

SA Series: Space applications and meteorology

Frequency sharing between space research service and fixed satellite service (space-to-Earth) systems in the 37.5-38 GHz band

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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.2079-1

Frequency sharing between space research service and fixed satellite service (space-to-Earth) systems in the 37.5-38 GHz band

(2015-2023)

Scope

This Recommendation covers the frequency sharing between the space research service (SRS) and the fixed satellite service (FSS) in the 37.5-38 GHz band (space-to-Earth). It gives e.i.r.p. and pfd limits for the space-VLBI (SVLBI) and lunar systems of SRS, and the geostationary orbit (GSO) and highly inclined elliptical Orbit (HEO) systems of FSS. It also provides mitigation techniques covering all types of non-GSO FSS systems, including low Earth orbit (LEO) and medium Earth orbit (MEO) constellations.

Keywords

SRS near-Earth systems, FSS GSO and HEO systems, e.i.r.p. and p.f.d. limits, frequency sharing, 37.5-38 GHz

The ITU Radiocommunication Assembly,

considering

a)   that the space research service (SRS) (s-E) has a primary allocation in the 37-38 GHz band and the fixed-satellite service (FSS) (s-E) has a primary allocation in the 37.5-42.5 GHz band, and these allocations overlap in the 37.5-38 GHz band;

b)   that the protection criteria for the SRS downlinks in the 37-38 GHz band are given in Recommendation ITU-R SA.1396;

c)   that calculation of interference to an SRS earth station that may result from atmospheric and precipitation effects should be based on weather statistics for 0.001% of the time for manned missions and for 0.1% of time for unmanned missions;

d)   that deep space SRS downlinks often carry data of unique science events that are not repeatable;

e)   that the emissions from deep space downlinks typically have a power flux-density (pfd) on the surface of the Earth that is much lower than any other satellite signal and is therefore extremely vulnerable to interference from satellites operating in the same frequency band;

f)   that space-based very long baseline interferometry (SVLBI) SRS downlinks have interference criteria as given in Report ITU-R SA.2065, and that these links may be able to tolerate higher interference levels than indicated in Recommendation ITU-R SA.1396;

g)   that protection of SRS and FSS systems sharing the 37.5-38 GHz band has been studied in Report ITU-R SA.2307 whose results are summarized in the Annex;

h)   that transmissions from the SRS SVLBI and lunar systems with e.i.r.p. levels below the limits given in Report ITU-R SA.2307 meet the protection criteria of the FSS GSO and HEO systems;

i)   that transmissions from the FSS GSO and HEO systems with e.i.r.p. levels below the limits given in Recommendation ITU-R S.1328 meet the protection criteria of SRS SVLBI and unmanned lunar systems, but FSS GSO transmissions require a lower e.i.r.p limit to meet the protection criterion of SRS manned lunar missions;

j)   that transmissions from the FSS HEO systems operating at pfd limits given in ITU Radio Regulations Article **21**, Table **21-4** meet the protection criteria of the SRS SVLBI and lunar missions;

k)   that FSS LEO and MEO constellations operating in this frequency band are expected to use steerable beams to address traffic demand;

l)   that other non-SVLBI near-Earth SRS systems, such as Lagrange L1/L2 missions, with low system noise temperature (about 60 K) may be about 8 dB more sensitive to interference than the lunar systems with background noise temperature from the Moon (about 353 K);

m)   that for a small percentage of time, when propagation impairments in the 37 GHz band are severe during the fading conditions, the satellite systems in this band could increase their e.i.r.p. spectral density to overcome the fading conditions,

>   *recognizing*

a)   that FSS satellite systems may use the 37.5-38 GHz band for very small aperture terminal applications (the VSAT mode), or for gateway applications that use large antennas (the gateway mode);

b)   that FSS systems operating in the VSAT mode may use the 37.5-38 GHz band when operating in areas away from the SRS earth stations, and a different frequency band above 38 GHz when operating in areas near the SRS earth stations;

c)   that, for FSS systems using the gateway mode, the gateway stations may be located away from the SRS earth stations,

>   *recommends*

1   that the SRS deep-space missions should use the 37-37.5 GHz band as much as possible to be fully protected in accordance with Recommendation ITU-R SA.1396;

