

## RECOMMENDATION ITU-R S.1328-1

**SATELLITE SYSTEM CHARACTERISTICS TO BE CONSIDERED IN FREQUENCY  
SHARING ANALYSES BETWEEN GEOSTATIONARY-SATELLITE ORBIT (GSO)  
AND NON-GSO SATELLITE SYSTEMS IN THE  
FIXED-SATELLITE SERVICE (FSS) INCLUDING FEEDER LINKS  
FOR THE MOBILE-SATELLITE SERVICE (MSS)\***

(Questions ITU-R 205/4, ITU-R 206/4 and ITU-R 231/4)

(1997-1999)

The ITU Radiocommunication Assembly,

*considering*

- a) that the World Radiocommunication Conference (Geneva, 1995) (WRC-95), in Resolutions 116 (WRC-95) and 117 (WRC-95), allocated frequencies to the FSS for use by feeder links of non-GSO MSS systems;
- b) that WRC-95, in Resolution 118 (WRC-95), provided for parts of the 30/20 GHz bands in the FSS to be used by the non-GSO FSS without the restrictions of Radio Regulations (RR) No. S22.2;
- c) that WRC-95, in Resolution 120 (WRC-95), provided for parts of the 30/20 GHz band in the FSS to be shared with feeder links of the non-GSO MSS;
- d) that WRC-95, in Resolution 121 (WRC-95), advocated the development of interference criteria and methodology for sharing between feeder links of the non-GSO MSS and networks of the GSO FSS;
- e) that the World Radiocommunication Conference (Geneva, 1997) in Resolution 130 (WRC-97), advocated the development of interference criteria and methodology for sharing between non-GSO FSS and networks of the GSO FSS,

*recommends*

- 1** that, in the planning and development of new FSS networks, both GSO and non-GSO, and feeder links for MSS systems affecting the FSS allocations, the technical characteristics of existing and planned satellite systems in Annexes 1 to 11 be taken into consideration;
- 2** that, in studies pertaining to the development of sharing criteria between satellite systems, the technical characteristics of existing and planned systems in Annexes 1 to 11 be used in interference analyses;
- 3** that administrations planning modifications to these systems or proposing future satellite system networks in FSS bands are urged to submit their technical characteristics to the ITU-R to update this data source.

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\* NOTE 1 – References to Ku bands refer to the 10-15 GHz bands.

References to Ka bands refer to the 17-30 GHz bands.

References to V bands refer to the 40-50 GHz bands.

## ANNEX 1

TABLE 1

## Technical characteristics of several LEO and GSO satellite networks

Parameters	Non-GSO MSS							
	LEO A	LEO B	LEO C	LEO D	LEO E	LEO F	LEO G	
<i>1 Orbital parameters</i>								
Shape of orbit	Circular	Circular	Circular	Circular	Elliptical	Circular	Circular	Circular
Height (km)	780	10 355	2 000	1 414	7 846 × 520	80-90	10 355	1 500
Inclination angle (degrees)	86	50	55	52	116.6	0	45	74
Coherence (track repeat (h))	–	–	–	47.5	3	4.8	–	–
Number of satellites per plane	11	4	5	6	5	7	5	12
Number of orbital planes	6	3	8	8	2	1	2	4
Satellite separation within plane (degrees)	32.7	90	45	60	72	51	–	30
Satellite phasing between planes (degrees)	31.6 (22)	30	–	7.5	36	–	0	90
<i>2 Targeted frequency range and polarization</i>								
Uplink frequency (GHz)	29.1-29.3	29.1-29.5	5.091-5.250	5.091-5.250	15.45-15.65	–	5.100-5.250	14
Uplink polarization	RHCP	LHCP	RHCP/LHCP	LHCP/RHCP	–	–	–	LHCP
Downlink frequency (GHz)	19.4-19.6	19.3-19.7	6.875-7.075	6.875-7.055	6.875-7.075	–	6.925-7.075	11
Downlink polarization	LHCP	RHCP	RHCP/LHCP	LHCP/RHCP	–	–	–	RHCP
<i>3 Spectrum required in each direction (MHz)</i>								
	200	400	200	159/180	200	–	100	50
<i>4 Carrier transmission parameters</i>								
Modulation type	FDMA/QPSK Rate ½, coded Rate 6.25 Mbit/s	CDMA	CDMA/FDMA	CDMA/FDMA	QPSK	QPSK	TDMA/QPSK	CDMA/FDMA
Number of service link beams	–	–	32	16	61	37	16,3	–
Number of feeder-link segments/polarization	–	–	1	8	31	31	–	–
Segment bandwidth (MHz)	–	–	12	16.5	12	12	–	–
Receiver bandwidth (kHz)	3 000	2 500	200	1 230	3 000/7 000	3 000/7 000	25	5 800
Transmission bandwidth (kHz)	4 370	2 500	2 500	1 230	3 000/7 000	3 000/7 000	25	5 800
Overall ( $C/N_0$ ) per user (dB/Hz) or ( $C/N$ ) (dB)	–	–	44.7-46.6	44	–	–	48	42 ( $E_b/N_0$ )

TABLE 1 (continued)

Parameters	Non-GSO MSS							
	LEO A	LEO B	LEO C	LEO D	LEO E		LEO F	LEO G
<i>4 Carrier transmission parameters (continued)</i>								
Uplink e.i.r.p./carrier (dBW)	ARC 34.0 to 43.5	54.25	40.2	54	50	50	47.5	49
Downlink e.i.r.p./carrier (dBW)	ARC 4.5 to 15.0	5.31	-8.5	-5	-	-	0	-6 (nadir)
Type of satellite transponder	Regenerative	Transparent	Transparent	Transparent	Transparent	Transparent	-	-
<i>5 Satellite antenna parameters</i>								
Tx maximum gain (dBi)	26.9, 2 dB axial ratio	35.7	3	2	11	15	13	5 (nadir)
Rx maximum gain (dBi)	30.1, 2 dB axial ratio	38.5	3	2	11	15	10	5 (nadir)
Main lobes	RR Appendix S8	-	-3 dB	ISO flux $\pm$ 2 dB	-	-	RR Appendix S30B	-
Side lobes	RR Appendix S8	-	-3 dB	-14 dB	-16 dB	-16 dB	-	-
Back lobes	-	-	-10 dB	-35 dB	-38 dB	-38 dB	-	-
Steerable antenna or not	(Programmed pointing) Steerable (4/SAT)	Steerable	No	No	No	No	No	No
<i>6 Earth station antenna parameters</i>								
Peak Tx gain (dBi)	56.3 (beamwidth 0.24°)	64.8	47.7	47.5	55.3		47.8	41
Peak Rx gain (dBi)	53.2 (beamwidth 0.36°)	60.8	50.2	50.0	48.2		50.7	42
Radiation pattern	RR Appendix S8	Rec. ITU-R S.465	Rec. ITU-R S.580	Rec. ITU-R S.465	-		Rec. ITU-R S.465	32.3 - 25 log $\phi$
Minimum operating elevation angle (degrees)	5 Acquisition 8.3 Service (auto tracking)	10	10	10	5		5	10
<i>7 Number of earth stations and distribution</i>								
	25 ww 7 USA	8-12	50-100	100-200	20-40		6-30	3 or more
<i>8 Earth station switching strategy</i>								
	Nom. 10° minimum, make before break	$\geq$ minimum elevation angle	Highest elevation angle	Select highest elevation angle	Highest and 2nd highest elevation angle		$\geq$ minimum elevation angle	

TABLE 1 (continued)

Parameters	Non-GSO FSS		LEO N user and feeder-links			
	LEO N	MEO V	User links	Feeder-links		
<i>1 Orbital parameters</i>						
Shape of orbit	Circular	Circular	Circular			
Height (km)	700	10 360	700			
Inclination angle (degrees)	82	82.5	82			
Coherence (track repeat (h))	46	24	46			
Number of satellites per plane	13	6	13			
Number of orbital planes	7	4	7			
Satellite separation within plane (degrees)	27.7	60	27.7			
Satellite phasing between planes (degrees)	25.7	45	25.7			
<i>2 Targeted frequency range and polarization</i>						
Uplink frequency (GHz)	12.75-13.25	29.5-29.9	1.98-2.01 2.675-2.69	19.3-19.6		
Uplink polarization	Circular	Circular	Circular	Circular		
Downlink frequency (GHz)	10.7-10.95	19.8-20.2	2.17-2.20	15.43-15.63		
Downlink polarization	Circular	Circular	Circular	Circular		
<i>3 Spectrum required in each direction (MHz)</i>						
	200	400	45 <sup>(1)</sup> /30 <sup>(2)</sup>	300 <sup>(1)</sup> /200 <sup>(2)</sup>		
<i>4 Carrier transmission parameters</i>						
Modulation type	FDM/TDMA/QPSK		CDMA/QPSK	TDMA/QPSK		
Number of service link beams	37		37	–		
Number of feeder-link segments/polarization	–		–	1		
Segment bandwidth (MHz)	–		–	–		
Receiver bandwidth (kHz)	Up 50 000 <sup>(3)</sup> ; 4 160 <sup>(4)</sup>	Down 50 000 <sup>(3)</sup> ; 4 920 <sup>(4)</sup>	Up 40 000 <sup>(3)</sup> ; 50 000 <sup>(4)</sup>	Down 50 000 <sup>(3)</sup> ; 40 000 <sup>(4)</sup>	1 250 <sup>(1)</sup> , 15 000 <sup>(2)</sup>	20 000 <sup>(1)</sup> ; 20 000 <sup>(2)</sup>
Transmission bandwidth (kHz)	50 000 <sup>(3)</sup> ; 4 160 <sup>(4)</sup>	50 000 <sup>(3)</sup> ; 4 920 <sup>(4)</sup>	40 000 <sup>(3)</sup> ; 50 000 <sup>(4)</sup>	50 000 <sup>(3)</sup> ; 40 000 <sup>(4)</sup>	1 250 <sup>(1)</sup> , 15 000 <sup>(2)</sup>	20 000 <sup>(1)</sup> ; 20 000 <sup>(2)</sup>
Overall ( $C/N_0$ ) per user (dB/Hz) or ( $C/N$ ) (dB)	6.5 dB ( $E_b/N_0$ )		6 dB ( $E_b/N_0$ )		6.5 dB ( $E_b/N_0$ )	6.5 dB ( $E_b/N_0$ )
Uplink e.i.r.p./carrier (dBW)	53.7 <sup>(3)</sup> ; 40.7 <sup>(4)</sup>		57-67 (ARC) <sup>(3)</sup> ; 45.8-55.8 (ARC) <sup>(4)</sup>		1.5	67.2
Downlink e.i.r.p./carrier (dBW)	90°:10.5; 65°:12.3; 45°:16.2; 20°:20 <sup>(3)</sup> 90°:11.9; 65°:13.7; 45°:17.6; 20°:21.4 <sup>(4)</sup>		43.6 <sup>(3)</sup> , 50.4 <sup>(4)</sup>		31.7	15.8
Type of satellite transponder	On-board processing		Transparent		Processing	Processing

TABLE 1 (continued)

