RECOMMENDATION ITU-R SA.1626*

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

(2003)

The ITU Radiocommunication Assembly,

considering

a) that in the band 14.8-15.35 GHz, the fixed and mobile services are allocated on a primary basis, the space research service (SRS) is allocated on a secondary basis;

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 requirements exist for wideband SRS downlinks to transmit future high data rate scientific data;

d) that the WRC-03 under agenda item 1.12 is invited to review allocations to the space research service near 15 GHz with a view to accommodating wideband space-to-Earth space research applications;

e) that under favourable conditions the required separation distances between receiving SRS earth stations and transmitting fixed stations are relatively small (under 30 km) and under less favourable conditions may be relatively large (up to 200 km);

f) that separation distances may decrease significantly due to frequency channelization, natural site shielding, terrain clutter, and other terrain features,

noting

a) that due to the small number of expected SRS earth stations to be deployed worldwide (10-40 stations), coordination between fixed and land mobile systems and the SRS stations would not put undue constraints on either of the services,

recommends

1 that sharing between a GSO SRS satellite transmitting in the space-to-Earth direction and a receiving GSO data relay satellite (DRS) operating near 15 GHz is feasible if the satellites are separated by 12 km (equivalent to an orbital separation of 0.02º) or more;

2 that, when designing SRS systems, the probability of receiving brief periods of interference from DRS user satellites should be taken into account. This interference should exist for less than 0.1% of the time;

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* This Recommendation should be brought to the attention of Radiocommunication Study Groups 8 and 9.

3 that GSO SRS systems operate within the following pfd limits at the Earth's surface under assumed free space propagation conditions in the band 14.8-15.35 GHz:

Limit (dB(W/m²)) in 1 MHz bandwidth for angle of arrival, δ, above the horizontal plane		
0°-5°	5°-25°	25°-90°
–126	–126 + 0.5(δ – 5)	–116

4 that non-GSO SRS systems operate within the following pfd limits at the Earth's surface under assumed free space propagation conditions in the band 14.8-15.35 GHz:

Limit (dB(W/m²)) in 1 MHz bandwidth for angle of arrival, δ, above the horizontal plane		
0°-5°	5°-25°	25°-90°
–124	–124 + 0.5(δ – 5)	–114

5 that separation distances required by SRS receiving earth stations for protection from fixed and mobile transmitting stations may be derived using the methodology outlined in Annex 1 and the protection criterion for space-to-Earth SRS links contained in Recommendation ITU-R SA.609;

6 that suitable measures related to the deployment of SRS earth stations may need to be identified in order not to constrain the use of the band 14.8-15.35 GHz by the fixed service.

Annex 1

Feasibility of sharing between the SRS (space-to-Earth) and the fixed and mobile services in the band 14.8-15.35 GHz

1 Introduction

International space agencies are currently planning on implementing high data rate space research missions with bandwidth requirements up to 400 MHz. Satellites for these missions will carry telescopes and/or other passive instruments to measure phenomenon such as the Earth's magnetosphere and solar flares. At present, 8 450-8 500 MHz is the only band below the 37-38 GHz band that is available on a primary basis in the SRS to transmit moderate to high-rate data directly from Earth orbiting satellites to earth stations. Since this band will not meet the requirements of future high rate space research missions, a new allocation is needed.

The band 14.8-15.35 GHz has been proposed as a possibility for a primary SRS allocation to satisfy these requirements. The current allocations in the band 14.8-15.35 GHz are shown in Table 1. They include primary allocations to the fixed and mobile services and a secondary allocation to the SRS. In addition, RR No. 5.339 allocates the 15.20-15.35 GHz segment of the band to the SRS (passive) and the EESS (passive) on a secondary basis.

TABLE 1

Allocations in the band 14.8-15.35 GHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
14.8-15.35	FIXED MOBILE Space research 5.339	

5.339 The bands 1 370-1 400 MHz, 2 640-2 655 MHz, 4 950-4 990 MHz and 15.20-15.35 GHz are also allocated to the space research (passive) and earth exploration-satellite (passive) services on a secondary basis.

