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Radiocommunication Sector of ITU

Recommendation ITU-R M.1184-2
(06/2003)

Technical characteristics of mobile satellite systems in the frequency bands below 3 GHz for use in developing criteria for sharing between the mobile-satellite service (MSS) and other services

M Series

Mobile, radiodetermination, amateur and related satellite services

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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R M.1184-2*

Technical characteristics of mobile satellite systems in the frequency bands below 3 GHz for use in developing criteria for sharing between the mobile-satellite service (MSS) and other services

(Question ITU-R 201/8)

(1995-2000-2003)

The ITU Radiocommunication Assembly,

considering

a) that, while some MSS system parameters are still under development, a summary of representative technical characteristics of MSS systems is useful for conducting sharing studies and for development of appropriate sharing criteria by the ITU-R;

b) that MSS system designs will evolve and new MSS systems may be proposed and therefore representative characteristics should be maintained as an on-going activity,

noting

a) that the necessary frequency sharing studies require the involvement of several Radiocommunication Study Groups;

b) that the technical parameters in this Recommendation are referenced and used in several other ITU-R Recommendations;

c) that MSS networks and the associated lists of the technical parameters in this Recommendation have been chosen specifically for use in modelling frequency sharing and interference,

recommends

1 that the representative technical characteristics for non-GSO MSS systems, as given in Annexes 1 and 2, be used by the ITU-R in conducting sharing studies and in the development of Recommendations on sharing criteria for non-GSO MSS systems;

2 that the representative technical characteristics for geostationary MSS systems given in Annex 1 be used for conducting sharing studies and in the development of ITU-R Recommendations on sharing criteria for geostationary MSS systems;

3 that the characteristics given in Annexes 1 and 2 be updated periodically to reflect changes in the MSS example system designs and to incorporate new MSS system examples as they are proposed and as their designs mature.

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* Radiocommunication Study Group 4 made editorial amendments to this Recommendation in 2009 in accordance with Resolution ITU-R 1.

Annex 1

Characteristics of representative 1-3 GHz MSS networks

1 Satellite orbits

Currently, the GSO is being used for the MSS. Some proposed mobile-satellite systems plan to use non-GSO orbits. Suitable orbits are determined by coverage requirements, service considerations and frequency sharing, as well as other considerations.

2 Global and regional/national GSO systems

Current Inmarsat and Russian Volna satellites utilize Earth-coverage antennas to provide near-global coverage from the GSO. The Russian systems are similar to those of Inmarsat systems, the characteristics of which are presented in Table 2. Several administrations are implementing regional/national GSO mobile-satellite systems to provide aeronautical, land and maritime services at 1.6/1.5 GHz. In addition to the above systems at 1.6/1.5 GHz, Japan is planning to put into operation a GSO mobile-satellite system in the 2.6/2.5 GHz bands.

The future generation of Inmarsat and Russian satellites and the planned regional and national systems will use spot beam to provide greater spectrum efficiency and conserve transmitted power of the satellite and mobile earth station.

2.1 Maritime mobile-satellite service

The Inmarsat-B system provides a power and bandwidth efficient replacement for the original Inmarsat-A and provides voice, facsimile, data and telex services. In parallel with Inmarsat-B, Inmarsat-M uses lower symbol transmission rates for voice, data and facsimile requirements for smaller ships. The Inmarsat-C system provides store and forward data and telex using small, low cost equipment.

2.2 Aeronautical mobile-satellite service

The International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPs) for aeronautical mobile-satellite (R) service (AMS(R)S), airborne equipment have been published in Annex 10 to the Convention on International Civil Aviation. The SARPs include a requirement for priority and pre-emption for safety communications over all other communications. All systems providing AMS(R)S services to the international civil aviation community have to conform with the applicable ICAO SARPs.

In summary, the aeronautical satellite communication systems will have to take into account the priority needs for safe operation of aircraft and the avionics will have to satisfy the severe requirements of aircraft environments.

2.3 Land mobile-satellite service

The land mobile-satellite service (LMSS) has proven to be an effective means for providing dependable communications in remote and sparsely populated areas, either as extensions of terrestrial VHF and UHF networks or as replacements for HF networks. Worldwide roaming capability is a mandatory function of International Mobile Telecommunications-2000 (IMT-2000) and the satellite component defined in Recommendations ITU-R M.687 and ITU-R M.818 is one of the important components that encourage the IMT-2000 capability. The interworking of the mobile-satellite system with the terrestrial system can encourage user convenience within not only IMT-2000 but also general LMSS.