2   that SRS manned lunar missions in the 37.5-38 GHz band should use 0.1% exceedance protection criterion from FSS systems rather than 0.001%;

3   that, to meet the FSS protection criterion, the SRS SVLBI and lunar systems transmitting in the 37.5-38 GHz band should operate below the maximum e.i.r.p. spectral density levels or below the pfd levels, under clear sky conditions, at the FSS earth stations shown in the Table below (Note 1);

SRS systems	Maximum e.i.r.p. spectral density (dBW/MHz)	Pfd limit on Earth's surface (dBW/MHz/m^2)
SVLBI	32	−127
Lunar	56	−128

4   that, to meet the SRS SVLBI systems and lunar mission interference criteria, the GSO and HEO FSS systems in the 37.5-38 GHz band should operate below the maximum e.i.r.p. spectral density levels or the pfd levels, under clear sky conditions, at the SRS earth stations given in the Table below (Note 1);

FSS systems	Maximum e.i.r.p. spectral density (dBW/MHz)	Pfd limit on Earth's surface (dBW/MHz/m^2)
GSO	42	−121
HEO	48	−105 (RR Table **21-4** limit)

5   that, to meet the SRS SVLBI systems and lunar mission interference criteria, the LEO and MEO FSS satellites should not point their emission beams operating in the 37.5-38 GHz band towards the SRS earth station locations;

6   that the FSS LEO and MEO Earth Stations and FSS GSO and HEO systems operating in the VSAT mode should use frequency bands above 38 GHz in geographical areas near the SRS earth stations (see Annex 1);

7   that the pfd at the Earth's surface for SRS and FSS systems transmitting in the 37.5-38 GHz band should be no greater than the level(s) required to meet their link availability and performance objectives of the subject applications;

8   that other near-Earth SRS systems, such as Lagrange L1/L2 missions, should consider designing their downlink with an additional link margin of about 8 dB to achieve compatibility with FSS systems, similar to a lunar SRS system.

NOTE 1 − During excessive fading conditions, the e.i.r.p. spectral density in Tables above can be exceeded by the amount needed to maintain link availability while meeting the pfd limits.

Annex

Frequency sharing between SRS near-Earth and FSS systems in the 37.5-38 GHz band

1   Introduction

This Annex summarizes the results of the Report ITU-R SA.2307, which gives the frequency sharing analysis between the SVLBI and lunar systems of SRS and systems of FSS. The interference between the FSS GSO and HEO systems and SRS is simulated for two cases. In Case 1, the systems are assumed to operate using the parameters and e.i.r.p. density levels as given in the following sections. In Case 2, the systems are assumed to operate with higher transmit powers generating the maximum pfd spectral density levels on the Earth's surface as given by Radio Regulation Article **21**, Table **21-4**. Additional studies of FSS LEO and MEO constellations and SRS Earth Stations are performed.

2   SRS systems

The planned parameters for the SVLBI and lunar SRS systems are summarized in Table 1. These parameters are used in calculating the interference levels between these SRS systems and the GSO and HEO FSS systems for Case 1.

TABLE 1

Planned SRS SVLBI and lunar system parameters (Case 1)

Parameters	SVLBI	Lunar
Space station parameters		
Orbital inclination (degrees)	20, 31, 65	Moon
Transmit power (dBW)	3	14.5
Antenna gain (dBi)	48.1	64
Data rate (Mbit/s)	500	250
Max transmit e.i.r.p. density (dBW/MHz)	24.1	54.5

TABLE 1 (*end*)

Parameters	SVLBI	Lunar
Earth station parameters		
Antenna diameter (m)	15, 34	6
Gain pattern	RR AP**8-10**	RR AP**8-10**
Lowest elevation (degrees)	10	10
Noise temperature (K)	150	353
Protection criterion Io/No (dB)	−6	−6
Interference protection (dBW/MHz)	−153	−149.1
Exceedance percentage	2%	0.1% (unmanned) 0.001% (manned)

For Case 2, it is assumed that the transmissions from SRS SVLBI and lunar systems satisfy the pfd limits specified in RR Table **21-4** on the surface of the Earth for the 37.5-38 GHz band.

In the results section, the SVLBI systems with different orbital inclinations will be identified as SVLBI-20, SVLBI-31, and SVLBI-65.