Based on these allocations, establishment of a primary SRS allocation in this band requires the consideration of a variety of interference scenarios, as detailed in Table 2. An analysis of these environments to facilitate the identification of appropriate sharing conditions has been performed and is documented herein. Section 2 provides information on the SRS system characteristics used for this analysis. Section 3 provides example fixed service system characteristics for the 14.8-15.35 GHz band. Section 4 provides the key characteristics of the DRS system operating in this band. The criteria for protection of fixed service or mobile service stations from SRS emissions are derived in Section 5. Section 6 addresses interference to SRS receiving earth stations from fixed or mobile service transmissions. Section 7 derives sharing conditions for SRS (space-Earth) and receiving DRS operations. Protection of SRS (passive) and EESS (passive) links is not addressed at this time as none of these systems are known to exist in this band.

TABLE 2

Applicable interference scenarios

Interferer	Victim	Comments
SRS (space-to-Earth) Low-orbiting satellite GSO satellite	Receiving fixed/mobile service station	Line-of-sight propagation assumed
Transmitting fixed/mobile service station	SRS receiving earth station	Separation distances determined using the methods of Recommendation ITU-R SM.1448 assuming mode (1) propagation over an inland great-circle path (zone A2)
SRS (space-to-Earth) Low-orbiting satellite GSO satellite	Receiving DRS Adjacent Near antipodal	Line-of-sight propagation assumed
SRS (space-to-Earth) Low-orbiting satellite GSO satellite	SRS/EESS (passive)	No known use of the 15.20-15.35 GHz band under the provisions of RR No. 5.339

2 Characteristics of future high-rate SRS missions

These missions will be limited in number with an estimated three to five satellites per year worldwide, and will generally be either in a low-polar orbit or in an equatorial orbit with some at geostationary altitudes and others at the L1 or L2 libration points. The characteristics of the GSO and low-orbiting SRS satellites transmitting in the space-to-Earth direction are reflected in the link budgets given in Table 3. The links were assumed to support a data rate of 400 Mbit/s on the space-to-Earth link. The e.i.r.p. spectral density was adjusted so that the pfd limits of Recommendation ITU-R SA.510 would be satisfied at low 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 3

Example high-rate SRS mission link budgets

Frequency (GHz)	15	
Satellite altitude (km)	800	35 785
Data rate (Mbit/s)	400	
Modulation method	QPSK	
Transmitter power (W)	5.0	20.0
(dBW)	7.0	13.0
Filter, cable loss (dB)	–0.5	
Transmitting antenna diameter (m)	0.38	0.86
Transmitting antenna gain (dBi)	33.0	40.0
Antenna 3 dB beamwidth (degrees)	3.68	1.64
e.i.r.p. (dBW)	39.5	52.5
Beam-edge allowance (dB)	–3.0	
Path loss (dB)	–183.4	–208.1
Spectral pfd (dB(W/(m^2 · 4 kHz)))	–146.0	–157.6
Receiving antenna gain (dBi)	45.0	55.0
Receiver noise temperature (K)	100.0	
Elevation angle (degrees)	10.0	
Antenna noise temperature (K)	50.0	
Receiving system temperature (K)	150.0	
Modulation filter loss (dB)	–0.5	
Demodulator loss (dB)	–0.5	
Mean received E_b/N_0 (dB)	18.9	17.2
Theoretical E_b/N_0 (BER = 1×10^{-6}) (dB)	10.5	
Required E_b/N_0 (BER = 1×10^{-6}) (dB)	11.5	
Margin (dB)	7.4	5.7

3 Characteristics of fixed service systems in the 14.8-15.35 GHz band

Examples of typical fixed service system characteristics in the 14.8-15.35 GHz band are shown in Table 4. The parameter values for Systems A and B are taken from Recommendation ITU-R F.758. Systems C and D are typical of many other fixed service systems currently deployed.

