

RECOMMENDATION ITU-R S.1591

Sharing of inter-satellite link bands around 23, 32.5 and 64.5 GHz between non-geostationary/geostationary inter-satellite links and geostationary/geostationary inter-satellite links

(Question ITU-R 265/4)

(2002)

The ITU Radiocommunication Assembly,

considering

- a) that inter-satellite links (ISLs) within geostationary (GSO) satellite systems use, or are planned to use, the inter-satellite service (ISS) frequency allocations 22.55-23.55 GHz, 24.45-24.75 GHz, 32.0-33.0 GHz and 59.3-71.0 GHz;
- b) that ISLs between GSO and non-GSO satellites use, or are planned to use, the ISS frequency allocations 22.55-23.55 GHz, 24.45-24.75 GHz, 32.0-33.0 GHz and 59.3-71.0 GHz;
- c) that the ITU-R needs criteria and methods of calculation in order to assess the potential for ISLs of the type mentioned in *considering* b) to share frequencies with ISLs of the type mentioned in *considering* a);
- d) that the criteria and calculation methods mentioned in *considering* c) could possibly enable the Radiocommunication Bureau (BR) to process notices submitted in accordance with Appendix 4 of the Radio Regulations (RR) for spectrum for ISLs of the type mentioned in *considering* b);
- e) that the simulations described in Annex 1 show that instances of significant interference between co-frequency ISLs of the types mentioned in *considerings* a) and b) occur in only a small proportion of cases, and in those cases for only small percentages of the time;
- f) that Annex 1 also verifies that the maximum levels of interference occur when the non-GSO/GSO ISL is instantaneously in the Equatorial plane, and that those levels may therefore be calculated manually;
- g) that *considerings* e) and f) make it convenient for frequency sharing between the two types of ISL to be facilitated by coordination, and that coordination would not be needed in many cases;
- h) that the need to coordinate may be checked by calculating the minimum carrier-to-interference, C/I , ratios and comparing them with a simple threshold C/I ,

recommends

- 1 that frequency sharing between a non-GSO/GSO ISL and a GSO/GSO ISL is practical and in exceptional cases may require coordination;
- 2 that the need to coordinate should be determined by the method described in Annex 2;

3 that coordination should take place if the minimum C/I ratio in a bandwidth of 1 MHz at any of the four ISL receivers, calculated by the method in Annex 2, is less than either the C/N identified for that receiver in item C.8 e) of RR Appendix 4 + 3 dB or, in the absence of a C/N , 30 dB;

4 that, in cases where coordination is found to be necessary from *recommends* 2 and 3, Annex 1 may be used by the coordinating parties for guidance.

ANNEX 1

Investigation of interference between a non-GSO/GSO ISL and a GSO/GSO ISL

1 The feasibility of frequency sharing by ISLs

In general, systems with ISLs in microwave bands have or are expected to have antenna diameters between 0.5 and 2 m. The lowest frequency ISS allocation is 22.55 to 23.55 GHz, and in this frequency range a 0.5 m antenna has a gain of about 39 dBi and a half-power beamwidth of about 2°. For larger diameters and higher frequencies, the beamwidths can be a fraction of a degree.

The angular range over which an ISL antenna may be pointed is large, thus reducing the probability of conjunctions or near conjunctions with interfering ISLs. The number of systems using the ISS allocations in the year 2001 was small. It is anticipated that this number will grow, but will probably be limited by the introduction of optical communications in space, and in any case it could not be expected to be as many as the number of systems with fixed-satellite service (FSS) links, which successfully share frequencies by means of coordination.

Interference, to or from any ISL that has a non-GSO satellite, is dependent on time-varying geometry. Hence, instances of significant interference will occur for only short durations in situations at or very close to the worst-case geometry. At all other times the antenna discrimination at one or both ends of the interference path will be substantial and this will reduce the interference power.

2 Selection of ISL parameters for computation of interference statistics

From a BR database compiled from filings for spectrum assignments, the transmission parameters of ISLs of both types in all three frequency bands associated with a number of MEASAT GSO and MEASAT low Earth orbit (LEO) satellites (Malaysia) were obtained. Also obtained from this source were parameters of 32 GHz ISLs associated with satellites in the LUXSAT series (Luxembourg), and of 67 GHz ISLs associated with satellites in the SMO-GEO series (France). Additionally, relevant information on GSO/GSO ISLs was extracted from Recommendations ITU-R S.1151 (32.5 GHz), ITU-R S.1326 (51 GHz FSS band) and ITU-R S.1327 (62.2 GHz).