3   FSS systems

The planned parameters for the FSS GSO and HEO systems are summarized in Table 2. These parameters are used in calculating the interference levels between these FSS systems and the SVLBI and lunar SRS systems for Case 1.

TABLE 2

Planned FSS GSO and HEO system parameters (Case 1)

Parameters	GSO	HEO
Space station parameters		
Number of satellites	2	3
Transmit power (dBW)	11	11
Antenna gain (dBi)	53	53
Occupied bandwidth (MHz)	500	500
Max transmit e.i.r.p. density (dBW/MHz)	37	37
Earth station parameters		
Antenna gain (dB)	58.9	58.9
Gain pattern	Recommendation ITU-R S.465	Recommendation ITU-R S.465
Lowest elevation (degrees)	10	10
Noise temperature (K)	343	340
Protection criterion Io/No (dB)	0	0
Interference protection (dBW/MHz)	−143	−143
Exceedance percentage	0.005%	0.005%

For Case 2, it is assumed that the transmissions from FSS GSO and HEO systems satisfy the pfd limits specified in RR Table **21-4** on the surface of the Earth for the 37.5-38 GHz band.

TABLE 3

Planned orbital characteristics of FSS LEO and MEO systems

Constellation	Inclination (degree)	Altitude (km)	Number of planes	Number of satellites/ planes	Total number of satellites
#1 (LEO at 1 200 km)	87.9	1 200	36 (spread over 180°)	49	1 764
	55	1 200	32 (spread over 360°)	50	1 600
	40	1 200	32 (spread over 360°)	50	1 600
#2 (LEO at ~ 600 km)	51.9	630	34 (spread over 360°)	34	1 156
	42	610	36 (spread over 360°)	36	1 296
	33	590	28 (spread over 360°)	28	784
#3 (MEO)	0	8 062	1	48	48
	70	8 062	4 (spread over 360°)	12	48
	90	8 062	4 (spread over 180°)	12	48

TABLE 4

Planned FSS LEO and MEO emission parameters

Constellation	(#1) LEO	(#2) LEO	(#3) MEO
Satellite			
Antenna gain (dBi)	34.1, 42.6, 50.6	47.8, 51.9, 55.5	25, 35, 45
Antenna pattern	Rec. ITU-R S.1528 $L_s = -25$	Rec. ITU-R S.1528 $L_s = -25$	Rec. ITU-R S.1528 ($L_s = -25$)
Peak power density (dBW/Hz)	−67	−67.6	−62.1
e.i.r.p. (dBW)	54.1, 62.6, 70.6	54, 60.7	46.9, 56.9, 66.9
Earth station			
Antenna gain (dBi)	36.6, 42.6, 48.6, 55.7, 61.9	47.8, 51.9, 55.5	31.6, 41.1, 51.6, 56.7, 59.2, 63, 64.7, 68.9, 71.6
Antenna pattern	RR Appendix **8**	RR Appendix **8**	RR Appendix **8**
Noise temperature (K)	150	251	120
Link			
Centre frequency (MHz)	37 750	37 750	37 625, 37 875
Maximum bandwidth (MHz)	500	475	250
Number of co-frequency beams (Nco)	10	4	1

4 Results for GSO and HEO FSS systems

For Case 1, Table 5 summarizes interference level exceedance observed at the SRS and FSS earth stations.

TABLE 5

**Exceedance of protection criteria for SRS and FSS systems
using planned e.i.r.p. density levels in the 37.5-38 GHz band (Case 1)**

Case 1: e.i.r.p. Interfering systems		(Victim systems) Exceedance of protection criteria (dB)					Max. exceedance (dB)
		SRS			FSS		
		SVLBI-20 SVLBI-31 SVLBI-65	Lunar (unmanned)	Lunar (manned)	GSO	HEO	
SRS	SVLBI-20 SVLBI-31 SVLBI-65	><	−17 −16 −22	><	−8 −10 −14	−36 −34 −8	−8
	Lunar	−22 −19 −29	><	><	−2	−41	−2
FSS	GSO	−16 −18 −20	−5	25	><	−46	−5 (unmanned lunar) 25 (manned lunar)
	HEO	−31 −28 −11	−29	−27	−41	><	−11