TABLE 4

Example FS characteristics for the band 14.8-15.35 GHz

	Frequency band 14.8-15.35 GHz			
Modulation	**64-QAM (A)**	**QPSK (B)**	**4-FSK (C)**	**4-FSK (D)**
Capacity (Mbit/s)	140	4	6.3	12.6
Channel spacing (MHz)	28	10.5	5	10
Antenna diameter (m)	2.4	1.8	0.6	1.2
Antenna gain (maximum) (dBi)	49.0	45.0	36.5	42.5
Feeder/multiplexer loss (minimum) (dB)	2	0	2	2
Receiver IF bandwidth (MHz)	40	3.5	5	10
Receiver noise figure (dB)	4	4	5	7
Receiver thermal noise (dBW)	–124	–136	–132	–129
Nominal long-term interference (dBW)	–134	–146	–142	–139
Spectral density (dB(W/MHz))	–150.0	–149.8	–149.0	–149.0
Maximum low arrival angle single entry pfd(1) (dB(W/(m^2/MHz)))	–149.0	–147.0	–136.0	–142.0

(1) pfd = interference spectral density + feeder loss – antenna gain – gain (1 m^2) + 3 dB linear to circular polarization discrimination.

4 Characteristics of the DRS system operating in the 14.8-15.35 GHz band

The DRS network consists of several GSO-satellites used to relay signals between centrally located earth stations and low-orbiting user satellites. The DRS network uses frequencies allocated to the SRS in the 2 GHz and 13-15 GHz bands and bands allocated to the inter-satellite service in the 23/26 GHz bands. The frequency plan for the 14.8-15.35 GHz band segment is shown in Fig. 2. As shown, the DRS receives in this band. Earth-to-space transmissions include a frequency pilot, a multiple access (MA) signal to be retransmitted in the 2 025-2 110 MHz band and a single access (KSA2) signal to be transmitted in a band centred at 13.775 GHz. These Earth-to-space transmissions originate at earth stations located in the United States of America and on the island of Guam. Fig. 2 also shows that the DRS receives space-to-space transmissions from low-orbiting satellites. These transmissions are centred near 15 GHz and occupy a bandwidth up to 225 MHz.

FIGURE 1

Architecture of a DRS network (Recommendation ITU-R SA.1018)

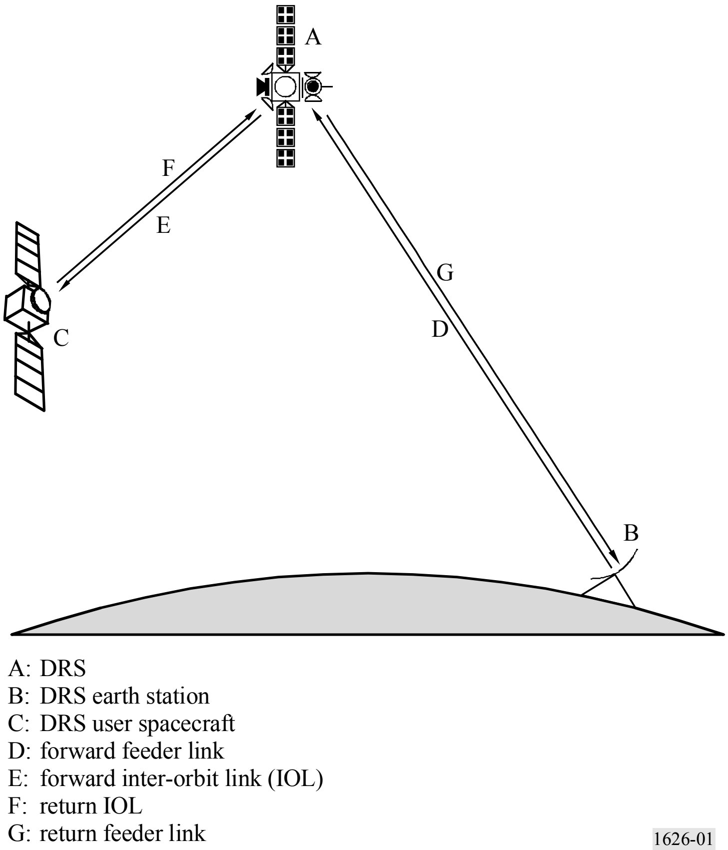
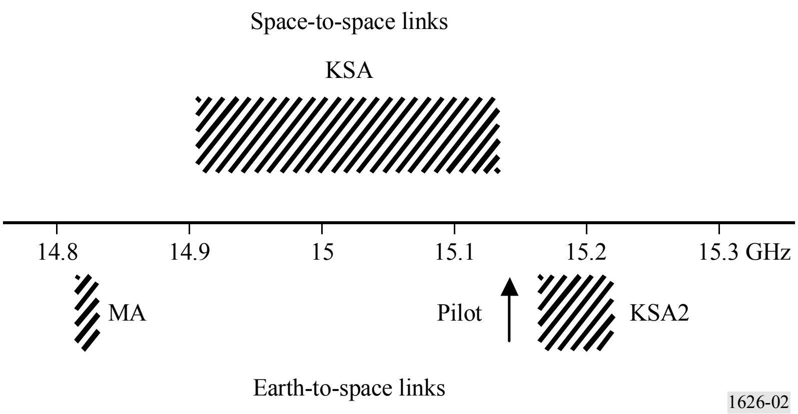