Parameters	Non-GSO FSS		LEO N user and feeder-links	
	LEO N	MEO V	User links	Feeder-links
<i>5 Satellite antenna parameters</i>				
Tx maximum gain (dBi)	16.4	43.9	16.4	5.2
Rx maximum gain (dBi)	16.4	43.9	16.4	5.2
Main lobes	–	–	–	–
Side lobes	–	–	–	–
Back lobes	–	–	–	–
Steerable antenna or not	Yes	Yes	No	No
<i>6 Earth station antenna parameters</i>				
Peak Tx gain (dBi)	45 <sup>(3)</sup> ; 32 <sup>(4)</sup>	55.6 <sup>(3)</sup> ; 43.2 <sup>(4)</sup>	3	48.4
Peak Rx gain (dBi)	43.5 <sup>(3)</sup> ; 32 <sup>(4)</sup>	52.1 <sup>(3)</sup> ; 39.7 <sup>(4)</sup>	3	48.4
Radiation pattern	Rec. ITU-R S.580 <sup>(3)</sup> Rec. ITU-R S.465 <sup>(4)</sup>	Rec. ITU-R S.580 <sup>(3)</sup> Rec. ITU-R S.580 <sup>(4)</sup>	Not yet defined	Rec. ITU-R S.465
Minimum operating elevation angle (degrees)	10	40	10	10
<i>7 Number of earth stations and distribution</i>				
	–	–	Up to 4 million	Up to several dozens
<i>8 Earth station switching strategy</i>				
	By programme	By programme	≥ minimum operating elevation angle	Maximum duration of communication session

TABLE 1 (continued)

Parameters	Non-GSO/MSS	GSO FSS					GSO MSS
	LEO	GSO 1	GSO 2	GSO 3	GSO 13	GSO 20	
<i>1 Orbital parameters</i>							
Shape of orbit	Circular				Circular	Circular	Circular
Height (km)	1 000	36 000	36 000	36 000	36 000	36 000	36 000
Inclination angle (degrees)	83	–	–	–	0	–	–
Coherence (track repeat (h))	–	–	–	–	–	–	–
Number of satellites per plane	1	–	–	–	17	–	–
Number of orbital planes	7	–	–	–	1 (GSO)	–	–
Satellite separation within plane (degrees)	–	–	–	–	At least 2 for co-channel sharing	–	–
Satellite phasing between planes (degrees)	51.4	–	–	–	Not applicable	–	–
<i>2 Targeted frequency range and polarization</i>							
Uplink frequency (GHz)	7	6	6	14	30	30	30
Uplink polarization	RHCP	Circular	Circular	V and H	Circular with re-use	LHCP/RHCP	LHCP/RHCP
Downlink frequency (GHz)	5	4	4	12	20	20	20
Downlink polarization	LHCP	Circular	Circular	V and H	Circular with re-use	LHCP/RHCP	RHCP
<i>3 Spectrum required in each direction (MHz)</i>	50 up 66 down	500	500	500	1 000-2 500	1 000	500
<i>4 Carrier transmission parameters</i>							
Modulation type	CDMA/FDMA	FM/TV	64 kbit/s	FM/TV	FDMA up/FDMA down	FDMA/QPSK	FDMA/QPSK
Number of service link beams	–	–	–	–	48	8	4
Number of feeder-link segments/polarization	–	–	–	–	Not applicable	–	–
Segment bandwidth (MHz)	–	–	–	–	Not applicable	–	–

TABLE 1 (continued)

Parameters	Non-GSO/MSS	GSO FSS					GSO MSS
	LEO	GSO 1	GSO 2	GSO 3	GSO 13	GSO 20	
<i>4 Carrier transmission parameters (continued)</i>							
Receiver bandwidth (kHz)	2 050	30 000	51.2	27 000	500 uplink/ 120 000 downlink	241 up	1 800
Transmission bandwidth (kHz)	2 050	30 000	51.2	27 000	340 uplink/ 81 000 downlink	1 800 down	1 800
<i>5 Satellite antenna parameters</i>							
Tx maximum gain (dBi)	3				46.5/35.0	48.9	40.9
Rx maximum gain (dBi)	3				46.5/35.0	48.9	40.9
Main lobes	–				ex-CCIR Report 558	RR Appendix S30B	RR Appendix S30B
Side lobes	–				ex-CCIR Report 558	–	–
Back lobes	–				ex-CCIR Report 558	–	–
Steerable antenna or not	No				No, fixed pointed array	Yes	Yes
<i>6 Earth station antenna parameters</i>							
Peak Tx gain (dBi)	43.1	57.8	51.6	62.3	44.5/53.3	34.0-43.5	37.5-43.5
Peak Rx gain (dBi)	48.5	54.0	47.7	60.2	44.5/53.3	30.5-40.0	34.0-40.0
Radiation pattern	$29 - 25 \log \phi$	–	–	–	$29 - 25 \log \phi$	$32 - 25 \log \phi$	$32 - 25 \log \phi$
Minimum operating elevation angle (degrees)	10	–	–	–	5	10	10
<i>7 Number of earth stations and distribution</i>	4 or more				Unlimited, through urban and suburban areas and certain rural areas		
<i>8 Earth station switching strategy</i>					Not needed/used	Not applicable	Not applicable

TABLE 1 (continued)

Parameters	Non-GSO FSS			FSS	
	MEO J	MEO K	LEO SAT-1	GSO 30	QUASI-GSO 31
<i>1 Orbital parameters</i>					
Shape of orbit	Circular	Circular	Circular	Circular	Elliptical
Height (km)	13 900	13 900	700	36 000	1 000-43 000
Inclination angle (degrees)	75	75	98.2	–	63
Coherence (track repeat (h))	8	8	Not applicable	–	12
Number of satellites per plane	1	1	40	1	1
Number of orbital planes	9	9	21	12	8
Satellite separation within plane (degrees)	Not applicable	Not applicable	9	–	–
Satellite phasing between planes (degrees)	73.5	73.5	Random	–	Varies
<i>2 Targeted frequency range and polarization</i>					
Uplink frequency (GHz)	29.5-30	27.6-28.6	28.6-29.1	30	30
Uplink polarization	LHCP/RHCP	LHCP/RHCP	LHCP/RHCP	RHCP/LHCP	RHCP/LHCP
Downlink frequency (GHz)	19.7-20.2	17.8-18.8	18.8-19.3	19	19
Downlink polarization	LHCP/RHCP	LHCP/RHCP	LHCP/RHCP	RHCP/LHCP	RHCP/LHCP
<i>3 Spectrum required in each direction (MHz)</i>	500	1 000	500	1 000-3 200	1 000-3 200
<i>4 Carrier transmission parameters</i>					
Modulation type	QPSK FDMA/TDMA up TDM down	TCM TDM	Shaped QPSK FDMA up/ TDMA down	Phase	Phase
Number of service link beams	256	256	< 49 per satellite	–	–
Number of feeder-link segments/polarization	–	–	–	–	–
Segment bandwidth (MHz)	–	–	–	–	–



TABLE 1 (*end*)

Parameters	Non-GSO FSS			FSS	
	MEO J	MEO K	LEO SAT-1	GSO 30	QUASI-GSO 31
<i>4 Carrier transmission parameters (continued)</i>					
Receiver bandwidth (kHz)	250 000	125 000	0.275-35.2 (MHz)	3 200 000	3 200 000
Transmission bandwidth (kHz)	125 000	125 000	500 (MHz)	3 200 000	3 200 000
<i>5 Satellite antenna parameters</i>					
Tx maximum gain (dBi)	–	–	29.8 (90°), 30.9, 32.0 (40°)	55	55
Rx maximum gain (dBi)	–	–	29.8 (90°), 30.9, 32.0 (40°)	55	55
Main lobes	–	–	–	ex-CCIR Report 558	ex-CCIR Report 558
Side lobes	–	–	–	ex-CCIR Report 558	ex-CCIR Report 558
Back lobes	–	–	–	ex-CCIR Report 558	ex-CCIR Report 558
Steerable antenna or not	No	No	64 steerable beams	Yes	Yes
<i>6 Earth station antenna parameters</i>					
Peak Tx gain (dBi)	45	62.1	36	70	70
Peak Rx gain (dBi)	41.5	58.6	33	70	70
Radiation pattern	29 – 25 log $\phi$	29 – 25 log $\phi$	RR Appendix S8, Annex III	RR Appendix S8	RR Appendix S8
Minimum operating elevation angle (degrees)	–	10	40	5	5
<i>7 Number of earth stations and distribution</i>	$\pm 90^\circ$ of coverage latitude bounds Unlimited within coverage	$\pm 90^\circ$ of coverage latitude bounds	Up to 20 million, worldwide	Global	Global
<i>8 Earth station switching strategy</i>	Best elevation	–	Track nearest satellite		

ARC: Automatic Range Compensation

LHCP: left-hand circular polarization

RHCP: right-hand circular polarization

(1) Uplink.

(2) Downlink.

(3) Feeder link/gateway.

(4) Service link/user station.

## ANNEX 2

TABLE 2

## Technical characteristics of feeder links of GSO MSS satellite networks

Parameters	GSO-C	GSO-D	GSO-E	GSO-F	GSO-G	GSO-H
<b>2 Frequency range (GHz)</b>						
Uplink	12.75-13.25	12.75-13.25	6	28.75-28.6/29.5-30.0	27.5-29.5	27.5-29.5
Downlink	10.7-10.95	11.2-11.45	4	18.55-18.80/19.7-20.2	18.4-19.7	18.4-19.7
<b>3 Spectrum requirements in each direction (MHz)</b>	200	150	50	250/500 up 250/500 down	1 300	1 300
<b>4 Carrier transmission parameters</b>						
Carrier type	600HG1ECF, 2K40G1EDF, 5K25G1EDF, 12K0G1EDF, 56K0G1EDF	2K40G1EDF, 4K80G1EDF, 32K0M7EDT, 144KG1EDF, 1M25G1EDC	QPSK/TDMA	FDM/TDMA/QPSK up TDM/QPSK down	QPSK	QPSK
Receiver bandwidth (kHz)	0.75-70	3-90	30	125 000	76.8	76.8
Allocated bandwidth (kHz)	5-100	5-1 250	33	125 000	84.5	84.5
Overall ( $C/N_0$ ) (dB(Hz))	32-58	41-57	48	19.4 up/14.1 down per user	66.6	66.6
Uplink e.i.r.p./carrier (dBW)	34-47	36-52.0	53.2	53.2	67.5	61.5
Downlink e.i.r.p./carrier (dBW)	-8 to 5	-2 to 14	3.8	61.8	40.6	34.6
<b>5 Satellite antenna parameters</b>						
Peak Tx gain (dBi)	30 at all frequencies	30 at all frequencies	20	49.0	-	-
3 dB bandwidth (degrees)	-	-	17.8	-	-	-
Peak Rx gain (dBi)	-	-	20	49.0	-	-
3 dB bandwidth (degrees)	-	-	17.8	-	-	-
Sidelobe gain or pattern			RR Appendix S30B standard	RR Appendix S30B	Rec. ITU-R S.672	Rec. ITU-R S.672
Roll-off pattern			RR Appendix S30B standard	-	Square law	Square law
Steerable antenna or not	None	None	No	Fixed points		
<b>6 Earth station antenna parameters</b>						
Maximum Tx gain (dBi)	61.3 at 13 GHz	61.3 at 13 GHz	50.2	57.2	49.2	55.2
Maximum Rx gain (dBi)	60.0 at 11 GHz	60.0 at 11 GHz	45.5	53.5	45.7	51.7
Radiation pattern	Rec. ITU-R S.580	Rec. ITU-R S.580	Rec. ITU-R S.580	Rec. ITU-R S.465	Rec. ITU-R S.580	Rec. ITU-R S.580
Minimum elevation angle (degrees)	25	25	5	10	10	10
<b>7 Number of earth stations and distribution</b>	Diversity pair	Diversity pair	Up to 30	Unlimited	-	-