2.4 Distress and safety service

Technical and operating characteristics of the Inmarsat 1.6 GHz satellite EPIRB system are described in Recommendation ITU-R M.632.

Tables 1 to 3 present representative technical characteristics of service links for selected MSS networks that utilize space stations in GSOs.

TABLE 1a

Technical characteristics of GSO mobile-satellite systems (service return link)

System / Parameter	GSO					
	A	**B**	**C**	**D**	**E**	**F**
Polarization						
Feeder link	Linear	Linear	Linear	Linear	Circular	Linear
Service link	RHCP	RHCP	RHCP	RHCP	RHCP	Circular
Direction of transmission	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space
Frequency bands						
Feeder link (GHz)	5	12	11	11	4	4, 11, 12
Service link (GHz)	1.6	1.6	1.6	2.0	2.0	1.6
Orbit						
Altitude (km)	36 000	36 000	36 000	36 000	36 000	36 000
Satellite separation (degrees)	120	78	Not applicable	Not applicable	*	Not applicable
Number of satellites	3	2	1	1	4 to 6	1 or 2
Orbital planes	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Inclination angle	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Satellite antennas						
Number of beams (service link)	180	50	7	28	250	Over 200
Beam size (degrees)	1	1	6	2	*	0.7

TABLE 1a (*end*)

System / Parameter	GSO					
	A	**B**	**C**	**D**	**E**	**F**
Satellite antennas (cont.)						
Satellite coverage area	Global	Regional	North America, Alaska, Hawaii	North America, Alaska, Hawaii	Global	Regional
Average beam side lobes (dB)	*	–25	–25	–25	*	–20
Beam frequency reuse	5	5	1.3	2	*	1 to 30
Link characteristics						
Nominal user e.i.r.p. (dBW)	6	0.5	12.5	10.9	–1 to +8	–7.5 to 3.5
EOC satellite G/T (dB(K^{-1}))	10	11	3.0	9.8	11	15.7
Transmission parameters						
Modulation	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK
Coding	FEC	FEC	*	*	FEC	FEC
Access scheme	CDMA	FDMA	FDMA	FDMA	FDMA/ TDMA	FDMA/ TDMA
Duplex scheme	*	FDD	FDD	FDD	FDD	FDD
Frame length	Not applicable	Not applicable	Not applicable	Not applicable	*	40
Burst rate (kbit/s)	Not applicable	Not applicable	Not applicable	Not applicable	32	46.8
Chip rate (Mchip/s)	8.33	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Voice activity factor	0.4	0.4	0.4	0.4	0.4	0.4
RF carrier spacing (MHz)	*	0.006	0.006	0.006	*	0.03125
RF channel spacing (MHz)	*	0.006	0.006	0.006	*	0.03125
Modulation bandwidth (MHz)	*	0.0045	0.0047	0.0047	*	0.0234
Required E_b/N_0 (dB)						
Voice	2.5	9.0	9.0	9.0	4.0	3.5
Data	4.1	9.0	9.0	9.0	*	5.5 to 7.0
Maximum MES antenna discrimination towards the horizon (dBi)	*	7	7	7	1.0	7 to 19

NOTE 1 – See the legend for special terms and symbols at the end of Table 4.

TABLE 1b

Technical characteristics of GSO mobile-satellite systems (service forward link)

