

RECOMMENDATION ITU-R S.1327

**REQUIREMENTS AND SUITABLE BANDS FOR OPERATION OF THE
INTER-SATELLITE SERVICE WITHIN THE RANGE 50.2-71 GHz**

(Question ITU-R 246/4)

(1997)

The ITU Radiocommunication Assembly,

considering

- a) that Resolution 643 of the World Radiocommunication Conference (Geneva, 1995) (WRC-95) instructs the ITU-R to carry out the necessary studies to identify the bands most suitable for the inter-satellite service (ISS) in order to enable the World Radiocommunication Conference (Geneva, 1997) (WRC-97) to make appropriate allocations to that service;
- b) that the technical and operational requirements of the ISS in the frequency range 50.2-71 GHz are identified in Annex 2 of this Recommendation;
- c) that the networks identified in Annex 2 typically require wide bandwidths, and typically form high data rate trunk links for the space segments of networks;
- d) that there is extensive planned use of the ISS in the range 50.2-71 GHz;
- e) that there is a potential for unacceptable interference from large numbers of inter-satellite links into the Earth exploration-satellite service (EESS) (passive) in this range;
- f) that there are no known existing or currently planned terrestrial or space systems in the current allocations in the range 65-71 GHz;
- g) that the absorption characteristics of the atmosphere to radio waves, within the range under consideration, may improve sharing conditions with terrestrial stations of other services;
- h) that studies have confirmed that sharing between the ISS and terrestrial services in the band 66-71 GHz is feasible (see Annex 3),

recommends

- 1 that the bands most suitable for the ISS in the range 50.2-71 GHz include:
 - 54.25-58.2 GHz, limited to networks employing geostationary-satellite orbit (GSO) satellites in accordance with [Recommendation ITU-R S.Doc. 4/1005];
 - 59-64 GHz;
 - 65-71 GHz;

- 2 that the allocations to the ISS in this frequency range be contiguous bands of sufficient width to accommodate the unique needs of the ISS.

NOTE 1 – [Recommendations ITU-R S.Doc. 4/1005] and ITU-R [7C/43] address feasibility of sharing between the ISS and spaceborne passive sensors in the frequency range 50-65 GHz.

NOTE 2 – Recommendation ITU-R S.1326 addresses sharing between the fixed-satellite service (FSS) and the ISS in the band 50.4-51.4 GHz.

NOTE 3 – Annex 1 to this Recommendation summarizes the sharing potential of the ISS with other services in the frequency range 50.2-71 GHz.

ANNEX 1

This Annex summarizes potential for the ISS sharing with the following services:

- a) Fixed service in the bands 50.2-51.4, 54.25-58.2 and 59-64 GHz

Sharing is feasible in these bands. However, the band 50.2-51.4 GHz may not be of sufficient bandwidth to accommodate ISS requirements.

b) FSS in the band 50.4-51.4 GHz

Studies have shown that sharing between GSO ISS and GSO FSS in this band would be feasible with certain mitigation techniques. However, sharing between other systems, such as GSO and non-GSO FSS sharing with non-GSO ISS may be difficult and requires further study (see Recommendation ITU-R S.1326).

c) Mobile service in the bands 50.2-51.4, 54.25-58.2, 59-64 and 66-71 GHz

Studies have shown that oxygen absorption, as well as antenna discrimination, will attenuate signals to an extent which will allow sharing with these systems.

d) EESS (passive) and space research service (SRS) (passive) in the bands 50.2-50.4 GHz, 51.4-59 GHz, 59-64 GHz, and 64-65 GHz

Studies have shown that there is potential for unacceptable interference from non-GSO systems utilizing the ISS in these bands. Sharing between GSO ISS or Hybrid ISS and EESS (passive) is feasible, and sharing conditions are given in [Recommendation ITU-R S.Doc. 4/1005]. In the band 59-64 GHz, existing non-GSO ISS systems could also cause harmful interference and possibly even damage to EESS (passive) sensors. It is recommended that passive sensors be made aware of the potential for interference from existing systems. It is also noted that there are no requirements for the EESS (passive) or SRS (passive) in the band 64-65 GHz, therefore, this band may be suitable for non-GSO ISS. However, this band is also allocated by footnote to the radio astronomy service (RAS), and no sharing studies have been carried out on the feasibility of the ISS to share with the RAS.

e) Radionavigation service (RNS) in the band 66-71 GHz

Studies have shown that oxygen absorption, as well as antenna discrimination will attenuate signals to an extent which could allow sharing between these systems. Information is required on the RNS service to enable firm conclusions to be drawn.

f) Mobile-satellite service (MSS) in the bands 66-71 GHz

Studies have shown that an interference potential would exist from the ISS into MSS spaceborne receivers for systems with similar orbital heights. However, sharing at similar orbital heights may also be possible if use is made of polarization discrimination. Other potential interference situations exist as the MSS has a bidirectional allocation. Interference between these systems requires further study.

g) Radionavigation-satellite service (RNSS) in the band 66-71 GHz

Studies have shown that an interference potential would exist from the ISS into RNSS spaceborne receivers for systems with similar orbital heights. However, sharing at similar orbital heights may also be possible if use is made of polarization discrimination. Other potential interference situations exist as the RNSS has a bidirectional allocation. Interference between these systems requires further study.

h) SRS and the EESS in the band 65-66 GHz

This band will not be used for spaceborne passive sensing; it is intended to be used for the transmission of data in the space-to-Earth direction. Liaison within the ITU-R revealed that there are no current plans for EESS or SRS systems in the band. Sharing between satellite networks in the EESS (space-to-Earth) and SRS (space-to-Earth), and those of the ISS is not expected to be difficult.