TABLE 3

## Technical characteristics of GSO satellite networks using FSS frequency bands

1a Frequency band (GHz)	6/4 (Conv.)				6/4 (Allot.)	14/12 (Conv.)		14/12 (Allot.)	30/20		
1b System	GSO 1	GSO 2	GSO 5	GSO 6	GSO 9	GSO 3	GSO 7	GSO 10	GSO 11	GSO 12	GSO 13
Number of co-located satellites	1				1	1		1	1	1	2
Number of beams/satellite and polarization	2 and RHCP + 2 and LHCP					V and H		V and H	7V and 7H	1 circular polarization	24 and RHCP + 24 and LHCP
2 Spectrum required in each direction (MHz)	500				300	500		500	800	1 000	1 000-2 500
3a Uplink carrier	FM/TV		64 kbit/s IDR			FM/TV	64 kbit/s		147 Mbit/s	65 Mbit/s	384 kbit/s
Beam identification	Global	Hemi	Global	Hemi		Spot	Spot		Spot	Spot	Spot (global)
Occupied bandwidth	30 MHz	30 MHz	51.2 kHz	51.2 kHz		27 MHz	51.2 kHz		110 MHz	110 MHz	500 kHz
Minimum required $C/N$ or $E_b/N_0$ (dB)											8
3b Downlink carrier	Same as uplink				Same as uplink	Same as uplink		Same as uplink	Same as uplink		Data mask
Occupied bandwidth (MHz)	Same as uplink				Same as uplink	Same as uplink		Same as uplink	Same as uplink		120
Minimum required $C/N$ or $E_b/N_0^{(1)}$ (dB)	17.7		9.7			17.7	9.7				5
4 Uplink parameters											
Transmitter power to antenna (dBW)									20		-11.5 to -3.5 (power control)
Transmitting antenna size (m)									5	11.5	0.66
Transmitting antenna gain (dBi)	57.8	57.8	51.6	51.6	52.5	62.3	55.5	50.7	61.9	69.0	44.3
e.i.r.p. (dBW)	85.4	87.8	48.3	46.1	6.6 <sup>(2)</sup>	86.3	40.9	14.6 <sup>(2)</sup>	81.9	91.0	32.8-40.8 (power control)
Peak system $G/T$ (dB(K <sup>-1</sup> ))									21.8		18.9
Receiving antenna beamwidth (degrees)											0.9
Receiving antenna side-lobe pattern											
Steerable or not											No

TABLE 3 (end)

5 Downlink parameters											
Transmitter power to antenna (dBW)									6	12.5	
Peak transmitting antenna gain (dBi)									49.5	33.0	46.5
Peak e.i.r.p. (dBW)	30.5	35.0	0.5	0.9	-35.6 <sup>(2)</sup>	50.0	7.7	-21 <sup>(2)</sup>	55.5	39.0	59
Transmitting antenna beamwidth (degrees)									0.44	1.4	
Receiving antenna size (m)									5	0.66	
Peak receiving antenna gain (dBi)	54.0	54.0	47.7	47.7	49.1	60.2	53.5	49.4	58.4	33.0	41.0
6 Earth segment											
Number of earth stations										600 000	
Distribution of earth stations										Home and business location	

IDR: intermediate data rate.

(1) For GSO 1-GSO 12, this is the C/N for the overall link (uplink and downlink).

(2) The e.i.r.p. is given in dB(W/Hz). The total e.i.r.p. is given in Annex 1 of Appendix S30B as the indicated e.i.r.p. density averaged over the necessary bandwidth.

## ANNEX 3

TABLE 4

## Technical characteristics of planned 30/20 GHz GSO FSS networks

<i>Satellite system</i>	A	A'	B	J	K	L	M	N	S	T	U
<i>General parameters</i>											
Nominal frequency (GHz)	20/30	20/30	20/30	20/30	20/30	20/30	20/30	20/30	20/30	20/30	20/30
Number of transponders per satellite	64	64	48	48	40						48
Transponder bandwidth (MHz)	120	250	120	120	120	120	120	24	120	54	36
Transponder high power amplifier (W)	30	30	20	30	60			95		40-60	60-90
Satellite e.i.r.p. (dBW) <sup>(1)</sup>	61	61	59	61	61	60	60.2	54	58	61	51-55
Polarization <sup>(2)</sup>	Circular	Circular	Circular	Circular	Circular	Circular	Circular	Circular	Circular	Linear	Linear
<i>Downlink parameters</i>											
Modulation/access	TDM	CDMA	TDM	TDM	TDM	TDM	TDM	TDM	TDM	PSK/MCPC	PSK/MCPC
Central frequency (GHz)	19.5	19.5	19.5	19.5	19.7	19.5	19.95	19.5	20.0	19.92	18.95
Data rate (Mbit/s)	92	95.04	92	155	92	155	130	40	90	51.84	38.88
Digital service <sup>(3)</sup>	Narrow-band data	Narrow-band data	Narrow-band data	Narrow-band data	Narrow-band data	Narrow-band data	Narrow-band data	Narrow-band data	Narrow-band data	SC/TV	SC/TV
e.i.r.p. spectral density (dB(W/Hz))	-23.6	-26.6	-21.3	-25.9	-20.8	-20.8	-20.9	-22.0	-22.6	-16.3	-18.0
<i>Uplink parameters</i>											
Central frequency (GHz)	29.5	29.5	29.5	29.5	29.5	29.5	29.75	29.5	30.0	29.72	28.75
Modulation/access	CDMA	CDMA	FDM	FDM	FDM	FDM	FDM	FDM	FDM	TV/MCPC	TV/MCPC
Nominal rate (kbit/s)	384	384	384	384	384	384	128	384	384	51 840	38 880
Minimum earth station antenna diameter (m)	0.66	0.66	0.66	0.66	0.70	0.70	0.65	0.75	0.70	4.6/0.6	4.6/0.6
Up/down earth station antenna discrimination at 2° (dB)	22.5/19	22.5/19	22.5/19	22.5/19	23/19.5	23/19.5	22.5/19	23.5/20	23/19.5	40/18	40/18
Maximum power spectral density (dB(W/Hz))	-61.7	-70	-60.5	-58.9	-57.9	-57.9	-65.9	-63.7	-58.9	-61.1	-61.9

TABLE 4 (end)

<i>Satellite system</i>	V	W	X	Y	Z
<i>General parameters</i>					
Nominal frequency (GHz)	20/30	20/30	20/30	20/30	20/30
Number of transponders per satellite					360 <sup>(4)</sup>
Transponder bandwidth (MHz)	125				25-120
Transponder high power amplifier (W)	40				
Satellite e.i.r.p. (dBW) <sup>(1)</sup>	60-62	22.6	62.8		70 <sup>(5)</sup>
Polarization <sup>(2)</sup>	Circular				Linear
<i>Downlink parameters</i>					
Modulation/access	TDM	TDM	FDM		TDM/FDM/CDMA
Central frequency (GHz)	20	20	20.2	17.7-20.2	<sup>(6)</sup>
Data rate (Mbit/s)	92.16	0.064	1.544/0.384		To be determined
Digital service <sup>(3)</sup>	Narrow-band data	Narrow-band data	Narrow-band data/video		
e.i.r.p. spectral density (dB(W/Hz))	-19.1	-25.5	-23.1/-16.0	-63/-38	-4.1
<i>Uplink parameters</i>					
Central frequency (GHz)	30	30	30	27.5-30.0	<sup>(6)</sup>
Modulation/access	FDM	FDM	FDM		TDM/FDM/CDMA
Nominal rate (kbit/s)	384	64	1 544/384		
Minimum earth station antenna diameter (m)	0.70	0.60	1.0/0.3		0.3-12.0
Up/down earth station antenna discrimination at 2° (dB)	23/19.5	21.5/18	26/12		Rec. ITU-R S.580
Maximum power spectral density (dB(W/Hz))	-58.8	-45.1	-65.9/-56.8	-40	-44.0

MCPC: multi-channel per carrier

SC: single carrier

(1) Estimated peak e.i.r.p. values of spot beams, with edge of coverage of spot beams from 3 to 5 dB below peak.

(2) Left- and right-hand circular polarization used for up and downlinks.

(3) Narrow-band digital data rates may include mixtures of 64, 128, 384 and 1 544 kbit/s.

(4) Co-location of six or more satellites providing a total of 360 transponders with 25 MHz bandwidth. Where larger bandwidths are used the number of transponders will vary.

(5) In compliance with No. 2578 of the Radio Regulations (edition of 1994).

(6) Uplink frequency (GHz): 18.1-18.2/27.5-28.0/28.0-31.0.

Downlink frequency (GHz): 21.9-22.0<sup>(7)</sup>, 21.4-21.9<sup>(7)</sup>/18.2-21.2.

(7) Downlink operation in accordance with RR Resolution 525 (WARC-92).

TABLE 5  
**Technical characteristics of planned 30/20 GHz GSO FSS networks**  
**Satellite system P**

Type of satellite/service	GSO FSS			
	Transparent		Regenerative	
Type of transponder				
Type of carrier	Ka-1	Ka-2	Ka-3	Ka-4
Up and/or downlink	Up and down	Up and down	Up	Down
Frequencies (GHz)				
Earth-to-space/space-to-Earth	30/20	30/20	30/20	30/20
Uplink e.i.r.p. (dBW)				
Minimum	73.0	66.1	37.7	–
Maximum	77.0	70.1	41.7	–
Earth station peak Tx gain (dBi)	63.7	63.7	45.1	–
Uplink free-space path length (dB)				
Minimum	213.1	213.1	213.1	213.1
Maximum	214.2	214.2	214.2	214.2
Downlink e.i.r.p. (dBW)				
Maximum	62.0	57.0	–	62.5
Minimum	58.0	53.0	–	58.5
Satellite peak Tx/Rx gain (dBi)	53.2	53.2	47.7	46.2
Earth station peak Rx gain (dBi)	60.1	60.1	–	41.6
Earth station Tx/Rx diameter (m)	6.0/6.0	6.0/6.0	0.66/–	–/0.66
Satellite Tx/Rx 3 dB beamwidth (degrees)	0.3/0.3	0.3/0.3	–/0.6	0.6/–
Occupied bandwidth (MHz)	186.6	186.6	0.333	115
Downlink free-space path length (dB)				
Minimum	209.5	209.5	209.5	209.5
Maximum	210.6	210.6	210.6	210.6
Earth station elevation angle to satellite (degrees)				
Minimum	10	10	10	10
Maximum	90	90	90	90
Intersatellite links (Yes or No)	Yes	Yes	Yes	Yes
On-board processing (Yes or No)	No	No	Yes	Yes
Message type (voice, data, video, paging, messaging, etc.)	All	All	All	All
Reference information data rate (Mbit/s) <sup>(1)</sup>	155.52	155.52	0.384	120
Modulation	QPSK	QPSK	QPSK	QPSK
FEC (type)	1/2 convolutional	1/2 convolutional	3/4 convolutional and Reed- Solomon	2/3 convolutional and Reed- Solomon
Spectral shaping factor	1.2	1.2	1.2	1.2
Network performance (design values): BER and performance mask				
4% of year	$1 \times 10^{-9}$	$1 \times 10^{-9}$	Not applicable	Not applicable
1% of year	Not applicable	Not applicable	$1 \times 10^{-10}$	$1 \times 10^{-10}$
0.6% of year	$1 \times 10^{-8}$	$1 \times 10^{-8}$	Not applicable	Not applicable
0.5% of year	Not applicable	Not applicable	$1 \times 10^{-8}$	$1 \times 10^{-8}$
0.04% of year	$1 \times 10^{-6}$	$1 \times 10^{-6}$	Not applicable	Not applicable
BER threshold	$1 \times 10^{-6}$	$1 \times 10^{-6}$	$1 \times 10^{-8}$	$1 \times 10^{-8}$
Required C/N (dB)	6.9	6.9	5.8	4.8
Required margin (dB)	18	12	2.5	2.5

(1) The above information data rates may vary according to traffic/user requirements, and should be taken as reference for general analysis.