FIGURE 2

Frequency utilization of a DRS network in the band 14.8-15.3 GHz



5 Protection of fixed service/mobile service stations from interference from SRS space stations

The interference criterion to protect the fixed service from time varying aggregate interference, as would be exhibited by non-GSO SRS satellites, is taken from Recommendation ITU-R F.1494. This Recommendation applies to the band 10.7-12.7 GHz; however, the fixed service applications in the 14.8-15.35 GHz band have quite similar characteristics. Thus, this Recommendation could also be applied in this case. Consequently, the non-GSO interference criteria are given as:

– short term: I/N should not exceed +20 dB (hard limit);

– long term: The fractional degradation of performance (FDP) should not exceed 10%.

For GSO satellites, the following interference criteria are applied:

– the route FDP should not exceed 10% in more than 10% of the fixed service routes; and

– the station I/N should not exceed −10 dB in more than 10% of the fixed service receive stations.

Results of simulations of the probabilistic interference from SRS, based on assumed deployment of 24 satellites in GSO orbit, into digital point-to-point fixed service systems show that the pfd limits in the band 10.7-11.7 GHz are necessary to protect the fixed service in the band 14.8-15.35 GHz. These limits are given as follows:

$$-126 \text{ dB(W/(m}^2 \cdot \text{MHz))} \quad \text{for} \quad 0^\circ < \delta \le 5^\circ$$

$$-126 + 0.5(\delta - 5) \text{ dB(W/(m}^2 \cdot \text{MHz))} \quad \text{for} \quad 5^\circ < \delta \le 25^\circ$$

$$-116 \text{ dB(W/(m}^2 \cdot \text{MHz))} \quad \text{for} \quad 25^\circ < \delta \le 90^\circ$$

where δ is the angle of arrival above the horizontal plane (degrees).

These pfd limits should permit operation of the 400 Mbit/s space-to-Earth SRS links as required. However, a limited number of existing fixed service links could be adversely impacted if antennas of these stations are aligned with specific satellite GSO SRS orbit locations with co-channel emissions.