System / Parameter	GSO					
	A	**B**	**C**	**D**	**E**	**F**
Polarization						
Feeder link	Linear	Linear	*	*	Circular	Linear
Service link	RHCP	RHCP	*	*	RHCP	Circular
Direction of transmission	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth
Frequency bands						
Feeder link (GHz)	6	14	13	13	6	6, 13, 14
Service (GHz)	2.5	1.5	1.5	1.9	2.2	1.5
Orbit						
Altitude (km)	36 000	36 000	36 000	36 000	36 000	36 000
Satellite separation (degrees)	120	78	Not applicable	Not applicable	*	Not applicable
Number of satellites	3	2	1	1	4 to 6	1 or 2
Orbital planes	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Inclination angle	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Satellite antennas						
Number of beams (service link)	180	50	7	28	150	Over 200
Beam size (degrees)	1	1	*	*	*	0.7
Satellite coverage area	Global	Regional	North America, Alaska, Hawaii	North America, Alaska, Hawaii	Global	Regional
Average beam side lobes (dB)	*	–25	–25	–25	*	–20
Beam frequency reuse	5	5	1.2	2	*	1 to 30
Link characteristics						
Maximum e.i.r.p./beam (dBW)	45.8	53.5	58.4	52.8	*	*
Average gain/beam (dBi)	*	44	32	41.1	*	44.5
e.i.r.p./carrier (dBW)	28.8	30	30	35.5	42	24.5 to 45.0
e.i.r.p./shadowed user (dBW)	*	30	30	35.5	*	*

TABLE 1b (*end*)

System / Parameter	GSO					
	A	**B**	**C**	**D**	**E**	**F**
Link characteristics (cont.)						
e.i.r.p./unshadowed user (dBW)	*	30	30	35.5	*	*
e.i.r.p./CDMA channel (dBW)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
pfd level per beam carrier (dB(W/(m^2 · 4 kHz)))	*	–131	–131.0	–127.5	–123.0	–138.0 to –117.5
Transmission parameters						
Number of channels/satellite	*	5 000	2 000	10 000	5 000	20 000
User G/T (dB(K^{-1}))	–20	–22	–16	–16	–23	–23.5 to –9.0
Minimum elevation angle (degrees)	5	5	5	5	10	20
Lifetime (years)	12	12	12	12	10 to 12	12
Modulation	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK
Coding	FEC	FEC	FEC	FEC	FEC	FEC
Access scheme	CDMA	FDMA/ TDMA	FDMA	FDMA	TDMA	FDMA/ TDMA
Frame length (ms)	*	Not applicable	Not applicable	Not applicable	*	40
Burst rate (kbit/s)	Not applicable	Not applicable	Not applicable	Not applicable	32	46.8
Chip rate (Mchip/s)	8.33	Not applicable	Not applicable	Not applicable	*	Not applicable
Voice activity factor	0.4	0.4	0.4	0.4	0.4	0.5
Required E_b/N_0 (dB)						
Voice	2.5	9	9	9	*	3.5
Data	4.1	9	9	9	*	5.5 to 7.0
MES geographical distribution	*	*	*	*	*	*
Maximum permissible levels of interference power	*	*	*	*	*	*

NOTE 1 – See the legend for special terms and symbols at the end of Table 4.

TABLE 2

Inmarsat GSO systems overview

	B	C	M		Mini-M	GAN	PMC	Aeronautical	
								High gain	High gain
Service	MMSS LMSS	MMSS LMSS	MMSS	LMSS	LMSS	LMSS	LMSS	AMSS AMS(R)S	AMSS AMS(R)S
Typical mobile station antenna gain (dBi)	21	0	14	12	10	18	16.5	12	0
Antenna type (example)	Dish	Quad helix	Short backfire	Linear array	Phased array	Phased array	Phased array	Phased array	Quad helix
Typical antenna size	1 m diameter	5 cm diameter	40 × 25 cm	60 × 9 cm	30 × 20 cm	65 × 45 cm	50 × 35 cm	2 panels 60 × 60 cm	20 × 15 cm
Mobile earth station figure of merit (G/T) (dB(K^{-1}))	–4	–23	–10	–12	–17	–7	–9	–12	–26
Mobile earth station e.i.r.p./channel (dBW)	33	11	27	25	14	28	21	26	12
User data rate	9.6 kbit/s	600 bit/s	2 400 bit/s	2 400 bit/s	2 400 bit/s	64 kbit/s	432 kbit/s	9.6 kbit/s	300 bit/s
Communication channel rate and modulation	24 kbit/s, OQPSK (voice)	600 bit/s, BPSK	8 kbit/s, OQPSK	8 kbit/s, OQPSK	5.6 kbit/s OQPSK	65.2 kbit/s 16-QAM	732 kbit/s 16-QAM	21 kbit/s, OQPSK	600 bit/s, BPSK
Typical C/N_0 for communication channel (dB(Hz))	47	32	42	42	41	53	65	44	32
Satellite e.i.r.p./channel (dBW)	16	20	17	17	24	27	44	22	22
Channel spacing (nominal) (kHz)	20	5	10	10	13	60	200	17.5	2.5
Satellite peak antenna gain [1] (dBi)	18	18	18	18	27	27	41	18	18
pfd	*	*	*	*	*	*	*	*	*

[1] Nominal value for first and second generation satellites.

