RECOMMENDATION ITU-R M.1184

TECHNICAL CHARACTERISTICS OF MOBILE SATELLITE SYSTEMS IN THE 1-3 GHz RANGE FOR USE IN DEVELOPING CRITERIA FOR SHARING BETWEEN THE MOBILE-SATELLITE SERVICE (MSS) AND OTHER SERVICES USING COMMON FREQUENCIES

(Question ITU-R 201/8)

(1995)

Summary

This Recommendation provides the technical characteristics of the geostationary-satellite orbit (GSO) or non-GSO MSS systems which should be used for conducting sharing studies in the MSS area. It is also recommended that the characteristics given in Annex 1 be updated periodically to reflect changes in MSS system designs and to incorporate new MSS systems.

The ITU Radiocommunication Assembly,

considering

a) that Resolution No. 46 of the World Administrative Radio Conference for Dealing with Frequency Allocations in Certain Parts of the Spectrum (Malaga-Torremolinos, 1992) (WARC-92) invited the ITU-R to study and develop Recommendations on sharing criteria associated with non-geostationary satellite systems;

b) that Recommendation No. 717 of WARC-92 recommends the ITU-R study, as a matter of urgency, appropriate sharing criteria for MSS systems and systems of other services in the same frequency bands;

c) that, while some MSS system parameters are still under development, a summary of representative technical characteristics of MSS systems in the 1-3 GHz band is useful for conducting sharing studies and for development of appropriate sharing criteria by the ITU-R;

d) that MSS system designs will evolve and new MSS systems in the 1-3 GHz band may be proposed and therefore representative characteristics should be maintained as an on-going activity,

recommends

1 that the representative technical characteristics for non-geostationary MSS systems, as given in Annex 1, be used by the ITU-R in conducting sharing studies and in the development of Recommendations on sharing criteria for non-geostationary 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 Annex 1 be updated periodically to reflect changes in MSS example system designs and to incorporate new MSS system examples as they are proposed and as their designs mature.

ANNEX 1

Characteristics of representative 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 will be published in Annex 10 to the Convention on International Civil Aviation on completion of the ICAO consultative procedure. 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 1-3 present representative technical characteristics of service links for selected MSS networks that utilize space stations in GSOs.

3 Non-GSO MSS system characteristics

Proposed personal communication systems using non-GSO satellites, including LEO, MEO or ICO satellites, are expected to provide voice, data communications and positioning on a worldwide basis using mobile terminals or handheld 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 maritime MSS (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 1a

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

System/Parameter	GSO				
	A	B	C	D	E
Polarization					
Feeder link	Linear	Linear	Linear	Linear	CP
Service link	RHCP	RHCP	RHCP	RHCP	RHCP
Direction of transmission	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-to-Space	Earth-to-Space
Frequency bands (GHz)					
Feeder link	5	12	11	11	4
Service link	1.6	1.6	1.6	2.0	2.0
Orbit					
Altitude (km)	36 000	36 000	36 000	36 000	36 000
Satellite separation (degrees)	120	78	Not applicable	Not applicable	*