TABLE 6

**Technical characteristics of a planned 30/20 GHz GSO/FSS networks using on-board processing  
Satellite system Q**

	Residential terminals	Business VSAT	Gateway
<i>1 Frequency range and polarization</i>			
Uplink frequency (GHz)	29.5-30.0	28.35-30.0	28.35-29.5
Uplink polarization	LHCP/RHCP	LHCP/RHCP	LHCP/RHCP
Downlink frequency (GHz)	19.7-20.2	18.55-20.2	18.55-19.7
Downlink polarization	LHCP/RHCP	LHCP/RHCP	LHCP/RHCP
Spectrum in each direction (MHz)	Up to 500	Up to 1 500	Up to 1 000
Transponder bandwidth (MHz)	110-120	110-120	110-120
<i>2 Uplink transmission parameters</i>			
Access technique	MF-TDMA	MF-TDMA	TDMA
Modulation type	O-QPSK/PFMO	O-QPSK/PFMO	O-QPSK/PFMO
User bit rate (Mbit/s)	0.512-2.048	2.048	65.536
Nominal carrier bandwidth (MHz)	0.8-3.0	3.0	110.0-115.0
Transmit earth station size (m)	0.45-0.75	1.2-1.8	3.0
Transmit earth station gain (dBi)	41.0-45.5	49.5-53.0	57.5
Uplink e.i.r.p. per carrier (dBW)	44.0-48.5	49.5-53.0	72.5-79.5
Typical clear sky $C/N_0$ (dB/Hz)	70.5-74.5	82.0	103.0
<i>3 Satellite antenna parameters</i>			
Beamwidth	0.55 diameter	0.55 diameter	0.55 diameter
Beam shape	Circular	Circular	Circular
Maximum Rx/Tx gain (dBi)	49.0	49.0	49.0
Radiation pattern	Rec. ITU-R S.672	Rec. ITU-R S.672	Rec. ITU-R S.672
Peak satellite $G/T$ (dB(K <sup>-1</sup> ))	20.0	20.0	20.0
Peak satellite e.i.r.p. (dBW)	65.0	65.0	65.0
Type of transponder	On-board processing	On-board processing	On-board processing
<i>4 Downlink transmission parameters</i>			
Modulation type	TDM/QPSK	TDM/QPSK	TDM/QPSK
User bit rate (Mbit/s)	65.536	65.536	65.536
Nominal carrier bandwidth (MHz)	109.5	109.5	109.5
Receive earth station size (m)	0.45-0.75	1.2-1.8	3.0
Receive earth station gain (dBi)	37.5-42.0	46.0-49.5	54.0
Receive earth station $G/T$ (dB(K <sup>-1</sup> ))	14.5-19.0	23.0-26.5	31.5
Typical clear sky $C/N_0$ (dB/Hz)	95.0	99.0	102.0
<i>5 Earth station parameters</i>			
Expected number of earth stations	Millions	Thousands	Less than 50
Minimum elevation angle (degrees)	10	10	20
Antenna pattern	32 – 25 log $\phi$	32 – 25 log $\phi$	29 – 25 log $\phi$
<i>6 Fade compensation strategy</i>			
	UPC, adaptive FEC, rate reduction	UPC, adaptive FEC, rate reduction	UPC, adaptive FEC, site diversity

PFMO: pulse frequency modulation (offset)

UPC: upward power control



## APPENDIX 1

## TO ANNEX 3

TABLE 7

**Typical one-way link availability objectives (BER of  $1 \times 10^{-9}$ )**

Connection between	One-way availability (%)
Residential terminal and residential terminal	99.5
Residential terminal and business VSAT	99.6
Residential terminal and gateway	99.7
Business terminal and business terminal	99.7
Business terminal and gateway	99.8
Gateway and gateway	99.8-99.9

## ANNEX 4

TABLE 8

**Technical characteristics of some current 30/20 GHz GSO FSS networks  
Satellite system R**

Satellite system	R-1	R-2	R-3	R-4	R-5	R-6
<i>General parameters</i>						
Nominal frequency (GHz)	20/30					
Number of transponders per satellite <sup>(1)</sup>	10					
Transponder bandwidth (MHz)	100					
Transponder high power amplifier (W)	29					
Satellite e.i.r.p. (dBW) <sup>(2)</sup>	55					
Polarization	Circular					
<i>Downlink parameters</i>						
Modulation/access	TDM	FDM	FDM	FDM	FDM	FM
Central frequency (GHz) <sup>(3)</sup>						
Data rate (Mbit/s)	20.4	0.032	0.032	1.544	7.2	Not applicable
Digital service	Voice, data and fax	Voice, data and fax	Voice, data and fax	Voice, data and fax	Digital video	TV-FM
e.i.r.p. spectral density (dB(W/Hz))	-9.1	-3.1	-5.3	-14.6	-17.0	-3.9 <sup>(4)</sup>
<i>Uplink parameters</i>						
Central frequency (GHz) <sup>(3)</sup>						
Modulation/access	TDMA	FDMA	FDMA	FDMA	FDMA	FM
Nominal rate (Mbit/s)	20.4	0.032	0.032	1.544	7.2	Not applicable
Minimum earth station antenna diameter (m)	7.6	1.4	3.6	3.6	1.4	3.0
Up/down earth station antenna discrimination at 2° (dB)	Rec. ITU-R S.465					
Maximum power spectral density (dB(W/Hz))	-31.1	-23.3	-25.3	-27.6	-28.2	-14.0 <sup>(4)</sup>

- (1) Include 3 transponders connected to spot beams.
- (2) Peak e.i.r.p. of national beam.
- (3) Not specified.
- (4) Modulated by 1 MHz peak-to-peak energy dispersal signal.

## ANNEX 5

TABLE 9

**Technical characteristics of a planned 10.95-11.2, 11.45-11.7/13.75-14.5 GHz non-GSO FSS network: FSAT-MULTI 1-B**

<b>1 Orbital parameters</b>				
Shape of orbit	Circular			
Height (km)	1 457			
Inclination angle (degrees)	55			
Coherence (track repeat (h))	665			
Number of satellites per plane	4			
Number of orbital planes	16			
Satellite separation (degrees) within plane	90			
Satellite phasing between planes	Not applicable			
<b>2 Targeted frequency range and polarization</b>				
Uplink frequency (GHz)	13-14			
Uplink polarization	Circular			
Downlink frequency (GHz)	11-12			
Downlink polarization	Circular			
<b>3 Spectrum required in each direction (MHz)</b>	1 000 within the above frequency range			
<b>4 Carrier transmission parameters</b>				
Modulation type	SSMA			
Number of service link beams	< 45			
Number of feeder-link segments/polarization	–			
Segment bandwidth (MHz)	–			
Receiver bandwidth (kHz)	Forward: 41 000; return: 5 200			
Transmission bandwidth (kHz)	Forward: 41 000; return: 5 200			
Overall ( $C/N_0$ ) per user (dB/Hz) or ( $C/N$ ) (dB)	4 dB ( $E_b/N_0$ )			
Uplink e.i.r.p./carrier (dBW)	63.8 <sup>(1)</sup>	68 <sup>(1)</sup> (13.75-14 GHz)	35.5 <sup>(2)</sup>	
Downlink e.i.r.p./carrier (dBW)	90°: 17.5 <sup>(2)</sup> 4.8 <sup>(1)</sup>	75°: 19.7 <sup>(2)</sup> 7.1 <sup>(1)</sup>	50°: 21.2 <sup>(2)</sup> 8.6 <sup>(1)</sup>	32°: 23.1 <sup>(2)</sup> 10.2 <sup>(1)</sup>
Type of satellite transponder	Transparent			
<b>5 Satellite antenna parameters</b>				
Tx maximum gain (dBi)	90°: 17.2	75°: 19.8	50°: 21.7 <sup>(2)</sup>	32°: 23
Rx maximum gain (dBi)	90°: 16.9	75°: 19.5	50°: 21.4	32°: 22.7
Main lobes	–			
Side lobes	–			
Back lobes	–			
Steerable antenna or not	Yes			
<b>6 Earth station antenna parameters</b>				
Peak Tx gain (dBi)	51.6 <sup>(1)</sup>	54.1 <sup>(1)</sup> (13.75-14 GHz)	33 <sup>(2)</sup>	
Peak Rx gain (dBi)	50.5 <sup>(1)</sup>	53 <sup>(1)</sup> (13.75-14 GHz)	31.8 <sup>(2)</sup>	
Radiation pattern	Rec. ITU-R S.580			–
Minimum operating elevation angle (degrees)	5			10
<b>7 Number of earth stations and distribution</b>	Up to 20 millions			
<b>8 Earth station switching strategy</b>	Track best elevation satellite within the operating range			

(1) Feeder link/gateway.

(2) Service link/user station.

TABLE 10

**Technical characteristics of a planned 30/20 GHz non-GSO satellite network: FSAT-MULTI 1-A**

## a) Orbital parameters

The satellites are distributed between two types of planes, as shown in the following Table:

Number of planes	161
Number of satellites per plane	1
Right ascension node (degrees)	$0 + 1315 i$ for $i = 0-160$
Altitude (km)	1 675
Eccentricity	0
Inclination (degrees)	87 1133

## b) Communication parameters

2 <i>Frequency range</i> (GHz)			
Uplink frequency	27.5-30.0		
Downlink frequency	17.3-20.2		
4 <i>Carrier transmission parameters</i>			
Modulation type	QPSK + Viterbi and Reed-Solomon coding		
Information rate (Mbit/s)	0.384	2.048	33.0
Transmission bandwidth (MHz)	0.500	2.66	42.9
Required $E_b/N_0$ (dB)	6.0	6.0	6.0
Uplink e.i.r.p./carrier (dBW) Minimum Maximum (depends on the antenna diameter and on the elevation angle (rain fades compensation))	32.4	29.5 53.4	
Downlink e.i.r.p./carrier (dBW) depends on the elevation angle (3 dB edge of the beam value)	–	–	41 at 20°, 36 at 30°, 31.2 at 50°, 29.2 at 70°, 28.9 at 90°
Type of satellite transponder	On-board processing		
5 <i>Satellite antenna parameters</i>			
Tx maximum gain (dBi) (beam edge)	31.7 at 20°, 28.6 at 30°, 24.5 at 50°, 22.7 at 70°, 22.4 at 90°		
Rx maximum gain (dBi) (beam edge)	31.7 at 20°, 28.6 at 30°, 24.5 at 50°, 22.7 at 70°, 22.4 at 90°		
Main/side/back lobes			
6 <i>Earth station antenna parameters</i>			
Radiation pattern	Rec. ITU-R S.580 (side lobes), RR Appendix S30B (main beam)		
Minimum operating elevation angle (degrees) (depends on the latitude)	20 at the Equator		