NOTE 1 – See the legend for special terms and symbols at the end of Table 4.

TABLE 3

National/regional GSO system overview

	Australia	Canada/ United States of America	Japan
			N-STAR[1]
Service	MSS	MSS	LMSS/ MMSS
Typical mobile station antenna gain (dBi)	12	8 to 13 0 to 4	To be determined
Antenna type (example)	To be determined	– Electrically scanned phased array – Mast type	To be determined
Typical antenna size	To be determined	25 to 50 cm diameter	To be determined
Mobile earth station figure of merit (G/T) (dB(K^{-1}))	–13	–15 to –12 –23 to –18	To be determined
Mobile earth station e.i.r.p./channel (dBW)	15	10 to 16	To be determined
User data rate	2 400 bit/s	2.4 to 4.8 kbit/s 4 to 8 kbit/s, voice	To be determined
Communication channel rate and modulation	6.6 kbit/s	4.8 to 9.6 kbit/s, OQPSK TCM	π/4 shifted QPSK
Typical C/N_0 for communication channel (dB(Hz))	48	45 to 51	To be determined
Satellite e.i.r.p./channel (dBW)	22	23 to 29	52[2]
Channel spacing (nominal) (kHz)	7.5	5 to 10	12.5
Satellite peak antenna gain[1] (dBi)	To be determined	32	34
pfd	*	*	*

(1) N-STAR uses the 2.5/2.6 GHz band, whereas the other systems in this Table use the 1.5/1.6 GHz band.

(2) Total satellite e.i.r.p.

NOTE 1 – See the legend for special terms and symbols at the end of Table 4.

3 Non-GSO MSS system characteristics

Proposed personal communication systems using non-GSO satellites, including satellites using low, medium and intermediate orbits, are expected to provide voice, data communications and positioning on a worldwide basis using mobile terminals or hand-held portable terminals using omnidirectional antennas.

Operation in a band contiguous with future land mobile communication systems would permit interoperability between non-GSO MSS and land mobile systems.

Table 4 presents representative technical characteristics of service links for selected MSS networks that utilize space stations in non-GSOs.

4 Propagation factors and mobile antenna characteristics

Signal level variation due to multipath effects and blockage by ship's superstructure occurs in MMSS links. Multipath, especially sea surface-reflected multipath, is a significant factor to be considered in the design of an aeronautical mobile-satellite system. In LMSS links, foliage shadowing is a significant additional effect which increases with frequency. Furthermore, several propagation factors should be taken into account when designing a non-GSO MSS system providing personal services. These propagation factors affect system characteristics, such as link margin and transmission power control techniques.

Reference radiation patterns for various types of LMSS mobile earth station antenna are recommended to assess the interference calculation for coordination studies (see Recommendation ITU-R M.1091).

TABLE 4a

Technical characteristics of non-GSO mobile-satellite systems (service return link)