TABLE 1a *(continued)*

System/Parameter	GSO				
	A	B	C	D	E
Number of satellites	3	2	1	1	4 to 6
Orbital planes	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Inclination angle	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Satellite antennas					
No. of beams (service link)	180	50	7	28	250
Beam size (degrees)	1	1	6	2	*
Sat. coverage area	GSO	GSO	North America, Alaska, Hawaii	North America, Alaska, Hawaii	GSO
Average beam side lobes (dB)	*	–25	–25	–25	*
Beam frequency re-use	5	5	1.3	2	*
Link characteristics					
Nominal user e.i.r.p. (dBW)	6	0.5	12.5	10.9	–1 to +8
EOC satellite G/T (dB(K^{-1}))	10	11	3.0	9.8	11
Transmission parameters					
Modulation	QPSK	QPSK	QPSK	QPSK	QPSK
Coding	FEC	FEC	*	*	FEC
Access scheme	CDMA	FDMA	FDMA	FDMA	FDMA/ TDMA
Duplex scheme	*	FDD	FDD	FDD	FDD
Frame length	Not applicable	Not applicable	Not applicable	Not applicable	*
Burst rate (kbit/s)	Not applicable	Not applicable	Not applicable	Not applicable	32
Chip rate (Mc/s)	8.33	Not applicable	Not applicable	Not applicable	Not applicable
Voice activity factor	0.4	0.4	0.4	0.4	0.4
RF carrier spacing (MHz)	*	0.006	0.006	0.006	*
RF channel spacing (MHz)	*	0.006	0.006	0.006	*
Modulation bandwidth (MHz)	*	0.0045	0.0047	0.0047	*
Required E_b/N_0 (dB)					
Voice	2.5	9.0	9.0	9.0	4.0
Data	4.1	9.0	9.0	9.0	*
Maximum MES antenna discrimination towards the horizon (dBi)	*	7	7	7	1.0

TABLE 1b

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

System/Parameter	GSO				
	A	B	C	D	E
Polarization					
Feeder link	Linear	Linear	*	*	CP
Service link	RHCP	RHCP	*	*	RHCP
Direction of transmission	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth
Frequency bands (GHz)					
Feeder link	6	14	13	13	6
Service	2.5	1.5	1.5	1.9	2.2
Orbit					
Altitude (km)	36 000	36 000	36 000	36 000	36 000
Satellite separation	120	78	Not applicable	Not applicable	*
Number of satellites	3	2	1	1	4 to 6
Orbital planes	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Inclination angle	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Satellite antennas					
No. of beams (service link)	180	50	7	28	150
Beam size (degrees)	1	1	*	*	*
Satellite coverage area	GSO	GSO	North America, Alaska, Hawaii	North America, Alaska, Hawaii	GSO
Average beam side lobes (dB)	*	–25	–25	–25	*
Beam frequency re-use	5	5	1.2	2	*
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	*
e.i.r.p./carrier (dBW)	28.8	30	30	35.5	42
e.i.r.p./shadowed user (dBW)	*	30	30	35.5	*
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
pfd level per beam carrier (dB(W/m^2/4 kHz))	*	–131	–131.0	–127.5	–123.0
Transmission parameters					
No. of channels/satellite	*	5 000	2 000	10 000	5 000
User G/T (dB(K^{-1}))	–20	–22	–16	–16	–23
Minimum elevation angle (degrees)	5	5	5	5	10
Lifetime (years)	12	12	12	12	10 to 12
Modulation	QPSK	QPSK	QPSK	QPSK	QPSK
Coding	FEC	FEC	FEC	FEC	FEC
Access scheme	CDMA	FDMA/ TDMA	FDMA	FDMA	TDMA
Frame length	*	Not applicable	Not applicable	Not applicable	*

TABLE 1b *(continued)*

System/Parameter	GSO				
	A	B	C	D	E
Burst rate (kbit/s)	Not applicable	Not applicable	Not applicable	Not applicable	32
Chip rate (Mc/s)	8.33	Not applicable	Not applicable	Not applicable	*
Voice activity factor	0.4	0.4	0.4	0.4	0.4
Required E_b/N_0 (dB)					
Voice	2.5	9	9	9	*
Data	4.1	9	9	9	*
MES geographical distribution	*	*	*	*	*
Maximum permissible levels of interference power	*	*	*	*	*