## ANNEX 6

TABLE 11

Additional parameters for the feeder links of the non-GSO MSS and FSS systems of LEO-G

	FL MSS	FL FSS	FSS
<b>1 Orbital parameters</b>			
Shape of orbit		Circular	
Height (km)		1 500	
Inclination angle (degrees)		74	
Satellites per plane		12	
Number of orbital planes		4	
Satellite separation within plane (degrees)		30	
Satellite phasing between planes (degrees)		90	
<b>2 Targeted frequency range and polarization</b>			
Uplink frequency (GHz)	19.3-19.6	28.6-29.1	28.6-29.1
Uplink polarization	LHCP	LHCP	LHCP
Downlink frequency (GHz)	15.45-15.65	18.8-19.3	18.8-19.3
Downlink polarization	RHCP	RHCP	RHCP
<b>3 Spectrum required in each direction (MHz)</b>	200	300	200
<b>4 Carrier transmission parameters</b>			
Receiver bandwidth (kHz)	48 000	64 000	32 000
Transmission bandwidth (kHz)	48 000	64 000	32 000
Overall $C/N_0$ per user (dB/Hz)	46	46	46
Uplink e.i.r.p./carrier (dBW)			
Maximum	67	63.9	60.9
Minimum	29.6	28.2	28.2
Downlink e.i.r.p./carrier (dBW)			
Maximum	24.9	29.1	29.7
Minimum	-3.8	2.0	5.6
<b>5 Satellite antenna parameters</b>			
Tx maximum gain (dBi)	22	30	30
Rx maximum gain (dBi)	22	30	30
Main, side and back lobes			
Steerable antenna or not	Yes	Yes	Yes
<b>6 Earth station antenna parameters</b>			
Peak Tx gain (dBi)	49	49	45
Peak Rx gain (dBi)	49	49	45
Radiation pattern			
Minimum operating elevation angle (degrees)	10	10	10
<b>7 Number of earth stations and distribution</b>	6 or more	6 or more	Multiple
<b>8 Earth station switching strategy</b>	≥ minimum elevation angle		

## ANNEX 7

TABLE 12

**Technical characteristics of two current 30/20 GHz GSO FSS networks: Ka-J1 and Ka-J2**

<i>Satellite system</i>	Ka-J1	Ka-J2
<i>General parameters</i>		
Nominal frequency (GHz)	20/30	20/30
Number of transponders per satellite	5	6
Transponder bandwidth (MHz)	100	200
Input power of satellite transmit antenna (dBW)	11	11
Satellite e.i.r.p. (dBW)	52	58
Polarization	Circular	Circular
Digital service (voice, data, video, paging, etc.)	All	All
<i>Downlink parameters</i>		
Modulation/access	QPSK/TDMA	QPSK/TDM
Central frequency (GHz) <sup>(1)</sup>		
Occupied bandwidth (MHz)	35	140
Earth station antenna diameter (m):		
Minimum	3.0	1.8
Maximum	11.5	4.2
e.i.r.p. spectral density (dB(W/Hz))	-23.4	-23.5
<i>Uplink parameters</i>		
Modulation/access	QPSK/TDMA	QPSK/TDM
Central frequency (GHz)		
Occupied bandwidth (MHz)	35	140
Earth station antenna diameter (m):		
Minimum	3.0	1.2
Maximum	11.5	4.2
Maximum power spectral density (dB(W/Hz))	4.6	-1.9

<sup>(1)</sup> Not specified.

TABLE 13

## Technical characteristics of a planned 30/20 GHz GSO FSS network: GSO-EKX

1 <i>Orbital parameters</i>	
Shape of orbit	Circular
Height (km)	35 786
Inclination angle (degrees)	0 inclination to equatorial plane
Number of satellites per plane	8-2 each in 4 orbit slots
Requested orbital locations	99° E, 117° W, 69° W, 26.2° W
Satellite separation (degrees) within plane	> 2
2 <i>Frequency range and polarization</i>	
3 <i>Spectrum required (GHz)</i>	1.0 for United States of America domestic network 1.5 for international network
4 <i>Carrier transmission parameters</i>	
Uplink Earth-to-space centre frequencies (United States of America) (GHz)	28.475, 29.375, 29.625 and 29.875
Downlink space-to-Earth centre frequencies (United States of America) (GHz)	17.925, 18.175, 18.425, 18.675, 19.825 and 20.075
Uplink Earth-to-space centre frequencies (Europe and S-E Asia) (GHz)	27.975, 28.225, 28.475, 29.375, 29.625 and 29.875
Downlink space-to-Earth centre frequencies (Europe and S-E Asia) (GHz)	17.925, 18.175, 18.425, 18.675, 19.825 and 20.075
Number of service link beams	32 dual polarization, receive and transmit
Modulation type	QPSK
User access	FDMA/TDMA
Receiver bandwidth (MHz)	250
Number of FDMA carriers per beam	8, 4 × 2 polarizations
Number of TDMA users	Up to 100 T1 users
Overall $C/N_0$ per user (dB/Hz)	89.5
Uplink e.i.r.p./carrier in clear (dBW)	62.2
Uplink e.i.r.p./carrier in rain (dBW)	67.2
Downlink e.i.r.p./carrier (dBW)	56.4
5 <i>Satellite antenna parameters</i>	
Tx maximum gain (dBi)	48.4
Rx maximum gain (dBi)	48.4
Tx side lobes (dB)	-15 relative to peak
Rx side lobes (dB)	-20 relative to peak
6 <i>Earth station antenna parameters</i>	
Tx maximum gain (dBi)	58.2 (typical value)
Rx maximum gain (dBi)	54.8 (typical value)
Tx side lobes (dB)	-15 relative to peak
Rx side lobes (dB)	-20 relative to peak
7 <i>Number of earth stations and distribution</i>	Number of sites is unlimited. Distribution of earth stations shall be in North and South America, Europe, Africa, South-East Asia and Australia, plus sites for transpacific and transatlantic
8 <i>Earth station switching strategy</i>	Interference avoidance while operating at the highest possible elevation angle

TABLE 14

## Technical characteristics of a planned 30/20 GHz non-GSO FSS network: NGSO-KX

1 <i>Orbital parameters</i>	
Shape of orbit	Circular
Height (km)	10 352
Inclination angle (degrees)	55
Repeatable track	Approximately every 6 h
Number of satellites per plane	5
Number of orbital planes	4
Satellite separation (degrees) within plane	72
2 <i>Frequency range and polarization</i>	
Uplink frequency (GHz)	28.6-29.1
Uplink polarization	LHCP/RHCP
Downlink frequency (GHz)	18.8-19.3
Downlink polarization	LHCP/RHCP
3 <i>Spectrum required in each direction (MHz)</i>	500
4 <i>Carrier transmission parameters</i>	
Modulation type	O-QPSK
Number of service link beams	20
Receiver bandwidth (MHz)	3-200
Transmission bandwidth (kHz)	3-200
Overall <i>C/N</i>	Depends on antenna size: uplink at 30° elevation: over 6 dB for users downlink at 30° elevation: over 6 dB
Uplink e.i.r.p./carrier (dBW)	37-45
Downlink e.i.r.p./carrier (dBW)	55-60
Type of satellite transponder	On-board processing
5 <i>Satellite antenna parameters</i>	
Minimum antenna gain (dBi)	39
Beamwidth	1° at the 3 dB point
Steerable antenna or not	Yes
6 <i>Earth station antenna parameters</i>	
Peak Tx gain (dBi)	39.7-53.8 (for 36 cm to 2 m)
Peak Rx gain (dBi)	35.9-50.1 (for 36 cm to 2 m)
Radiation pattern	Rec. ITU-R S.465
Minimum operating elevation angle (degrees)	30
7 <i>Number of earth stations and distribution</i>	Global/unlimited
8 <i>Earth station switching strategy</i>	Interference avoidance/highest elevation angle

TABLE 15

## Technical characteristics of a planned 30/20 GHz system: LEOSAT-2

1 <i>Orbital parameters</i>					
Satellites	63				
Shape of orbit	Circular				
Planes	7				
Altitude	1 400 km (870 miles)				
Inclination (degrees)	48				
Plane phasing (degrees)	+28.57				
Orbit period	6 825 s (1.9 h)				
Usable capacity (Gbit/s)	80				
Service region at 16° elevation angle	60° N and S latitude extends to 70° by mitigating affect of elevation angle (view or antenna)				
Peak d.c. power (kW)	13.6				
Average d.c. power (kW)	4.6				
Mission life (years)	8 (10 expendable)				
Stabilization and position sensing	3-axis stabilized; GPS				
Dimensions (length width height, stored)	3 × 2 × 5 m (120 × 80 × 200 in)				
Wet mass	3 100 kg (6 834 lb)				
Dry mass	2 500 kg (5 512 lb)				
Propellant	600 kg (1 323 lb)				
2 <i>Frequency range and polarization</i>					
Number of beams per satellite - uplink	432				
Frequency – uplink (GHz)	28.6-29.1 and 29.5-30.0				
Number of beams per satellite – downlink	260				
Frequency – downlink (GHz)	18.8-19.3 and 19.7-20.2				
Number of optical inter-satellite links per satellite	6				
Optical intersatellite link data rate (Gbit/s)	4.5				
3 <i>Spectrum required in each direction (MHz)</i>					1 000
4 <i>Carrier transmission parameters</i>					
Modulation type	QPSK, 8-PSK				
Information rate (Mbit/s)	2.048	10.0	16.384	51.84	155.52
Transmission bandwidth(MHz)	4.10	20.0	32.8	104	311
Required $E_b/N_0$ (dB)	6.2	6.2	8.9	8.0	14.3
Uplink e.i.r.p./carrier (dBW):					
Nominal	35.3	39.8	–	48.5	50.8
Maximum (rain faded)	39.0	52.0	–	60.7	60.4
Downlink e.i.r.p./carrier (dBW):					
Nominal	–	–	41.3	32.6	35.9
Maximum (rain faded)	–	–	44.8	40.6	42.9
Type of satellite transponder	On-board processing				
Satellite switch rate (Gbit/s)	17.5				
Aggregate data rate (Gbit/s)	8.9				
5 <i>Satellite antenna parameters</i>					
Tx maximum gain (dBi)	32.8 <sup>(1)</sup> , 37.4 <sup>(2)</sup>				
Rx maximum gain (dBi)	35.3 <sup>(1)</sup> , 40.9 <sup>(2)</sup>				
6 <i>Earth station antenna parameters</i>					
Radiation pattern					
Minimum operating elevation angle (degrees)	16				

(1) For data rates of 2.048, 10.0, 16.384 and 51.84 Mbit/s.

(2) For data rate of 155.52 Mbit/s.