Results of simulation studies of interference from non-GSO SRS satellite systems into fixed service point-to-point systems show that sharing between these services is feasible in the band 14.8-15.35 GHz using pfd limits 2 dB higher than those applicable to the band 10.7-11.7 GHz, namely:

$$-124 \text{ dB(W/(m}^2 \cdot \text{MHz))} \quad \text{for} \quad 0^\circ \le \delta \le 5^\circ$$

$$-124 + 0.5(\delta - 5) \text{ dB(W/(m}^2 \cdot \text{MHz))} \quad \text{for} \quad 5^\circ < \delta \le 25^\circ$$

$$-114 \text{ dB(W/(m}^2 \cdot \text{MHz))} \quad \text{for} \quad 25^\circ < \delta \le 90^\circ$$

where δ is the angle of arrival above the horizontal plane (degrees).

6 Protection of SRS receiving earth stations from the emissions of fixed and mobile service stations

Additional characteristics of the fixed service systems in the band, which are given in Table 5, are used to assess the separation distances appropriate to satisfying the protection criteria of SRS earth stations based on Recommendation ITU-R SA.609, i.e. the interference should not exceed –216 dB(W/Hz) for more than 0.1% of the time for unmanned missions. Because of the relatively high data rate of the space-to-Earth links, a reference bandwidth of 4 kHz will be used. The resulting interference power level criterion is –180 dB(W/4 kHz).

The following methodology was used to assess the range of separation distances required to protect an SRS receiving earth station:

– determine the e.i.r.p. spectral density in the worst 4 kHz band of the fixed service transmitting stations listed in Table 4;

– determine the maximum gain of the SRS earth station receiving antenna in the direction of the transmitting fixed service station using Recommendation ITU-R SA.509;

– compute the minimum permissible basic transmission loss for maximum emissions and for isotropic emissions of fixed service stations in the direction of the SRS earth station; and,

– using the procedures of Recommendation ITU-R SM.1448, compute the separation distance required to achieve the minimum permissible basic transmission loss assuming mode (1) propagation over an inland path (defined as zone A2 in the Recommendation).

6.1 e.i.r.p. spectral density of fixed service transmitting stations

The power spectral density (psd) of an M-PSK and an M-QAM carrier modulated by a random data stream is maximum around the carrier frequency and when the symbol rate is large with respect to the reference bandwidth, is given by:

$$psd = P_{avg} T_S b_{ref} \tag{1a}$$

$$T_S = \frac{\log_2 M}{R_b} \tag{1b}$$

where:

psd: the psd in the reference bandwidth, b_{ref}, at the input to the transmitting antenna (W/b_{ref})

P_{avg}: average power at the output of the transmitter (W)

T_s: the duration of one symbol (s)

M: number of discrete states of the signal space of transmitted signal (numeric)

R_b: combined information and coding bit rate of the transmitted signal (bit/s).

6.2 Typical separation distances

The minimum permissible basic transmission loss is given by:

$$L_B = psd + G_T(\theta_{FS}) + G_R(\theta_{Rmin}) - I_{PC} \tag{2}$$

where:

L_B: minimum permissible basic transmission loss (dB)

I_{PC}: protection criteria (dBW/b_{ref})

psd: transmitter psd at the input to the transmitting antenna (dBW/ b_{ref})

b_{ref}: reference bandwidth (4 kHz)

$G_T(\theta_{FS})$: fixed service transmitting antenna gain in the direction of the SRS receiving station (dB)

$G_R(\theta_{Rmin})$: maximum SRS receiving antenna gain in the direction of the fixed service station (dB).

The SRS receiving antenna that conforms to the reference radiation pattern of Recommendation ITU-R SA.509 has a maximum gain of +7 dBi towards the horizon when pointed at a minimum elevation angle of 10º.

The minimum permissible basic transmission loss is determined using the procedures given in Recommendation ITU-R SM.1448 for:

– 15 GHz operating frequency;

– propagation over smooth Earth on an inland path (zone A2);

– mode (1) propagation, minimum permissible transmission loss exceeded for more than 0.1% of the time;

– receiving antenna of the SRS earth station is 10 m above the surface of the Earth;

– transmitting antenna of the fixed service station is 30 m above the surface of the Earth.

Using the assumptions given above and the procedures of Recommendation ITU-R SM.1448, the resulting mode (1) basic transmission loss as a function of the separation distance is as shown in Fig. 3.