TABLE 2

INMARSAT GSO systems overview

	A	B	C	M		Aeronautical	
						High gain	Low gain
Service	MMSS LMSS	MMSS LMSS	MMSS LMSS	MMSS	LMSS	AMSS AMS(R)S	AMSS AMS(R)S
Typical mobile station antenna gain (dBi)	21	21	0	14	12	12	0
Antenna type (example)	Dish	Dish	Quad helix	Short backfire	Linear array	Phased array	Quad helix
Typical antenna size	1 m diam.	1 m diam.	5 cm diam.	40 × 25 cm	60 × 9 cm	2 panels 60 × 60 cm	20 × 15 cm
Mobile earth station figure of merit (G/T) ($dB(K^{-1})$)	–4	–4	–23	–10	–12	–12	–26
Mobile earth station e.i.r.p./channel (dBW)	36	33	11	27	25	26	12
User data rate	9.6 kbit/s	9.6 kbit/s	600 bit/s	2 400 bit/s	2 400 bit/s	9.6 kbit/s	300 bit/s
Communication channel rate and modulation	FM, 12 kHz deviation (voice)	24 kbit/s, OQPSK (voice)	600 bit/s, BPSK	8 kbit/s, OQPSK	8 kbit/s, OQPSK	21 kbit/s, OQPSK	600 bit/s, BPSK
Typical C/N_0 for communication channel (dB(Hz))	53	47	32	42	42	44	32
Satellite e.i.r.p./channel (dBW)	17.5	16	20	17	17	22	22
Channel spacing (nominal) (kHz)	50	20	5	10	10	17.5	2.5
Satellite peak antenna gain(1) (dBic)	18	18	18	18	18	18	18
pfd	*	*	*	*	*	*	*

(1) Nominal value for first and second generation satellites.

TABLE 3

National/regional GSO system overview

	Australia	Canada/United States of America	Canada Phase 1, MDS	Japan		
				ETS-V	ETS-VI[1]	N-STAR[1]
Service	MSS	MSS	LMSS MMSS	MSS	MSS	LMSS/ MMSS
Typical mobile station antenna gain (dBic)	12	8 to 13 0 to 4	2.5	3 to 17	8 to 17	To be determined
Antenna type (example)	To be determined	– Electrically scanned phased array – Mast type	Bifilar helix	Dish, patch array, short backfire, quad helix	To be determined	To be determined
Typical antenna size	To be determined	25 to 50 cm diam.	15 cm high	1 m diam. to 50 × 2 cm diam.	To be determined	To be determined
Mobile earth station figure of merit (G/T) ($dB(K^{-1})$)	–13	–15 to –12 –23 to –18	–22	–10 to 21	–16 to 7	To be determined
Mobile earth station e.i.r.p./channel (dBW)	15	10 to 16	15	6 to 32	4 to 26	To be determined
User data rate	2 400 bit/s	2.4 to 4.8 kbit/s 4 to 8 kbit/s voice	600 bit/s	600 bit/s to 330 kbit/s	To be determined	To be determined
Communication channel rate and modulation	6.6 kbit/s	4.8 to 9.6 kbit/s, OQPSK TCM	1 200 bit/s, BPSK	8/16 kbit/s OQPSK, 16/24 kbit/s MSK, NBFM, ACSSB, 160 kbit/s TDM/TDMA	QPSK or OQPSK	π/4 shifted QPSK
Typical C/N_0 for communication channel (dB(Hz))	48	45 to 51	39	40 to 67	To be determined	To be determined
Satellite e.i.r.p./channel (dBW)	22	23 to 29	21.6	35.5 Nominal	25 to 37	52[2]
Channel spacing (nominal) (kHz)	7.5	5 to 10	5	12.5, 25	To be determined	12.5
Satellite peak antenna gain[1] (dBic)	To be determined	32	18	26	34	34
pfd	*	*	*	*	*	*

(1) ETS-VI and N-STAR use the 2.6/2.5 GHz band, whereas the other systems in this table use the 1.6/1.5 GHz band.