Parameter \ System	A[1]	B	C	D	E			F	G		H	R
									Link 1	Link 2		
Polarization												
Feeder link	RHCP	RHCP	Circular	RHCP/ LHCP	RHCP/LHCP			Circular	RHCP	RHCP	LHCP	Circular
Service link	RHCP	LHCP	Circular	LHCP	RHCP			RHCP	LHCP	LHCP	RHCP	Circular
Direction of transmission	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space (service)			Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space
Frequency bands (GHz)												
Feeder link	30	20	5	7		< 19		7	11	11	5.2	19
Service link	1.6	1.6	1.6	1.6		1.6		2	0.2	1.6	1.6	1.9, 2.6
Orbit		[2]			Eccentric	Circular	Elliptical (alternate orbit)		Circular	Circular	Circular	Circular
Altitude (km)	780	10 355	2 000	1 414	520/7 846	7 846	4 376/7 846	10 355	1 500	1 500	1 000	700
Satellite separation (degrees)	32.7	90	45	60				72	30	30	51.4	27.7
Number of satellites	66	12	40	48	4-5	6-8	6-8	10	48	48	7	91
Orbital planes	6	3	5	8	2	1	1	2	4	4	7	7
Inclination angle (degrees)	86	50	55	52	116.6	0	0	45	74	74	83	82
Satellite antennas												
Number of beams (service link)	48	37	10	16	91 in eccentric orbit and 61 in circular orbit or 19 on each satellite			121	1	6	9	37
Beam size (km^2)	1.8×10^5 to 7×10^5	9.7×10^5 (6.3°)	*	6.3×10^5 to 2.3×10^6	7.78×10^5 to 2.6×10^6			5×10^5 to 2×10^6	5×10^7	8.4×10^6	2.6×10^5 to 2×10^6	7.6×10^4 to 3.5×10^5
Average beam side lobes (dB)	–20	–20	To be determined	–15	–15 and greater			–20 (peak)	–3	–2	–15	–20
Beam frequency reuse	0.167	1	1	1	*N* (where *N*: number of beams)			*	1	0.6	0.11	3
Link characteristics												
Nominal user e.i.r.p. (dBW)	–4 to +6 (peak)	–5.8 to –11	0-10	–3	Baseline (19 beams) +3 mobile/ portable +13 fixed	Enhanced (91/61 beams) –6 hand-held/mobile/ portable +13 fixed		–1 (average) +7 (peak)	6.1	6	8	1.5
EOC satellite *G*/*T* (dB(K^{-1}))	–3 to –10	–1.4 to 1.8	–11	–17	–5.75 ($G = 21$)[3]	–0.75 ($G = 26$)[3]		2	–25.5	–14	–18	–12.6

TABLE 4a (*end*)

Parameter \ System	A[1]	B	C	D	E	F	G		H	R
							Link 1	Link 2		
Transmission parameters										
Modulation	QPSK	QPSK	QPSK	QPSK	OQPSK spreading modulation	QPSK	QPSK	QPSK	BPSK	QPSK
Coding	FEC	FEC	FEC	FEC	FEC rate 1/3, $K = 9$	FEC	FEC	FEC	FEC	Convolutional code rate 1/2, $K = 7$
Access scheme	FDMA/ TDMA	FDMA/ CDMA	FDMA/ CDMA	FDMA/ CDMA	CDMA	FDMA/ TDMA	FDMA/ CDMA	FDMA/ CDMA	FDMA/ CDMA	FDMA/ CDMA
Duplex scheme	TDD	FDD	FDD	FDD	Full	FDD	Full	Full	Full	FDD
Transmission parameters (*cont.*)										
Frame length (ms)	90	Not applicable	Not applicable	Not applicable	320 and 25.86 (random access)	40	60	60	60	Not applicable
Burst rate (kbit/s)	50	Not applicable	Not applicable	Not applicable	0.3-9.6	36	Not applicable	Not applicable	50	Not applicable
Chip rate (Mchip/s)	Not applicable	~2	2.56	1.2288	1.9 and/or 7.6	Not applicable	0.15	2.4	3	0.624
Voice activity factor	0.4	0.5	0.4	0.4	0.4	0.4	Not applicable	Not applicable	Not applicable	Not applicable
RF carrier spacing (MHz)	0.04167	Not applicable	To be determined	Not applicable	Not applicable	0.025	0.05	0.05	0.25	1.25
RF channel bandwidth (MHz)	Not applicable	2.5	To be determined	1.2	Not applicable	0.025	0.5	5.8	2.05	1.25
Modulation bandwidth (MHz)	0.0315	2.5	To be determined	1.2	1.9 and/or 7.6	0.025	0.5	5.8	2.05	1.25
Required E_b/N_0 (dB)	6.1	4.0	2.8	4.8[4]	4.5 (with margin)	2.5	32.6	35.4	16	6.5
Maximum MES antenna gain towards the horizon (dBi)	0	0	To be determined	*	3 mobile 10 fixed 0 hand-held	2	1	1.2	2	0
Maximum permissible levels of interference power	*	*	To be determined	*	$S/IF = -20$ dB	*	To be determined	To be determined	To be determined	To be determined

(1) Satellite antenna gains adjusted to maintain near-constant received power independent of range to user.

(2) System B has a 6 h sidereal orbit.

(3) $T = 473$ K.

(4) Includes effect of feeder link.