A summary of the calculations to determine the separation distances is given in Table 5. Protection of SRS receiving earth stations from the emissions of fixed systems with the characteristics given in Recommendation ITU-R F.758 may be realized at separation distances as small as 18 km to 30 km under favourable conditions and at distances up to 200 km for less favourable conditions. These distances were determined for mode (1) propagation for an inland great-circle path over smooth Earth (zone A2) using the methodology in Recommendation ITU-R SM.1448. It is anticipated that these separation distances may decrease when such factors as frequency channelization plans, natural site shielding, terrain clutter and other terrain features are accounted for.

FIGURE 3

Basic transmission loss not exceeded for more than 0.1% of the time for mode (1) propagation for an inland path over smooth Earth: f = 15 GHz; h_1 = 10 m; h_2 = 30 m

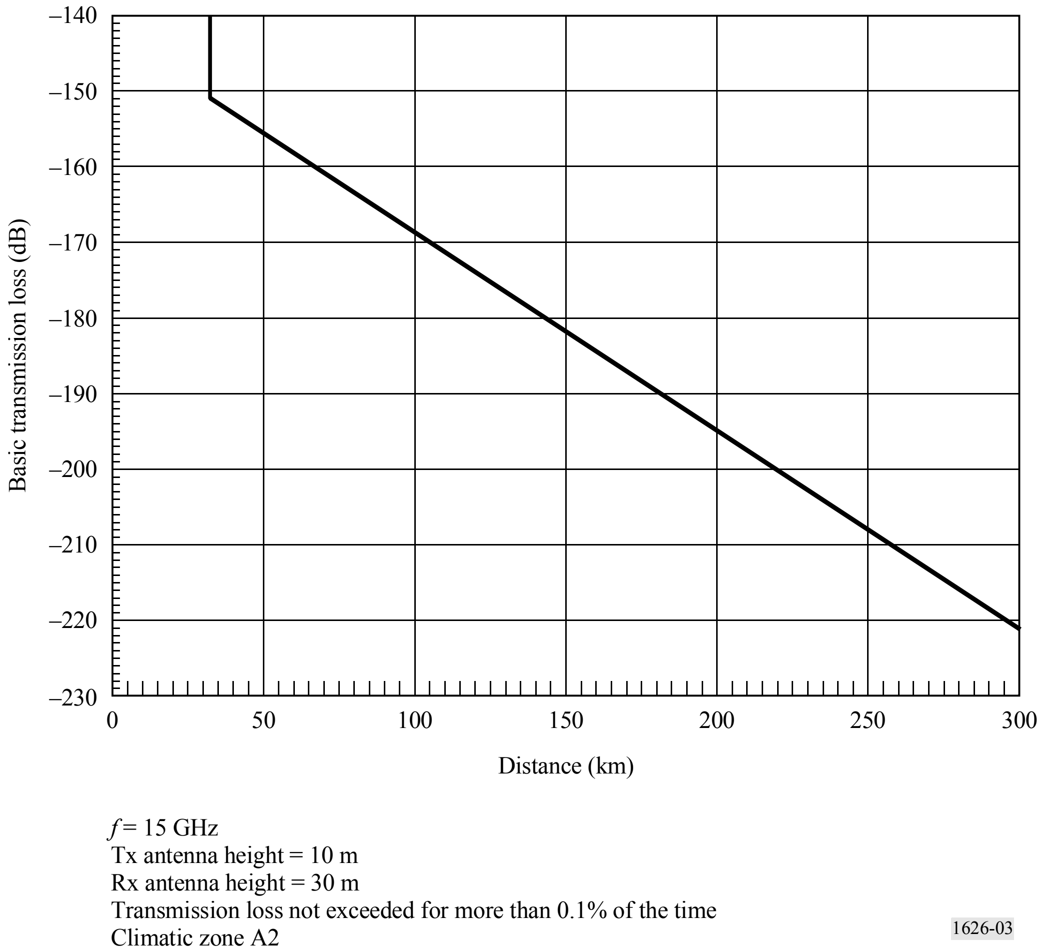


TABLE 5

Typical separation distances between an SRS receiving earth station and fixed service transmitting stations required to satisfy the protection criteria of Recommendation ITU-R SA.609: height of the SRS receiving antenna is 10 m above smooth Earth, and the fixed service transmitting antenna is 30 m above smooth Earth