TABLE 16

## Technical characteristics of the MEOSAT-X system in the 20/30 GHz bands

Band	20/30 GHz	40/50 GHz
<i>1 Orbital parameters</i>		
Shape of orbit	Circular	
Height (km)	10 352	
Inclination angle (degrees)	50	
Coherence (track repeat (h))	6	
Number of satellites per plane	8	
Number of orbital planes	4	
Satellite separation within plane (degrees)	30 and 60 (within each plane satellites will fly in pairs with 30° between members of a pair and 60° between pairs)	
Satellite phasing between planes (degrees)	67.5	
<i>2 Frequency range and polarization</i>		
Uplink frequency (GHz)	28.35-29.1 and 29.5-30.0	47.2-50.2
Uplink polarization	LHCP/RHCP	
Downlink frequency (GHz)	18.05-18.3, 18.8-19.3 and 19.7-20.2	37.5-42.5 (3 GHz of spectrum in this band)
Downlink polarization	LHCP/RHCP	
<i>3 Spectrum required in each direction (MHz)</i>	1 250	3 000
<i>4 Carrier transmission parameters</i>		
Modulation type	O-QPSK	
Number of service link beams	360 (MBA multi-beam antenna) beams for the downlink and 360 (MBA multi-beam antenna) beams for the uplink, 2 separate links for gateway applications	4 beams supporting 16 channels
Number of feeder-link segments/polarization	Not available	
Receiver bandwidth (MHz)	Uplink: 1.5, 3, 5, 17, 120 (depends on data rate); downlink: 120	500
Transmission bandwidth	Uplink: 100 kHz-125 MHz downlink: 125 MHz	Uplink: 500 MHz; downlink: 100 kHz, 500 MHz
Overall $C/N_0$ per user (dB/Hz) or $C/N$ (dB)	Uplink at 20° elevation: 20 dB for users 34 dB for gateways; downlink at 20° elevation: 10-19 dB (depends on antenna size); gateway uplink: 34 dB gateway downlink: 26.9 dB	Uplink at 20° elevation: 32.7 dB Downlink at 20° elevation: 27.3 dB

TABLE 16 (end)

Band	20/30 GHz	40/50 GHz
<i>4 Carrier transmission parameters (continued)</i>		
Uplink e.i.r.p./carrier (dBW)	51-66 (for 65 cm to 180 cm user antennas); 81.23 (for gateways)	88 (4.8 m antenna)
Downlink e.i.r.p./carrier (dBW)	53 (users); 54 (gateways)	60 (4.8 m antenna)
Type of satellite transponder	On-board processing	
<i>5 Satellite antenna parameters</i>		
Tx maximum gain (dBi)	37.5 (MBA), 38.32 (steerable beam)	45.19 (steerable beam)
Rx maximum gain (dBi)	37.48 (MBA), 42.21 (steerable beam)	47.86 (steerable beam)
Main lobes	2° beamwidth at the 3 dB point for the MBA	
Side lobes (dB)	14-17 first side lobe for the MBA; 20 for the steerable beam	20, first side lobe
Back lobes (dB)	25 for the MBA and the steerable beam	
Steerable antenna or not	No for MBA; yes for steerable beam	Yes
<i>6 Earth station antenna parameters</i>		
Peak Tx gain (dBi)	44-53 (for 65 cm to 180 cm)	66.08 (for 4.8 m)
Peak Rx gain (dBi)	40-50 (for 65 cm to 180 cm)	45.19 (for 4.8 m)
Radiation pattern	Rec. ITU-R S.580 (29 – 25 log (angle))	
Minimum operating elevation angle (degrees)	20	
<i>7 Number of earth stations and distribution</i>	Unlimited/global	
<i>8 Earth station switching strategy</i>	Interference avoidance/highest elevation angle	

## ANNEX 8

TABLE 17

## Technical characteristics of a planned GSO FSS network above 30 GHz: GSO-VX

1 <i>Orbital parameters</i>	
Shape of orbit	Circular
Height (km)	35 786 (geosynchronous)
Inclination angle (degrees)	0 (referenced to Equator)
Coherence (track repeat (h))	Not applicable
Number of satellites per plane	14
Number of orbital planes	1 (GSO)
Satellite separation (degrees) within plane	At least 2
Satellite phasing between planes (degrees)	Not applicable
Satellite locations (number per location)	99° W(2), 101° W(2), 103° W(2) 63° W(1), 53° W(1), 8.5° E(2), 48° E(1)
2 <i>Frequency range and polarization</i>	
Uplink frequency (GHz) V-band Ku-band	47.2-50.2 12.75-13.25
Uplink polarization V-band Ku-band	LHCP/RHCP LHCP/RHCP
Downlink frequency (GHz) V-band Ku-band	39.5-42.5 10.70-10.95, 11.2-11.45
Downlink polarization V-band Ku-band	LHCP/RHCP LHCP/RHCP
3 <i>Spectrum required in each direction (MHz)</i>	
V-band Ku-band	3 000 500
4 <i>Carrier transmission parameters</i>	
Modulation type V-band (uplink and downlink) Ku-band (uplink and downlink)	Differential QPSK, TDMA/FDMA Differential QPSK, TDMA/FDMA
Number of service link beams V-band Ku-band	40 16
FDM channels per beam V-band Ku-band	10 1
Bandwidth per FDM channel (MHz) V-band Ku-band	300 250
TDM channels per FDM channel V-band Ku-band	100 100
TDMA burst rate (Mbit/s) V-band Ku-band	155.52 to 200 155.52 to 200

TABLE 17 (end)

4 <i>Carrier transmission parameters (continued)</i>	
Receiver bandwidth (MHz) V-band Ku-band	300 250
Transmitter bandwidth (MHz) V-band Ku-band	300 250
Overall $C/N_0$ per user (dB/Hz) V-band  Ku-band	Uplink (clear air): 96.8 Uplink (rain): 93.9 Downlink (clear air): 95.4 Downlink (rain): 91.7  Uplink (clear air): 96.3 Uplink (rain): 93.7 Downlink (clear air): 97.2 Downlink (rain): 94.2
Uplink e.i.r.p./carrier (dBW) V-band Ku-band	73.8 68.5
Downlink e.i.r.p./carrier (dBW) V-band Ku-band	56.0 47.0
Type of satellite transponder	Processor controlled SS-TDMA switch
5 <i>Satellite antenna parameters</i>	
Transmit antenna maximum gain (dBi) V-band Ku-band	49.0 33.5
Receive antenna maximum gain (dBi) V-band Ku-band	49.0 48.8
Transmit side-lobe level (dB below peak) V-band Ku-band	18 18
Back lobes (dB below peak)	25
Steerable antenna or not	No, V-band and Ku-band antennas are satellite body mounted
6 <i>Earth station antenna parameters</i>	
Peak transmit gain (dBi) V-band Ku-band	59.5 for 2.5 m 48.8 for 2.5 m
Peak receive gain (dBi) V-band Ku-band	58.0 for 2.5 m 47.3 for 2.5 m
Radiation pattern	Rec. ITU-R S.580 (29 – 25 log (angle))
Minimum operating elevation angle (degrees)	20
7 <i>Number of earth stations and distribution</i>	Global/unlimited
8 <i>Earth station switching strategy</i>	Interference avoidance/highest elevation angle

SS: satellite switched.

TABLE 18

Technical characteristics of a planned GSO FSS network above 30 GHz: GEO-SV<sup>(1)</sup>

System	GEO-SV
<b>1 Orbital parameters</b>	
Shape of orbit	Circular
Height (km)	35 786
Inclination angle (degrees)	0
Coherence (track repeat (h))	–
Number of satellites per plane	6
Number of orbital planes	1 (GSO)
Satellite separation (degrees) within plane	At least 2
Satellite phasing between planes (degrees)	–
<b>2 Frequency range and polarization</b>	
Uplink frequency (GHz)	47.2-50.2
Uplink polarization	LHCP/RHCP
Downlink frequency (GHz)	39.5-42.5
Downlink polarization	LHCP/RHCP
<b>3 Spectrum required in each direction (MHz)</b>	
	3 000
<b>4 Carrier transmission parameters</b>	
Modulation type	D-QPSK
Number of service link beams	40, 0.15° uplink and downlink beams
User data rate per TDMA carrier (Mbit/s)	155 (1 to 2.5 m ground terminals) 26.4 (45 cm ground terminals)
Coding rate	0.609
Effective overall rate (coding and data overhead)	0.517
Carrier occupied bandwidth (MHz)	199.85 (1 to 2.5 m terminals) 34.04 (45 cm terminals)
Required $E_b/(N_0 + I_0)$ without loss (dB)	5.0
Modem implementation loss (dB)	1.5
Receiver/transmitter bandwidth (MHz)	257 (1 to 2.5 m ground terminals) 43.7 (45 cm terminals)
Uplink e.i.r.p. per carrier (dBW)	75.5 <sup>(2)</sup>
Downlink e.i.r.p. per carrier (dBW)	62.0
Type of satellite transponder	SS-TDMA
<b>5 Satellite antenna parameters</b>	
Receiver sensitivity, $G/T$ (dB(K <sup>-1</sup> ))	26.4
Tx maximum gain (dBi)	58.0
Rx maximum gain (dBi)	58.0
Antenna downlink beamwidth	0.15° at the 3 dB point
Steerable antenna or not	Not
Radiation pattern	
<b>6 Earth station antenna parameters</b>	
Apertures	Tx: 2.5 m only Rx: 2.5 m; 1 m; 45 cm
Peak Tx gain (dBi)	59.5
Peak Rx gain (dBi)	50.8 (1 m) 43.8 (45 cm)
Receiver sensitivity $G/T$ (dB(K <sup>-1</sup> ))	23.8 (1 m) 16.8 (45 cm)
Radiation pattern	Rec. ITU-R S.580 (29 – 25 log (angle))
Minimum operating elevation angle (degrees)	15
<b>7 Number of earth stations and distribution</b>	
	Global/unlimited
<b>8 Earth station switching strategy</b>	

(1) The GEO-SV system is a hybrid system that also includes a Ku-band payload.

(2) Uplink power control.

TABLE 19

## Technical characteristics of a planned GSO FSS network above 30 GHz: GEO-LV

1 <i>Orbital parameters</i>	
Shape of orbit	Circular
Height (km)	35 786
Inclination angle (degrees)	0
Number of satellites per plane	
Number of orbital planes	1 (GSO)
Satellite separation within plane (degrees)	At least 2
2 <i>Frequency range and polarization</i>	
Uplink frequency (GHz)	45.5-46.7
Uplink polarization	LHCP/RHCP
Downlink frequency (GHz)	37.5-38.6
Downlink polarization	LHCP/RHCP
3 <i>Spectrum required in each direction (GHz)</i>	
	1.1
4 <i>Carrier transmission parameters</i>	
Modulation type	QPSK
Number of service link beams	
Receiver bandwidth (MHz)	Depends on data rate: Uplink: minimum of 3 Downlink: minimum of 3
Transmission bandwidth (MHz)	Depends on data rate: Uplink: minimum of 3 Downlink: minimum of 3
Overall $C/N_0$ per user (dB/Hz)	Minimum of 59
Uplink e.i.r.p./carrier (dBW)	Depends on antenna size and data rate. Over 41
Downlink e.i.r.p./carrier (dBW)	Depends on antenna size and data rate. Over 55
Type of satellite transponder	On-board processing
5 <i>Satellite antenna parameters</i>	
Satellite minimum antenna gain (dBi)	52
Main lobes	0.15° beamwidth at the 3 dB point
Steerable antenna or not	Yes
6 <i>Earth station antenna parameters</i>	
Minimum Tx gain (dBW)	33
Minimum Rx gain (dBW)	31
Radiation pattern	RR Appendix S8, Annex III
Minimum operating elevation angle (degrees)	30
7 <i>Number of earth stations and distribution</i>	
	Global/unlimited