TABLE 4b

Technical characteristics of non-GSO mobile-satellite systems (service forward link)

Parameter \ System	A	B	C	D	E			F	G		H	R
									Link 1	Link 2		
Polarization												
Feeder link	RHCP	LHCP	Circular	RHCP/ LHCP	Dual circular			Circular	LHCP	LHCP	RHCP	Circular
Service link	RHCP	LHCP	Circular	LHCP	RHCP			RHCP	RHCP	RHCP	RHCP	Circular
Direction of transmission	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth (service)			Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth
Frequency bands (GHz)												
Feeder link	20	30	6	5	< 19			5	14	14	7	15
Service	1.6	2.5	2.5	2.5	2.5			2.2	0.4	1.5	2.5	2.1
Orbit		(2)			Eccentric	Circular	Elliptical (alternate orbit)		Circular	Circular	Circular	Circular
Altitude (km)	780	10 355	2 000	1 414	520/7 846	7 846	4 376/7 846	10 355	1 500	1 500	1 000	700
Satellite separation (degrees)	32.7	90	45	60	–	–	–	72	30	30	51.4	27.7
Number of satellites	66	12	40	48	4-5	6-8	6-8	10	48	48	7	91
Orbital planes	6	3	5	8	2	1	1	2	4	4	7	7
Inclination angle (degrees)	86	50	55	52	116.6	0	0	45	74	74	83	82
Satellite antennas												
Number of beams (service link)	48	37	10	16	91 in eccentric orbit and 61 in circular orbit or 19 on each satellite			121	1	6	9	37
Beam size (km^2)	1.8×10^5 to 17×10^5	9.7×10^5 (6.3°)	*	6.3×10^5 to 2.3×10^6	7.78×10^5 to 2.6×10^6			5×10^5 to 2×10^6	5×10^7	8.4×10^6	2.6×10^5 to 2×10^6	7.6×10^4 to 3.5×10^5
Average beam side lobes (dB)	–20	–20	To be determined	–15	–15 and greater			–20 (peak)	–3	–2	–15	–20
Beam frequency reuse	0.167	1	1	1	*N* (where *N*: number of beams)			*	1	0.6	0.11	3

TABLE 4b *(continued)*

Parameter \ System	A	B	C	D	E	F	G		H	R
							Link 1	Link 2		
Link characteristics										
Maximum e.i.r.p./beam (dBW)	*	~52	27.5	*	pdf ≤ –142 dB(W/(m^2 · 4 kHz))	52	–2	2.8	19	31.7
Average gain/beam (dBi)	17-25[1]	24-28	15.2	Not applicable	18.5 (baseline) at nadir-peak gain 28.8 (enhanced) at nadir-peak gain	30	3	13	10	31.7
e.i.r.p./carrier (dBW)			To be determined			33	–15	–7.2	15	31.7
Unshadowed user e.i.r.p. (dBW)	7-15	20.6	To be determined	Not applicable	13.92-18.66 for 19 beams per satellite or 13.92-21.5 for 61/91 beams per satellite	*	Not applicable	Not applicable	Not applicable	Not applicable
Shadowed user e.i.r.p. (dBW)	19-27	24.6	To be determined	0-5	Add 2.5 dB	*	Not applicable	Not applicable	Not applicable	Not applicable
e.i.r.p./CDMA channel (dBW)	Not applicable	*	–7 to 6	0 to 16	*	Not applicable	–5	–10.2	15 to 19	31.7
User G/T (dB(K^{-1}))	–23	–22.2 to –24	–22	–23	–25 to –15	–24	–23.8	–14	–24	–18
Minimum elevation angle (degrees)	8.3	20	15	10	15	10	7	10	10	10
Transmission parameters										[2]
Modulation	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK
Coding	FEC	FEC	FEC	FEC	FEC rate 1/3, $K = 9$	FEC	FEC	FEC	FEC	Convolutional code rate 1/2, $K = 7$
Access scheme	FDMA/TDMA	FDMA/CDMA	FDMA/CDMA	FDMA/CDMA	CDMA	FDMA/TDMA	FDMA/CDMA	FDMA/CDMA	FDMA/CDMA	FDMA/CDMA
Duplex scheme	TDD	FDD	FDD	FDD	FDD	FDD	Full	Full	Full	FDD
Frame length (ms)	90	*	Not applicable	*	320	40	Not applicable	Not applicable	Not applicable	Not applicable
Burst rate (kbit/s)	50	Not applicable	Not applicable	Not applicable	0.3 to 9.6	36	Not applicable	Not applicable	Not applicable	Not applicable