Modulation	64-QAM		8-PSK	
Capacity (Mbit/s)	140		156	
Maximum Tx output power (dBW)	5		0	
Peak-to-average power (dB)	–3.7		0	
Output power backoff (dB)	–1.3		0	
Feeder/mux loss (dB)	–2		–5	
psd (dB(W/4 kHz))	–39.7		–46	
Antenna gain in the direction of the SRS earth station (dB)	0	49	0	52

TABLE 5 (*Continued*)

Modulation	64-QAM		8-PSK	
e.i.r.p. spectral density in the direction of the SRS earth station (dB(W/4 kHz))	–39.7	+9.3	–46	+6
Maximum antenna gain of the SRS earth station towards the fixed service station (dBi)	+7		+7	
Maximum interference (dB(W/4 kHz))	–180			
Minimum permissible basic transmission loss (dB)	–147.3	–196.3	–141	–193
Separation distance (km)	30(1)	200	18(1)	190

(1) This distance is within line-of-sight.

7 Protection of a DRS system from SRS space station emissions

There are three primary cases for which a GSO DRS will receive interference from the emissions of a satellite in the SRS:

Case 1: when a transmitting GSO SRS satellite is located adjacent to a receiving GSO DRS;

Case 2: when a transmitting GSO SRS satellite is in a near-antipodal location with respect to a receiving GSO DRS; and,

Case 3: when a transmitting low-orbiting SRS satellite passes within view of a receiving GSO DRS.

For these three cases, conditions required to satisfy the protection criteria of Recommendation ITU-R SA.1155 will be evaluated. For Cases 1 and 2, the psd at the input to the transmitting antenna of the GSO SRS satellite is –40.5 dB(W/kHz) based on the example characteristics given in Table 1. For Case 3, the psd at the input to the transmitting antenna of the SRS satellite at an orbital altitude of 800 km is –46.5 dB(W/kHz), also based on the example characteristics given in Table 1. Free-space propagation is assumed for all three cases.

The received interference psd and associated margin above the protection criteria are given by

$$I_R = psd + G_T(\theta_T) + G_R(\theta_R) - L_{bf} \tag{3a}$$

$$M = I_{PC} - I_R \tag{3b}$$

where:

I_R: received interference psd (dB(W/kHz))

I_{PC}: DRS protection criteria given in Recommendation ITU-R SA.1155 (dB(W/kHz))

M: margin above the interference criterion (dB)

L_{bf}: free-space basic transmission loss (dB)

psd: psd at the input to the transmitting antenna (dB(W/kHz))

$G_T(\theta_T)$: transmitting antenna gain of the SRS satellite in the direction of the DRS (dBi)

$G_R(\theta_R)$: receiving antenna gain of the DRS in the direction of the SRS satellite (dBi)

θ_T: angle between boresight of the transmitting antenna and the DRS (degrees)

θ_R: angle between boresight of the DRS receiving antenna and the SRS satellite (degrees).

The principal results from evaluating equation (3) for the three cases are summarized in Table 6.

TABLE 6

Level of interference to and the operating margin above the protection criteria of Recommendation ITU-R SA.1155 for a GSO DRS receiving interference from the space-to-Earth emissions of SRS satellites

	Case 1	**Case 2**		**Case 3**
psd (dB(W/kHz))	–40.5	–40.5		–46.5
$G_T(\theta_T)$	0	0		0
$G_R(\theta_R)$	0	0	53.3[(1)]	53.3[(1)]
Range (km)	11.9	83 360		34 985[(2)]
Basic transmission loss (dB)	137.5	214.4		206.8
I_R (dB(W/kHz))	–178	–254.9	–201.6	–200
I_{PC} (dB(W/kHz))	–178[(3)]	–178[(3)]		–178[(3)]
Margin (dB)	0	+76.9	+23.6	+22.0

(1) See Recommendation ITU-R SA.1414.