TABLE 20

## Technical characteristics of a planned GSO FSS network above 30 GHz: MEO-LV

1 <i>Orbital parameters</i>	
Shape of orbit	Circular
Height (km)	10 352
Inclination angle (degrees)	55
Coherence (track repeat (h))	6
Number of satellites per plane	5
Number of orbital planes	4
Satellite separation (degrees) within plane	72
2 <i>Frequency range and polarization</i>	
Uplink frequency (GHz)	45.5-46.7
Uplink polarization	LHCP/RHCP
Downlink frequency (GHz)	37.5-38.6
Downlink polarization	LHCP/RHCP
3 <i>Spectrum required in each direction (GHz)</i>	
1.1	
4 <i>Carrier transmission parameters</i>	
Modulation type	QPSK
Receiver bandwidth (MHz)	Depends on data rate: Uplink: minimum of 3 Downlink: minimum of 3
Transmission bandwidth (MHz)	Depends on data rate: Uplink: minimum of 3 Downlink: minimum of 3
Overall $C/N_0$ per user (dB/Hz)	Minimum of 57
Uplink e.i.r.p./carrier (dBW)	Depends on antenna size and data rate. Over 41
Downlink e.i.r.p./carrier (dBW)	Depends on antenna size and data rate. Over 55
Type of satellite transponder	On-board processing
5 <i>Satellite antenna parameters</i>	
Satellite minimum antenna gain (dBi)	41
Main lobes	6° beamwidth at the 3 dB point
Steerable antenna or not	Yes
6 <i>Earth station antenna parameters</i>	
Minimum Tx gain (dBW)	33
Minimum Rx gain (dBW)	31
Radiation pattern	RR Appendix S8, Annex III
Minimum operating elevation angle (degrees)	30
7 <i>Number of earth stations and distribution</i>	
Global/unlimited	
8 <i>Earth station switching strategy</i>	
Interference avoidance/highest elevation angle	

TABLE 21

## Technical characteristics of several LEO and GSO satellite networks above 38 GHz

Parameters	Non-GSO above 38 GHz FSS		GSO above 38 GHz FSS	
	LEO V1		LEO V2	OSG V1
<b>1 Orbital parameters</b>				
Shape of orbit	Circular		Circular	Circular
Apogee/perigee (km)	1 350/1 350		10 355/10 355	35 878
Inclination angle (degrees)	47		50	
Number of satellites per plane	6		5	
Number of orbital planes	12		3	
Satellite separation within plane	60° + 25° plane inclination		72°	
Satellite phasing per plane, RAAN (degrees)	θ + 30		120	
<b>2 Targeted frequency range and polarization</b>				
Uplink frequency (GHz)	47.2-50.2		47.2-50.2	47.2-50.2
Uplink polarization/axial ratio (dB)	RHCP / __ dB		RHCP/LHCP	RHCP/LHCP
Downlink frequency (GHz)	37.5-40,5		37.5-42.5	37.5-42.5
Downlink polarization/axial ratio (dB)	LHCP / __ dB		RHCP/LHCP	RHCP/LHCP
<b>3 Carrier transmission parameters</b>				
Modulation type	QPSK		O-QPSK	O-QPSK
Coding rate	0.449		≈ 0.5	0.5
Number of service link beams	16		48	24
Target BER	1 × 10 <sup>-6</sup>	1 × 10 <sup>-9</sup>	1 × 10 <sup>-7</sup> to 1 × 10 <sup>-10</sup>	1 × 10 <sup>-7</sup> to 1 × 10 <sup>-10</sup>
Burst information data rate (Mbit/s)	10.24	51.84	OC3 to 10 × OC3	OC3 to 10 × OC3
Bandwidth per channel (MHz)	18	90	300 to 3 000	300 to 3 000
Required $E_b/(N_0 + I_0)$ without loss (dB)	2.2	2.7	6.0	6.0
Modem implementation loss (dB)	1.5	1.5 (+0.55/hop)	2.0	2.0
Receiver bandwidth (MHz)				
Transmission bandwidth (MHz)				
Uplink e.i.r.p./carrier (dBW)	44.9 to 50.5 ARC	60.2 to 65.8 ARC	69.7 to 78.9	73.7 to 80.0
Downlink e.i.r.p./carrier (dBW)	28.3 to 33.9 ARC	46.9 to 52.5 ARC	49.5 to 58.8	57.5 to 66.4
Type of satellite transponder	Transparent		Processed payload	Regenerative
<b>4 Satellite antenna parameters</b>				
Effective aperture (m)	0.45 Tx/0.36 Rx		0.65 Tx/0.52 Rx	1.36 Tx/1.1 Rx
Tx maximum gain (dBi)	40.6		45.5	53
Rx maximum gain (dBi)	40.6		45.2	53
Receiver sensitivity $G/T$ (dB(K <sup>-1</sup> ))	10.5		16.9	24.4
Radiation pattern	RR Appendix S8		Ex-CCIR Report 558	Ex-CCIR Report 558
Steerable antenna or not	Yes		Yes	Yes
<b>5 Earth station antenna parameters</b>				
Effective aperture (m)	0.66	1.5	2.2	2.2
Peak Tx gain (dBi)	49.3	56.4	59.7	59.7
Peak Rx gain (dBi)	47.3	54.4	57.8	57.8
Receiver sensitivity, $G/T$ (dB(K <sup>-1</sup> ))	19.3	26.4	32.4	32.4
Radiation pattern	Rec. ITU-R S.465 <sup>(1)</sup>	Rec. ITU-R S.465	Rec. ITU-R S.465	Rec. ITU-R S.465
Minimum operating elevation angle (degrees)	22		30	30
<b>6 Number of earth stations and distribution</b>				
	43 000 active worldwide	1 500 active worldwide	Unknown (< 50 000)	Unknown (< 30 000)
<b>7 Earth station switching strategy</b>				
	Make before break		Make before break	Make before break

OC3: optical carrier system operating at the 3rd hierarchical level.

RAAN: right ascension of the ascending node.

<sup>(1)</sup> Recommendation ITU-R S.465 radiation pattern is consistent with the proposed frequency of operation when extrapolated to the proposed frequency band.



TABLE 22

## Technical characteristics of the GEOSAT-X system in the 40/50 GHz bands

1 <i>Orbital parameters</i>	
Shape of orbit	Circular
Height (km)	35 786
Inclination angle (degrees)	–
Coherence (track repeat (h))	–
Number of satellites per plane	9
Number of orbital planes	1 (GSO)
Satellite separation within plane (degrees)	At least 2
Satellite phasing between planes (degrees)	–
2 <i>Frequency range and polarization</i>	
Uplink frequency (GHz)	47.2-50.2
Uplink polarization	LHCP/RHCP
Downlink frequency (GHz)	39.5-42.5 (3 GHz of spectrum in this band)
Downlink polarization	LHCP/RHCP
3 <i>Spectrum required in each direction (MHz)</i>	
	3 000
4 <i>Carrier transmission parameters</i>	
Modulation type	QPSK
Number of service link beams	48
Number of feeder-link segments/polarization	8 beams for gateway communication 2 downlink beams for HCDR service
Receiver bandwidth	<i>User service beams:</i> Uplink: 500 kHz, 3 MHz, 11 MHz, depending on data rate Downlink: 125 MHz <i>Gateway beams:</i> Uplink and downlink: 125 MHz <i>HCDR beams:</i> Downlink: 1 GHz
Transmission bandwidth	<i>User service beams:</i> Uplink: 500 kHz, 3 MHz, 11 MHz, depending on data rate Downlink: 125 MHz <i>Gateway beams:</i> Uplink and downlink: 125 MHz <i>HCDR beams:</i> Downlink: 1 GHz
Overall $C/N_0$ per user(dB/Hz) or $C/N$ (dB)	<i>User service beams <math>C/N_0</math>:</i> Uplink (clear air): 75.6, 76.9, 84.3, 93.2; (rain): 67.8, 67.8, 75.5, 81.6, depending on data rate Downlink (clear air): 89.8, 92.1, 94.8, 103.5; (rain): 82.8, 82.8, 86.2, 90.3, depending on terminal size <i>Gateway beams <math>C/N_0</math>:</i> Uplink (clear air): 111.8; (rain): 92.3 Downlink (clear air): 110.5; (rain): 93.0 <i>HCDR beams <math>C/N_0</math>:</i> Downlink (clear air): 115.8; (rain): 101.6
Uplink e.i.r.p./carrier (dBW)	User service beams (edge of coverage): 49.9, 53.0, 60.4, 69.2, depending on terminal size Gateway beams: 83.9

TABLE 22 (end)

<i>4 Carrier transmission parameters (continued)</i>	
Downlink e.i.r.p./carrier (dBW)	User service beams (edge of coverage): 61.2 Gateway beams: 62.7 HCDR beams: 62.2
Type of satellite transponder	On-board processing
<i>5 Satellite antenna parameters</i>	
Tx maximum gain (dBi)	56.5 for user and gateway links 53.7 for high data rate
Rx maximum gain (dBi)	53.8
Main lobes	
Side lobes (dB)	Tx: 14 below peak Rx: 25 below peak
Back lobes (dB)	25 below peak
Steerable antenna or not	Yes, phase array antenna for user and gateway beams
<i>6 Earth station antenna parameters</i>	
Peak Tx gain (dBi)	44.8-59.3 for user earth stations from 45 cm to 240 cm 64.8 for gateway earth stations
Peak Rx gain (dBi)	43.3-57.8 for user earth stations from 45 cm to 240 cm 63.3 for gateway earth stations 69.3 for HCDR earth stations
Radiation pattern	Rec. ITU-R S.580 (29 – 25 log (angle))
Minimum operating elevation angle (degrees)	20
<i>7 Number of earth stations and distribution</i>	Global/unlimited
<i>8 Earth station switching strategy</i>	Interference avoidance/highest elevation angle

HCDR: High capacity data rate.

## ANNEX 9

TABLE 23

## Technical characteristics of non-GSO FSS systems: System USAKU-L1

1 <i>Orbital parameters</i>			
Shape of orbit	Circular		
Height (km)	1 457		
Inclination angle (degrees)	55		
Coherence (track repeat (h))	665		
Number of satellites per plane	4		
Orbital planes	16		
Satellite separation (degrees) within plane	90		
2 <i>Targeted frequency range and polarization</i>			
Uplink frequency (GHz)	12/17		
Uplink polarization	Circular		
Downlink frequency (GHz)	10/12		
Downlink polarization	Circular		
3 <i>Spectrum required in each direction (MHz)</i>	1 050 within the above frequency range		
4 <i>Carrier transmission parameters</i>			
Modulation type	QPSK/BPSK		
Number of service link beams	< 45		
Number of uplink transponders/polarization	4		
Transponder bandwidth (MHz)	250 or 300		
Earth station noise bandwidth (MHz)	Forward: 22.6, return: 2.93		
Overall $E_b/N_0$ (dB)	3.5		
Earth station useful e.i.r.p. (dBW)	64.6 <sup>(1)</sup> to 68 <sup>(2)</sup> 30.3 to 43.4 <sup>(3)</sup>		
Satellite useful e.i.r.p./carrier (dBW)	16.4 to 18.5 (residential), 11 to 17.6 (provincial, international)		
Forward	-3.5 to -1.7 (residential), -7.2 to -2.4 (provincial, international)		
Return			
Type of satellite transponder	Transparent bent pipe		
5 <i>Satellite antenna parameters</i>			
Tx maximum gain (dBi)	15 at Nadir -22.8 at EOC		
Rx maximum gain (dBi)	18.2 at Nadir -25.7 at EOC		
Steerable antenna or not	Yes		
6 <i>Earth station antenna parameters</i>			
	Provincial	International <sup>(3)</sup>	Residential <sup>(3)</sup>
Peak Tx gain (dBi)	49.4 <sup>(1)</sup> /53.8 <sup>(2)</sup>	37	29.5-32.2
Peak Rx gain (dBi)	48.1 <sup>(1)</sup> /52.5 <sup>(2)</sup>	35.7	28.1-30.8
Radiation pattern	Rec. ITU-R S.580	RR Appendix S8	RR Appendix S8
Minimum specified elevation angle (degrees)	5	5	10
7 <i>Number of earth stations and distribution</i>	Up to 20 million worldwide		
8 <i>Earth station switching strategy</i>	Track best elevation satellite within the operating range outside the non-operating zone		

EOC: edge of coverage

(1) Gateway.