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

TABLE 4a

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

System	A[2]	B	C	D	E			F	G		H
Parameter									Link 1	Link 2	
Polarization											
Feeder link	RHCP	RHCP	CP	RH/LHCP	RH/LHCP			CP	RHCP	RHCP	LHCP
Service link	RHCP	LHCP	CP	LHCP	RHCP			RHCP	LHCP	LHCP	RHCP
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
Frequency bands (GHz)											
Feeder link	30	20	5	7	< 19			7	11	11	5.2
Service link	1.6	1.6	1.6	1.6	1.6			2	0.2	1.6	1.6
Orbit		[1]			Eccentric	Circular	Elliptical (alternate orbit)		Circular	Circular	Circular
Altitude (km)	780	10 355	2 000	1 414	5 20/7 846	7 846	4 376/7 846	10 355	1 500	1 500	1 000
Satellite separation (degrees)	32.7	90	45	60				72	30	30	51.4
Number of satellites	66	12	40	48	4-5	6-8	6-8	10	48	48	7
Orbital planes	6	3	5	8	2	1	1	2	4	4	7
Inclination angle (degrees)	86	50	55	52	116.6	0	0	45.0	74.0	74.0	83.0

TABLE 4a *(continued)*

System	A[2]	B	C	D	E			F	G		H
Parameter									Link 1	Link 2	
Satellite antennas											
No. 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
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
Average beam side lobes (dB)	–20	–20	To be determined	–15	–15 and greater			–20 (peak)	–3	–2	–15
Beam frequency re-use	0.167	1.0	1	1.0	*N* (where *N*: number of beams)			*	1	0.6	0.11
Link characteristics	[2]										
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 handheld/mobile/ portable +13 fixed		–1 (average) +7 (peak)	6.1	6.0	8.0
EOC satellite *G*/*T* ($dB(K^{-1})$)	–3 to –10	–1.4 to 1.8	–11	–17	–5.75 ($G = 21$)[2bis]	–0.75 ($G = 26$)[2bis]		2.0	–25.5	–14	–18.0
Transmission parameters											
Modulation	QPSK	QPSK	QPSK	QPSK	O-QPSK spreading modulation			QPSK	QPSK	QPSK	BPSK
Coding	FEC	FEC	FEC	FEC	FEC $R = 1/3$, $K = 9$			FEC	FEC	FEC	FEC
Access scheme	FDMA/ TDMA	FDMA/ CDMA	FDMA/ CDMA	FDMA/ CDMA	CDMA			FDMA/ TDMA	FDMA/ CDMA	FDMA/ CDMA	FDMA/ CDMA
Duplex scheme	TDD	FDD	FDD	FDD	Full			FDD	Full	Full	Full

TABLE 4a *(continued)*

System	A[2]	B	C	D	E	F	G		H
Parameter							Link 1	Link 2	
Frame length (ms)	90	Not applicable	Not applicable	Not applicable	320 and 25.86 (random access)	40	60	60	60
Burst rate (kbit/s)	50	Not applicable	Not applicable	Not applicable	0.3-9.6	36	Not applicable	Not applicable	50
Chip rate (Mc/s)	Not applicable	~2.0	2.56	1.2288	1.9 and/or 7.6	Not applicable	0.15	2.4	3.0
Voice activity factor	0.4	0.5	0.4	0.4	0.4	0.4	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
RF channel bandwidth (MHz)	Not applicable	2.5	To be determined	1.2	Not applicable	0.025	0.5	5.8	2.05
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
Required E_b/N_0 (dB)	6.1	4.0	2.8	4.8[3]	4.5 (with margin)	2.5	32.6	35.4	16
Maximum MES antenna gain towards the horizon (dBi)	0.0	0	To be determined	*	3 mobiles 10 fixed 0 handheld	2.0	1.0	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

(1) System B has a 6 sidereal hour orbit.

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

(2bis) $T = 473$ K for both.

(3) Includes effect of feeder link.