At the time of writing the United States of America has several space systems with ISLs in the ISS allocations between 56 GHz and 65 GHz; they are USBL, USFD, USGAE, USGX, USLL, and MILSTAR. Some of these systems are in the planning or design phase, others are under development, and others in operation. The orbits used by these systems include LEOs, high Earth orbits (HEOs) and the GSO. The orbit combinations for their ISLs include, *inter alia*, GSO to GSO, LEO to and from GSO, and HEO to and from GSO.

Finally, reference was made to Recommendation ITU-R S.1328 for orbital and other pertinent data on non-GSO FSS systems employing on-board processing, which might include ISLs in the bands of interest.

To keep the study within practicable bounds it was decided to review all of the available data and then compile sets of parameters for a LEO/GSO ISL, a medium Earth orbit (MEO)/GSO ISL and a GSO/GSO ISL, each of which is hypothetical but has characteristics which are typical of those in the filed systems. Four examples of the GSO/GSO ISL were included, and the parameters produced in this way are shown in Table 1.

For the non-GSO end of the non-GSO/GSO link the nearest satellite handover strategy was modelled. The antenna pattern modelled in each case was as defined by Recommendation ITU-R S.672 (single feed, –25 dB first sidelobe). Each ISL was treated as an individual link (i.e. no use was made of transmission gains coupling an ISL with a preceding or following link). The case of multiple satellites in an interfering system transmitting simultaneously toward the same satellite was not modelled; it is expected that this would lead to only slightly smaller minimum values of C/I than those in the present exercise; the minimum C/I instances would occur more often, but in practical cases would still aggregate to small percentages of time.

Since the e.i.r.p. required for a given ISL depends *inter alia* on its length, it was necessary to calculate the e.i.r.p. separately for each link, and this was done assuming an operating C/N of 15 dB at the input to each receiver, as follows:

$$e.i.r.p. - 20 \log (4 \times \pi \times d/\lambda) + G - 10 \log (k T B) = 15 \text{ dB}$$

where:

d : path length (m) (maximum in the non-GSO/GSO case)

λ : wavelength (m)

G : on-axis gain of the receiving antenna (dBi)

k : Boltzmann's constant (–228.6 dB(W/(Hz · K)))

T : link noise temperature referred to receiver input (K)

B : reference bandwidth (1 MHz).

TABLE 1

Parameters of typical inter-satellite links in ISS bands below 71 GHz

ISL type	LEO/GSO	MEO/GSO	GSO/GSO (A)	GSO/GSO (B)	GSO/GSO (C)	GSO/GSO (D)
Shape of orbits	Circular					
Height of orbits (km)	1 400	10 360	35 786			
Number of orbit planes	7 (+GSO)	4 (+GSO)	1			
Number of satellites per plane	9 (+1 in GSO)	6 (+1 in GSO)	2			
Non-GSO inclination (degrees)	48	82.5	0			
Ascending node displacement (degrees)	25.714	45	0			
True anomaly displacement (degrees)	0		Not available			
Longitude(s) of GSO satellite(s) (°E)	−3		0 and 159.3	0 and 158.74	0 and 133.23	0 and 9.99
Adjacent plane phasing (degrees)	28.57	45	Not available			
Hand-over strategy	Nearest LEO satellite	Nearest MEO satellite	Not available			
Satellite beam pointing method	Tracking		Fixed			
ISL antenna diameter (m)	1					
ISL antenna peak gain (dBi)	45.4 48.4 54.0					
23 GHz						
32.5 GHz						
62.2 GHz	54.0					
ISL antenna pattern	Recommendation ITU-R S.672 $L_N = -25$ dB					
ISL beamwidth (degrees)	0.91 0.65 0.34					
23 GHz						
32.5 GHz						
62.2 GHz						
ISL length (km)	Variable, maximum 43	Variable, maximum 45	83 128	82 877	77 396	7 339
C/N at receiver input (dB)	15					
e.i.r.p./MHz (dBW)	41.8	42.4	47.6	47.5	46.9	26.5
ISL system noise temperature (K)	700					