ANNEX 2

Characteristics and requirements of systems planning to use the ISS near 60 GHz

1 This Annex identifies systems operating, or planning to operate, in the ISS near 60 GHz. A distinguishing characteristic of these systems is the requirement for large bandwidths. ISS users typically form high data rate trunk links for the space segments of networks. A typical user of the networks might be a user of the FSS, or the MSS.

The typical user might be serviced by a 2.4 kbit/s voice link, or a 1.544 Mbit/s data link, and there might be as many as 250 000 end voice users on a single 1 Gbit/s inter-satellite link (ISL).

2 Estimated bandwidth requirements for ISS for systems near 60 GHz

In order to estimate the bandwidth required for operation of the GSO ISS, a survey of existing and planned GSO ISS systems was conducted. As of end-1996 there are ten GSO ISS systems planned for operation near 60 GHz, with 74 satellites and up to 178 GSO ISLs. Many of the planned GSO locations are crowded over regions of Europe and the United States of America. There are four proposed non-GSO ISS systems, with close to 1 000 satellites and nearly 8 000 links. Most of these systems are low-Earth orbiting systems.

2.1 Short ISLs (short links)

Short ISLs (system angle of 10° or less) are estimated to require up to 10° of orbital separation from co-frequency GSO ISS systems. Each node in a short link requires up to 2 GHz of bandwidth. With 10° of orbital separation required between each co-frequency short link, and 2° of orbital separation between any two GSO satellites, a factor of 5 is estimated to provide adequate spectrum for GSO ISS short links, for a total of 10 GHz.

2.2 Long ISLs (long links)

For long inter-satellite links (orbital separation greater than 10°), 2° of orbital separation between co-frequency GSO ISS systems is enough to achieve the performance criterion of $C/I \geq 30$ dB. Under these conditions, 4 GHz of spectrum is sufficient for frequency re-use, since at least one GSO ISS system is designed for a minimum of 4 GHz. However, there is no guarantee that 2° orbital separations can be maintained, especially in the crowded areas of the geostationary arc. A separation of 1° between systems would imply that twice as much spectrum is needed, as much as 8 GHz.

2.3 Growth

The above analysis does not account for the growth of GSO ISS systems. A growth factor of 1.5 can be used to estimate potential growth of the ISS in the near future (10-20 years). Applying the growth factor yields an estimated requirement of 15 GHz for short links, or 12 GHz for long link GSO ISS systems.

2.4 Estimated bandwidth requirements for non-GSO ISS for systems near 60 GHz

The total bandwidth estimated for the proposed non-GSO systems is 8.2 GHz. Allowing for a growth factor of 1.5, the estimated requirement for non-GSO systems is near 12 GHz.

2.5 Summary

Due to the orbital separations required between GSO ISS systems with short inter-satellite links, and to overcrowded conditions in certain regions of the geostationary arc, the estimated requirement for full use of planned and future GSO ISS systems is 15 GHz. For non-GSO systems, about 12 GHz is the estimate.

3 Additional work to be done

These data rates can be associated with the hypothetical digital reference path (HDRP) standards, to allow meaningful sensitivity to interference to be defined.

TABLE 1
GSO system characteristics

GSO systems	W-1	W-2a ⁽¹⁾	W-2b ⁽¹⁾	W-3	W-4	W-5	W-6	W-7	W-8	W-10
No. of satellites	3	4	15	12	17	4	2	2	5	10
No. of Tx/Rx pairs per satellite	2	2	2	2	2-4	2	1	1	2	1
Bandwidth (GHz)	1	3.2	0.04	0.5	1	1	0.12	0.12	1	2.5
Total bandwidth required (GHz)	2	3.2	0.08	1	4	2	0.24	0.24	2	5.0
Peak power (dBW)		16	-1	8.5	8	11.76	13	13	13	21
Peak e.i.r.p. (dBW)	71.3	75	57	54.5/63.5	68.3	64.78	63.3	62.1	68.7	75
Antenna gain (dBi)	58.5	60.3	58	46/55.5	60.3				55.7	53.5
Antenna diameter (m)	1.8	2		0.4/1.2	1.8		0.75	0.75	1	1
System noise temperature (K)	468.4	800	2 034		630		290	290	330	800
Rx G/T (dB(K ⁻¹))			24.9	19/28.5		19.8/25.9	23.4	23.4	27.4	24.5
Largest longitudinal separation angle (degrees)	145	163	163	141	163	17	34	24	100	106

(1) Any of the W-2 system nodes can communicate with other W-2 nodes.

TABLE 2
Non-GSO system characteristics

Non-GSO systems	LEOSAT 1	W-2c	W-2d	W-9
<i>Orbital parameters</i>				
No. of planes	21	10	12	12
No. of satellites per plane	44	1	1	6
Period (average) (min)	98.77	718.03	105	113
Inclination (average) (degrees)	98.16	63.4	55-110	47
Ascending node spacing (degrees)	9.5	Various	Various	30
Eccentricity		0.72	Various	0.0013
<i>RF parameters</i>				
No. of Tx/Rx pairs per satellite	8	2	2	4
Bandwidth of each beam (GHz)	1	3.2	3.2	1.5
Total bandwidth required (GHz)	2	3.2	3.2	3
Peak power (dBW)	7.4	16	16	4
Peak e.i.r.p. (dBW)	55.4	75	75	59.9
Antenna gain (dBi)	48	60.3	60.3	55.9
Antenna diameter (m)	0.5	2	2	1.2
System noise temperature (K)	438	800	800	501
Maximum geocentric separation angle (degrees)	19	—	—	30

NOTE 1 – Any of the W-2 system nodes can communicate with other W-2 nodes.

NOTE 2 – Maximum bandwidth cited. Lower bandwidths may also be used.