TABLE 4b (*end*)

Parameter \ System	A	B	C	D	E	F	G		H	R
							Link 1	Link 1		
Transmission parameters (*cont.*)										[2]
Chip rate (Mchip/s)	Not applicable	~2	2.56	1.228	1.9 and/or 7.6	Not applicable	0.15	2.4	6	7.5
Interleaving	*	*	*	*	Varies	None	None	None	None	Not applicable
Voice activity factor	0.4	0.5	0.4	0.4	0.4	0.4	Not applicable	Not applicable	Not applicable	Not applicable
Required E_b/N_0 (dB)	6.1	4	2.8	3.5[3]	4 (with no margin)	2.5	33.6	36.4	–8	6.5
MES geographical distribution	Worldwide	Worldwide	To be determined	*	Varies	*	AAB	AAB	AAB	Worldwide
Maximum permissible levels of interference power	*	*	To be determined	*	To be determined	*	To be determined	To be determined	To be determined	To be determined
Range of pfd (dB(W/(m^2 · 4 kHz)))	To be determined	To be determined	To be determined	To be determined	To be determined	To be determined	To be determined	To be determined	To be determined	Minimum: −144.8 Maximum: −132.0

[1] Satellite antenna gains adjusted to maintain near-constant received power independent of range to user.

[2] For system R, RF carrier spacing is 7.5 MHz and RF channel bandwidth 15 MHz.

[3] Includes effect of feeder link.

Legend for special terms and symbols used in Tables 1 to 4:

* Value requiring further study.

AAB: shared by several countries, but in a restricted area of the world

ACSSB: amplitude companded single sideband

EOC: edge of coverage

FDD: frequency division duplex

LHCP: left-hand circular polarization

MDS: multipoint distribution system

MES: mobile earth station

MSK: minimum shift keying

NBFM: narrow-band frequency modulation

OQPSK: offset quaternary phase-shift keying

RHCP: right-hand circular polarization

TDD: time division duplex

Annex 2

Technical parameters of MSS networks in the frequency bands below 1 GHz

TABLE 5

Parameters of several non-GSO MSS networks with primary frequency allocations below 1 GHz

System	L	M			N	P	Q		S
Orbital parameters									
Number of satellites	48				3	6	32		6
Altitude (km)	950	825		775	800	893	1 000		692, 667
Inclination (degrees)	50	45	0	70, 108	88	99	51	83	98.04
Orbit planes	8	3	1	2	3	2	6	2	2
Satellite/plane	6	8			1	3	5	1	3
Right ascension of ascending node (degrees)	0, 45, 90, 135, 180, 225, 270, 315	0, 120, 240	0	0, 180	0, 15, 90	9.8	0, 60, 120, 180, 240, 300	0, 90	143.5, 53.5
Subscriber uplink									
Band (MHz)	148-150.05[1]				148-150.05	148-148.855	148-150.05[1]		399.9-400.05
Tx power (W)	7	5			7	1	20		10
Tx e.i.r.p. (dBW)	8.5	7.5			11.5	–3.8	12		16
Maximum Tx antenna gain (dBi)	0	0.5			3	–3	0		7
Channel bandwidth (kHz)	15	5			30-90	855	25		150
Rate (kbit/s)	9.6/OQPSK	2.4/SDPSK			9.6, 19.2/FSK	1/QPSK	4.8, 9.6, 19.2/GMSK		4.8/MSK
Polarization (Tx wave)	Linear				RHCP	LHCP	Linear		RHCP
Satellite Rx G/T (dB(K^{-1}))	–22.9	–26			–30	–26.1	T = 940 K		–18.9

TABLE 5 (*continued*)