Note that the interference levels generated by the SRS (SVLBI and unmanned lunar) and FSS (GSO and HEO) systems using the planned system parameters satisfy the protection criteria of these systems. However, the interference from FSS GSO systems to SRS manned lunar systems exceeds the protection of SRS by 25 dB. Therefore, the frequency sharing between SRS (SVLBI and unmanned lunar) systems and FSS (GSO and HEO) in the 37.5-38 GHz band is possible. The frequency sharing is still possible even if the SRS (SVLBI and unmanned lunar) and FSS (GSO and HEO) systems increase their e.i.r.p. densities by the maximum exceedance levels. These systems can operate at these e.i.r.p. density levels 100% of the time without causing harmful interference to the other systems. For sharing between the FSS GSO systems and SRS manned lunar systems, mitigation methods are needed to reduce the interference to acceptable levels.

For Case 2, when the SRS and FSS systems operate with maximum pfd spectral densities on the Earth's surface of -105 dB(W/(m$^2 \cdot$ MHz)), the interference to the other systems will exceed their protection criteria using the clear weather atmospheric losses. The exceedance levels are shown in Table 6.

TABLE 6

**Exceedance of protection criteria for SRS and FSS systems
using pfd spectral density limits in the 37.5-38 GHz band (Case 2)**

Case 2: pfd Interfering systems		Victim systems: Exceedance of protection criteria (dB)					Max. exceedance (dB)
		SRS			FSS		
		SVLBI-20 SVLBI-31 SVLBI-65	Lunar (unmanned)	Lunar (manned)	GSO	HEO	
SRS	SVLBI-20 SVLBI-31 SVLBI-65	><	12 13 1	><	21 22 9	−35 −31 11	22
	Lunar	5 6 2	><	><	23	−32	23
FSS	GSO	4 2 1	16	44	><	−25	16 (unmanned lunar) 44 (manned lunar)
	HEO	−28 −25 −6	−27	−26	−25	><	−6

Note, however, that the SRS and FSS systems do not intend to use these high e.i.r.p. density levels 100% of the time, but only when the weather is bad and atmospheric attenuation is excessive. In this case, if the SRS and FSS earth stations are close to each other such that they have the same weather conditions, the interference will be much smaller than expected due to atmospheric losses, and will probably be below the protection criteria. If, however, the SRS and FSS earth stations are separated by large distance, then they might experience different weather conditions. If the interference goes through clear sky, the atmospheric attenuation might be small. In this case, however, the transmitting antenna will have a smaller off-boresight gain, and the spectral e.i.r.p. density towards the victim earth station will be reduced. For example, for an FSS GSO system, if the SRS and FSS earth stations are separated by 100 km, the interference e.i.r.p. density seen by the victim earth station would be reduced by 3 dB, and if they are separated by 200 km, the reduction would be 10 dB.

If the FSS systems cannot satisfy the specified pfd spectral density limits, then they should choose to use frequency bands above 38 GHz when operating near the SRS earth station locations, and only use the 37.5-38 GHz band when operating far from the SRS earth stations. FSS systems with spot beams should be able to satisfy this condition easily. The SRS systems without spot beams will have to operate at the specified e.i.r.p. density levels to avoid interfering with the FSS.

Above results indicate that, in the 37.5-38 GHz band, sharing between SRS (SVLBI and unmanned lunar) and FSS (GSO and HEO) is feasible using the planned system parameters. If interference exceeds the protection criteria of SRS or FSS systems, then mitigation methods exist to reduce the interference to an acceptable level.

5 Results for MEO and LEO FSS constellations

Assuming that LEO and MEO constellations satellites are using spot beams in the band 37.5-38 GHz, this report shows that no power limit would be required on FSS satellites emissions, provided that a separation distance is ensured between the FSS earth stations and the SRS earth stations. This separation distance depends on the LEO or MEO constellation characteristics and modes of operation and would be in the range of 35 to 70 km for gateway stations, and 40 to 70 km for user stations.

Given the currently low number of SRS earth stations operating in the band 37.5-38 GHz worldwide and their location are normally in remote areas, coexistence could normally be feasible. Under other operational circumstances, the coexistence should be dealt with on a case by case approach.

FSS earth stations operating closer than 40 to 70 km to SRS receiving earth stations may still use frequencies above 38 GHz.

It is worth mentioning that a certain assurance needs to be provided to comply with the above-mentioned assumption.