TABLE 4b

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

System	A	B	C	D	E			F	G		H
Parameter									Link 1	Link 2	
Polarization											
Feeder link	RHCP	LHCP	CP	RH/LHCP	Dual circular			CP	LHCP	LHCP	RHCP
Service link	RHCP	LHCP	CP	LHCP	RHCP			RHCP	RHCP	RHCP	LHCP
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
Frequency bands (GHz)											
Feeder link	20	30	6	5	< 19			5	14	14	7
Service	1.6	2.5	2.5	2.5	2.5			2.2	0.4	1.5	2.5
Orbit					Eccentric	Circular	Elliptical (alternate orbit)		Circular	Circular	Circular
Altitude (km)	780	10 355	2 000	1 414	5 20/7 846	7 846	4 376/7 846	10 355	1 500	1 500	1 000
Satellite separation (degrees)	32.7	90	45	60	–	–	–	72	30	30	51.4
Number of satellites	66	12	40	48	4-5	6-8	6-8	10	48	48	7
Orbital planes	6	3	5	8	2	1	1	2	4	4	7
Inclination angle (degrees)	86	50	55	52	116.6	0	0	45	74.0	74.0	83.0
Satellite antennas											
No. 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
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
Average beam side lobes (dB)	–20	–20	To be determined	–15	–15 and greater			–20 (peak)	–3	–2	–15

TABLE 4b *(continued)*

System	A	B	C	D	E	F	G		H
Parameter							Link 1	Link 2	
Beam frequency re-use	0.167	1.0	1	1.0	*N* (where *N*: number of beams)	*	1	0.6	0.11
Link characteristics									
Maximum e.i.r.p./beam (dBW)	*	~52	27.5	*	pfd ≤ –142 dB(W/m^2/4 kHz)	52	–2	2.8	19
Average gain/beam (dBi)	17 – 25[(2)]	24 to 28	15.2	Not applicable	18.5 (Baseline) at nadir-peak gain 28.8 (Enhanced) at nadir-peak gain	30	3	13	10
e.i.r.p./carrier (dBW)			To be determined			33	–15	–7.2	15
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
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
e.i.r.p./CDMA channel (dBW)	Not applicable	*	–7 to 6	0 – 16	*	Not applicable	–5.0	–10.2	15 to 19
User G/T (dB(K^{-1}))	–23	–22.2 to –24	–22	–23	–25 to –15	–24	–23.8	–14	–24
Minimum elevation angle (degrees)	8.3	20	15	10	15	10	7	10	10
Transmission parameters									
Modulation	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK
Coding	FEC	FEC	FEC	FEC	FEC R = 1/3, K = 9	FEC	FEC	FEC	FEC
Access scheme	FDMA/ TDMA	FDMA/ CDMA	FDMA/ CDMA	FDMA/ CDMA	CDMA	FDMA/ TDMA	FDMA/ CDMA	FDMA/ CDMA	FDMA/ CDMA
Duplex scheme	TDD	FDD	FDD	FDD	FDD	FDD	Full	Full	Full
Frame length (ms)	90	*	Not applicable	*	320	40	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

TABLE 4b *(continued)*

System	A	B	C	D	E	F	G		H
Parameter							Link 1	Link 2	
Chip rate (Mc/s)	Not applicable	~2.0	2.56	1.228	1.9 and/or 7.6	Not applicable	0.15	2.4	6.0
Interleaving	*	*	*	*	Varies	None	None	None	None
Voice activity factor	0.4	0.5	0.4	0.4	0.4	0.4	Not applicable	Not applicable	Not applicable
Required E_b/N_0 (dB)	6.1	4.0	2.8	3.5(1)	4.0 (with no margin)	2.5	33.6	36.4	–8
MES geographical distribution	Worldwide	Worldwide	To be determined	*	Varies	*	AAB	AAB	AAB
Maximum permissible levels of interference power	*	*	To be determined	*	To be determined	*	To be determined	To be determined	To be determined
Range of pfd	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

(1) Includes effect of feeder link.

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

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
BPSK:	binary phase shift keying
CDMA:	code division multiple access
EOC:	edge of coverage
FDD:	frequency division duplex
FDMA:	frequency division multiple access
FEC:	forward-error correction
LHCP:	left-hand circular polarization
MES:	mobile earth station
MSK:	minimum shift keying
NBFM:	narrow-band frequency modulation
OQPSK:	offset quaternary phase shift keying
pfd:	power flux-density
QPSK:	quaternary phase shift keying
RHCP:	right-hand circular polarization
TDD:	time division duplex
TDM:	time division multiplex
TDMA:	time division multiple access