(2) Satellite at an altitude of 800 km located in the equatorial plane directly below the DRS.

(3) Protection criteria from Recommendation ITU-R SA.1155.

This analysis shows that an existing DRS network would be protected from the emissions of the example low-orbiting satellites and GSO satellites. It was found that the separation distance between a receiving GSO DRS and a transmitting GSO SRS satellite could be as little as 12 km (equivalent to an orbital separation of less than 0.02º). It was also found that a minimum protection margin of +23 dB existed for the near-antipodal case of GSO SRS satellite emissions in the direction of a receiving DRS. Similar results were found for the case of a low-orbiting SRS satellite transmitting in the space-to-Earth direction that is located within the main beam of the receiving antenna of the DRS. In this case, the margin of the interference with respect to the protection criteria given in Recommendation ITU-R SA.1155 was +22 dB.

8 Conclusions

Results of simulations of the probabilistic interference from SRS, based on assumed deployment of 24 GSO satellites, into digital point-to-point fixed service systems show that the pfd limits in the band 10.7-11.7 GHz are necessary to protect the fixed service in the band 14.8-15.35 GHz.

These limits are given as follows:

-126 dB(W/(m^2 · MHz)) for $0° < \delta \leq 5°$

$-126 + 0.5(\delta - 5)$ dB(W/(m^2 · MHz)) for $5° < \delta \leq 25°$

-116 dB(W/(m^2 · MHz)) for $25° < \delta \leq 90°$

where δ is the angle of arrival above the horizontal plane (degrees).

These pfd limits should permit operation of the 400 Mbit/s space-to-Earth SRS links as required. However, a limited number of existing fixed service links could be adversely impacted if antennas of these stations are aligned with specific GSO SRS orbit locations with co-channel emissions.

Results of simulation studies of interference from non-GSO SRS satellite systems into fixed service point-to-point systems show that sharing between these services is feasible in the band 14.8-15.35 GHz using pfd limits 2 dB higher than those applicable to the band 10.7-11.7 GHz, namely:

-12 dB(W/(m^2 · MHz)) for $0° < \delta \leq 5°$

$-12 + 0.5(\delta - 5)$ dB(W/(m^2 · MHz)) for $5° < \delta \leq 25°$

-114 dB(W/(m^2 · MHz)) for $25° < \delta \leq 90°$

where δ is the angle of arrival above the horizontal plane (degrees).

Protection of SRS receiving earth stations from the emissions of fixed systems with the characteristics given in Recommendation ITU-R F.758 may be realized at separation distances as small as 18 km to 30 km under favourable conditions and at distances up to 200 km for less favourable conditions. These distances were determined for mode (1) propagation for an inland great-circle path over smooth Earth (zone A2) using the methodology in Recommendation ITU-R SM.1448. It is anticipated that these separation distances may decrease when such factors as frequency channelization plans, natural site shielding, terrain clutter and other terrain features are accounted for.

The study showed that an existing DRS network would be protected from the emissions of the example low-orbiting satellites and GSO satellites. It was found that the separation distance between a receiving GSO DRS and a transmitting GSO SRS satellite could be as little as 12 km (equivalent to an orbital separation of less than 0.02°). It was also found that a minimum protection margin of +23 dB existed for the near-antipodal case of GSO SRS satellite emissions in the direction of a receiving DRS. Similar results were found for the case of a low-orbiting SRS satellite transmitting in the space-to-Earth direction that is located within the main beam of the receiving antenna of the DRS. In this case, the margin of the interference with respect to the protection criteria given in Recommendation ITU-R SA.1155 was +22 dB.