(2) Gateway in 13.75-14 GHz.

(3) User terminal.

TABLE 24

## Technical characteristics of a quasi-GSO FSS network: USAKU-HI

<i>1 Orbital parameters</i>	
Shape of orbit	Elliptical
Apogee/perigee (km)	41 449/4 100
Inclination (degrees)	63.4
Coherence (track repeat (h))	14 (approximately)
Number of satellites per plane	4
Number of orbital planes	3
Satellite phasing between planes (degrees)	120
Argument of perigee (degrees)	270
Minimum satellite separation from geosynchronous plane (degrees)	40
Maximum latitude/longitude operating range (degrees)	19/3
Nominal operational longitude	100° W/30° W/120° E/170° E
<i>2 Frequency range</i>	
Uplink frequency (GHz)	17.3-17.8
Uplink polarization	LHCP/RHCP
Downlink frequency (GHz)	10.7 to 12.7
Downlink polarization	RHCP/LHCP
<i>3 Spectrum required in each direction (MHz)</i>	500
<i>4 Carrier transmission parameters</i>	
Modulation	QPSK
Access	FDMA/TDM
Number of service link beams	10
Segment (transponder) bandwidth (MHz)	24
Receive bandwidth (MHz)	24
Transmission bandwidth (MHz)	24
Overall $C/N_0$ (dB/Hz)	86
Uplink e.i.r.p./carrier (dBW)	77
Downlink e.i.r.p./carrier (dBW)	58
<i>5 Satellite communication parameters</i>	
Type of satellite transponder	Transparent
Transmit maximum gain (dBi)	38
Receive maximum gain (dBi)	24
Steerable antenna or not	Yes (phased array)
<i>6 Earth station characteristics</i>	
Feeder link transmit gain (dBi)	55
Feeder link e.i.r.p. per 24 MHz (dBW)	77
Receive antenna gain (minimum) (dBi)	30
Antenna pattern	29 – 25 log ( $\theta$ )

TABLE 25

## Technical characteristics of a quasi-GSO FSS network: Tanya

<b>1 Orbital parameters</b>	
Shape of orbit	Elliptical
Apogee/perigee (km)	41 449/4 100
Argument of perigee (degrees)	270
Inclination (degrees)	63.4
Coherence (track repeat (h))	12 (approximately)
Number of satellites per plane	1
Number of orbital planes	4
Satellite phasing between planes (degrees)	90
Minimum satellite separation from geostationary orbit plane (degrees)	53.3
Operational stationary latitude/longitude locations	58.3° N/90° E 58.3° N/90° W
Maximum latitude/longitude operating range (degrees)	10/2
Minimum elevation angle from earth stations (degrees)	25
Short-term/long-term pfd at Earth's surface (dB(W/(m <sup>2</sup> · MHz)))	Identical
<b>2 Frequency range</b>	
Uplink frequency (GHz)	13.75-14.5/17.3-17.8
Uplink polarization	LHCP/RHCP
Downlink frequency (GHz)	10.7-12.7
Downlink polarization	RHCP/LHCP
<b>3 Spectrum required in each direction (MHz)</b>	1 250
<b>4 Carrier transmission parameters</b>	
Modulation	QPSK
Access	FDMA/TDM
Number of service link beams	10
Segment (transponder) bandwidth (MHz)	24
Receive bandwidth (MHz)	24
Transmission bandwidth (MHz)	24
Overall $C/N_0$ (dB/Hz)	86
Uplink e.i.r.p./carrier (dBW)	77
Downlink e.i.r.p./carrier (dBW)	58
<b>5 Satellite communication parameters</b>	
Type of satellite transponder	Transparent
Transmit maximum gain (dBi)	38
Receive maximum gain (dBi)	24
Steerable antenna or not	Yes (phased array)
<b>6 Earth station characteristics</b>	
Feeder link transmit gain (dBi)	55
Feeder link e.i.r.p. per 24 MHz (dBW)	77
Receive antenna gain (minimum) (dBi)	30
Antenna pattern	29 – 25 log (θ)

## ANNEX 10

TABLE 26

## Technical characteristics of two GSO satellite telemetry and command sub-systems

	Emergency		On-station	
	GSO-A	GSO-B	GSO-A	GSO-B
<i>Telemetry</i>				
Frequency (GHz)	11.7		11.7	
Modulation	PM		PM	
Satellite e.i.r.p. (dBW)	7.2	10.1	12.4	16
Earth station $G/T$ (dB(K <sup>-1</sup> ))	37	35	37	35
$C/N_0$ (dB/Hz)	66.5	67.4	71.7	73.5
Losses (dB)	7	5	7	5
Telemetry bit rate (dB/Hz)	27.1	33.1	27.1	33.1
$E_b/N_0$ (dB)	32.4	29.3	37.6	35.2
Required $E_b/N_0$ (dB/Hz)	9.6	12	9.6	12
<i>Command</i>				
Frequency (GHz)	14.5	17.3	14.5	17.3
Modulation	FM		FM	
Earth station e.i.r.p. (dBW)	88	89	59	65
Satellite antenna gain (dBi)	0	0	43	29
Receiver input power (dBW)	-125.9	-126.3	-122.9	-125
Receiver threshold (dBW)	-141.5	-143	-141.5	-143
System noise temperature (dB(K <sup>-1</sup> ))	28	27.4	29.6	28.9
$C/N_0$ (dB/Hz)	74.7	74.9	76.1	74.7
Required $C/N_0$ (dB/Hz)	58.5	57	58.5	57

PM: phase modulation.

## ANNEX 11

TABLE 27

## Technical characteristics of a planned V-band system: GSOV-B1

2 Frequency range and polarization						
Uplink frequency (GHz)			47.2-50.2			
Uplink polarization			Linear			
Downlink frequency (GHz)			37.5-40.5			
Downlink polarization			Linear			
3 Spectrum required in each direction (MHz)			3 000			
4 Carrier transmission parameters						
Modulation type			QPSK/SS-TDMA			
Number of service link beams			24 × 0.3° beams			
User data rate per TDMA carrier			88 Mbit/s 128 kbit/s			
Occupied bandwidth			105.6 MHz 167 kHz			
Coding			R 1/2			
5 Satellite antenna parameters						
Antenna beam gain (dBi)			51.5			
Satellite $G/T$ (dB(K <sup>-1</sup> ))			23.4			
Satellite noise temperature (K)			650			
Beam size (degrees)			0.3			
Number of beams			24			
6 Earth station antenna parameters						
Antenna gain			See item 7 below			
Minimum elevation angle (degrees)			20			
7 Power characteristics						
			194KG7W		123MG7W	
Uplink/downlink	Earth station diameter (m)	Earth station gain (dBi)	Maximum power density (dB(W/Hz))	Minimum power density (dB(W/Hz))	Maximum power density (dB(W/Hz))	Minimum power density (dB(W/Hz))
Uplink clear sky	0.45	45.2	-47.3	-65.8	-48.7	-51.7
	0.9	51.2	-53.3	-71.8	-54.7	-57.7
	1.2	53.7	-55.8	-74.3	-57.2	-60.2
	6	67.7	-69.8	-88.3	-71.2	-74.2
Uplink degraded	0.45	45.2	-37.3	-65.8	-38.7	-51.7
	0.9	51.2	-43.3	-71.8	-44.7	-57.7
	1.2	53.7	-55.8	-74.3	-47.2	-60.2
	6	67.7	-59.8	-88.3	-61.2	-74.2
Downlink	0.45	43.7	-60.3	-69.3	(1)	(1)
	0.9	49.7	(2)	(2)	-66.2	-73.3
	1.2	52.2	67.3	-75.5	-66.2	-74.9
	6	66.2	-75.8	-78.8	-66.2	-77.5

(1) Not provided.

(2) Out of range.

TABLE 28

**Technical characteristics of a planned V-band system: GSO V-B2**  
**Technical characteristics of CANSAT GSO FSS satellite networks in the 50/40 GHz bands**

GSO FSS network name – “CANSAT-__”	2A	2B	3A	3B	3C	3D	3E
Orbital position (° W)	70.5	82.0	91.0	111.1	114.9	118.7	107.3
<b>1 Orbital parameters</b>							
Shape of orbit	Circular						
Height (km)	35 786 (geosynchronous)						
Inclination angle (degrees)	≤ 0.1						
Number of orbital planes	1 (GSO)						
Separation within plane	–						
<b>2 Frequency range and polarization</b>							
Uplink frequency (GHz)	47.2-50.2						
Uplink polarization	–						
Downlink frequency (GHz)	37.5-40.5						
Downlink polarization	–						
<b>3 Spectrum required in each direction (MHz)</b>							
	3 000						
<b>4 Carrier transmission parameters</b>							
Modulation type	QPSK or 8-PSK						
Number of service link beams	Up to 80						
FDM channels/beam	Up to 5						
Number of bandwidth/FDM channel (MHz)	150						
Number of user rate/TDM channel (Mbit/s)	0.144 to 155.52		1.544 to 155.52				
Receiver bandwidth (MHz)	0.150 to 150 (depending upon data rate)		1.50 to 150 (depending upon data rate)				
Transmission bandwidth (MHz)	0.150 to 150 (depending upon data rate)		1.50 to 150 (depending upon data rate)				
Overall C/N per user (dB)	Minimum of 5.0 (depends on coding)						
Uplink e.i.r.p./carrier (dBW)	49.6 (144 kbit/s) 60.0 (1.544 Mbit/s) 76.2 (44.736 Mbit/s) 84.7 (155.52 Mbit/s)		60.0 (1.544 Mbit/s) 76.2 (44.736 Mbit/s) 84.7 (155.52 Mbit/s)				
Downlink e.i.r.p./carrier (dBW)	70.1 (144 kbit/s) 63.8 (1.544 Mbit/s) 47.1 (44.736 Mbit/s) 37.1 (155.52 Mbit/s)		63.8 (1.544 Mbit/s) 47.1 (44.736 Mbit/s) 37.1 (155.52 Mbit/s)				
Type of transponder	–						
<b>5 Satellite antenna parameters</b>							
Transmit gain (maximum) (dBi)	53.1						
Receive gain (maximum) (dBi)	53.1						
Main lobes	–						
Side lobes	–						
Steerable antenna or not	Yes						
<b>6 Earth station antenna parameters</b>							
Transmit gain (maximum) (dBi)	45.5 (46 cm) to 65.4 (4.5 m)		52.3 (1.0 m) to 65.4 (4.5 m)				
Receive gain (maximum) (dBi)	43.8 (46 cm) to 63.6 (4.5 m)		50.5 (1.0 m) to 63.6 (4.5 m)				
Radiation pattern	29 – 25 log (θ)						
Minimum operating elevation angle (degrees)	Generally ≥ 20		Minimum elevation determined by climatic zone, and desired availability				
<b>7 Number of earth stations and distribution</b>							
	Unlimited/visible Earth		Unlimited/anywhere on visible Earth				
<b>8 Earth station switching strategy</b>							
	–						