System	L		M	N	P	Q		S
Subscriber uplink (*cont.*)								
Maximum Rx antenna gain (dBi)	–2 (gain at nadir)		0		5.6	6 maximum; –3 at nadir		7
Rx antenna pattern	Isoflux		Toroidal, RHCP	10 log (cos 2 θ)	10 log (cos 2 θ)	Isoflux		Cardioide
$C/(I+N)$ (dB)	5.5		10.3	8	$E_b/(N_0+I_0)$ = 8.7 dB	E_b/N_0 = 13.5 dB		E_b/N_0 = 13.4 dB
Subscriber downlink								
Band (MHz)	137-138	400.15-401	137-138	400.15-401	137.0725-137.9275	137-138	400.15-401	400.6-400.9
Tx power (W)	25		18.2	6.3	1	32		10
Tx e.i.r.p. (dBW)	19.7		13.6	10	3.8	17.8		16
Maximum Tx antenna gain (dBi)	–2 (gain at nadir)		1	2	4.9	(6 maximum, isoflux, –3 at nadir)		7
Channel bandwidth (kHz)	25	35	15/25	30-85	855	25	45	300
Rate (kbit/s)	24/OQPSK 9.6/FSK		4.8/9.6/SDPSK	9.6, 19.2/FSK	Regenerated	4.8, 9.6, 19.2, 30/GMSK	4.8, 9.6, 19.2/GMSK	4.8/MSK
Polarization (Tx wave)	RHCP				LHCP	RHCP		LHCP
Subscriber Rx G/T (dB(K^{-1}))	–30.8		–28.6	–20.6	–21.2	T = 1 565 K	T = 505 K	–20.4
Maximum Rx antenna gain (dBi)	5.7		0.5	3	–3	3		7
$C/(I+N)$ (dB)	5.1		Rec. ITU-R M.1232	8	$E_b/(N_0+I_0)$ = 3.7 dB	E_b/N_0 = 13.5 dB		E_b/N_0 = 13.4 dB
Gateway downlink								
Band (MHz)	400.15-401		137-138	400.15-401	137.0725-137.9275	137-138	400.15-401	400.6-400.9
Tx power (W)	15		4.9	6.3	1	32		10
Tx e.i.r.p. (dBW)	17.5		5.0 (peak)	10	3.8	17.8		18
Maximum Tx antenna gain (dBi)	17		0	2	4.8	(6 maximum isoflux, –3 at nadir)		7

TABLE 5 (*end*)

System	L	M	N	P	Q		S
Gateway downlink (cont.)							
Channel bandwidth (kHz)	60	50	30-85	855	175	45	300
Rate (kbit/s)	50/OQPSK	57.6/OQPSK	9.6, 19.2, 38.4/FSK	Regenerated	112/GMSK	30/GMSK	4.8/MSK
Polarization (Tx wave)	RHCP			LHCP	RHCP		
Gateway Rx G/T (dB(K^{-1}))	–18.3	–12.8	–9.6	–21.2	T = 1 565 K	T = 505 K	–18.9
Maximum Rx antenna gain (dBi)	5.7	17, RHCP	14	7.6	12		7
$C/(I + N)$ (dB)	8.5	Rec. ITU-R M.1232	8	$C/(N_0 + I_0)$ = 3.7 dB(Hz)	E_b/N_0 = 13.5 dB		E_b/N_0 = 13.4 dB
Gateway uplink							
Band (MHz)	148-150.05			148-148.855	148-150.05		399.9-400.05
Tx power (W)	1.2	250 (peak)	5	1	150		10
Tx e.i.r.p. (dBW)	13.8	40 (peak)	21	7.3	32.8		18
Maximum Tx antenna gain (dBi)	18	17	14	8.3	12		7
Channel bandwidth (kHz)	50		30-90	855	50		150
Rate (kbit/s)	50/OQPSK	57.6/OQPSK	9.6. 19.2/FSK	1/QPSK	30/GMSK		4.8/MSK
Polarization (Tx wave)	RHCP			LHCP	RHCP		
Satellite Rx G/T (dB(K^{-1}))	–22.9	–33.3	–30	–23.1	T = 940 K		–20.4
Maximum Rx antenna gain (dBi)	16	0, RHCP	0	5.7	6 maximum, isoflux, –3 at nadir		7
$C/(I + N)$ (dB)	8.5	10.6	8	$C/(N_0 + I_0)$ = 42.5 dB(Hz)	E_b/N_0 = 13.5 dB		E_b/N_0 = 13.4 dB

(1) MSS networks using dynamic channel assignment techniques, such as those described in Recommendation ITU-R M.1039.

GMSK: Gaussian filtered MSK.

SDPSK: Symmetrical differential PSK.