

Recommendation ITU-R M.1184-4 (08/2026)

M Series: Mobile, radiodetermination, amateur
and related satellite services

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

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the appropriate ITU-R patent information available at <https://www.itu.int/en/ITU-R/study-groups/Pages/itu-r-patent-information.aspx>.

Series of ITU-R Recommendations

(Also available online at <https://www.itu.int/publ/R-REC/en>)

Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	Broadcasting service (television)
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radio-wave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

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

*Electronic Publication
Geneva, 2026*

© ITU 2026

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without written permission of ITU.

RECOMMENDATION ITU-R M.1184-4

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

(Question ITU-R 201-1/4)

(1995-2000-2003-2018-2026)

Scope

This Recommendation contains technical characteristics of mobile-satellite systems in the frequency bands below 3 GHz as a depository for use in sharing and compatibility studies between the mobile-satellite service (MSS) and other services, where appropriate and applicable.

Keywords

Characteristics, compatibility, GSO, non-GSO, mobile-satellite service (MSS), sharing

Abbreviations/Glossary

AMS(R)S	Aeronautical mobile-satellite (R) service
AMSS	Aeronautical mobile-satellite service
CDMA	Code division multiple access
DQPSK	Differential quadrature phase shift keying
EOC	Edge of coverage
FBB	Fleet broadband
FDD	Frequency division duplex
FDMA	Frequency division multiple access
FEC	Forward error correction
GMSK	Gaussian filtered MSK
GSO	Geostationary orbit
GSPS	Global satellite phone service
ICAO	International Civil Aviation Organization
IDP	IsatData Pro
IMT	International Mobile Telecommunication
LHCP	Left-hand circular polarization
LMSS	Land mobile-satellite service
MDS	Multipoint distribution system
MES	Mobile Earth station
MMSS	Maritime mobile-satellite service
MSK	Minimum shift keying

MSS	Mobile-satellite service
NBFM	Narrow-band frequency modulation
OQPSK	Offset quadrature phase-shift keying
PIFA	Planar inverted-F antenna
QPSK	Quadrature phase-shift keying
RHCP	Right-hand circular polarization
SARPs	Standards and recommended practices
SDPSK	Symmetrical differential PSK
TDD	Time division duplex
TDMA	Time division multiple access
UHF	Ultra-high frequency
VHF	Very-high frequency

Related ITU-R Recommendations, Reports

Recommendation ITU-R M.687 – International Mobile Telecommunications-2000 (IMT-2000)

Recommendation ITU-R M.818 – Satellite operation within International Mobile Telecommunications-2000 (IMT-2000)

Recommendation ITU-R M.1850 – Detailed specifications of the radio interfaces for the satellite component of International Mobile Telecommunications-2000 (IMT-2000)

Recommendation ITU-R M.2047 – Detailed specifications of the satellite radio interfaces of International Mobile Telecommunications-Advanced (IMT-Advanced)

The ITU Radiocommunication Assembly,

considering

that, while some mobile-satellite service (MSS) system parameters are still under development, a summary of representative technical characteristics of MSS systems is useful for conducting sharing and compatibility studies by the ITU-R,

recommends

1 that the representative technical characteristics for non-GSO MSS systems, as given in Annexes 1 and 2, should be considered in conducting sharing and compatibility studies, where appropriate and applicable;

2 that the representative technical characteristics for GSO MSS networks, as given in Annex 1, should be considered in conducting sharing and compatibility studies, where appropriate and applicable.

TABLE OF CONTENTS

Page

Annex 1 – Characteristics of representative 1-3 GHz MSS GSO satellite networks and non-GSO satellite systems	3
1 Satellite orbits	3
2 Global and regional/national GSO satellite networks	3
2.1 Maritime mobile-satellite service	4
2.2 Aeronautical mobile-satellite service	4
2.3 Land mobile-satellite service	4
2.4 GSO MSS satellite network characteristics	4
3 Non-GSO MSS satellite system characteristics.....	13
4 Propagation factors and mobile antenna characteristics.....	13
Annex 2 – Technical parameters of MSS satellite networks in the frequency bands below 1 GHz.....	24

Annex 1**Characteristics of representative 1-3 GHz MSS GSO satellite networks and non-GSO satellite systems****1 Satellite orbits**

Currently, GSO satellite networks and non-GSO satellite systems are being used for MSS communications. Suitable orbits are determined by coverage requirements, service considerations and frequency sharing, as well as other considerations.

2 Global and regional/national GSO satellite networks

Current United Kingdom and Russian mobile-satellite networks utilize Earth-coverage antennas to provide near-global service from the GSO in the 1.6/1.5 GHz band. The Russian satellite networks are similar to those of the United Kingdom satellite networks, the characteristics of which are presented in Table 2. The United Arab Emirates operates GSO MSS satellite networks to provide coverage in Regions 1 and 3 in the 1.6/1.5 GHz band. Several administrations are implementing regional/national GSO mobile-satellite networks to provide aeronautical, land and maritime services at 1.6/1.5 GHz. In addition to the above satellite networks at 1.6/1.5 GHz, Japan operates a GSO mobile-satellite network in the 2.6/2.5 GHz bands, and China has deployed its mobile-satellite networks and systems to provide regional service in the 1.6/2.5 GHz bands. Also, administrations are implementing regional/national GSO satellite networks in 2 GHz band.

Many MSS satellite networks use spot beams to provide greater spectrum efficiency and conserve transmitted power of the satellite and mobile earth station. China is planning to deploy the future generation of mobile-satellite networks and systems to provide its global service in the 1.6/2.5 GHz bands.

2.1 Maritime mobile-satellite service

A maritime mobile-satellite service (MMSS) system which is based on IMT-2000 standards provides broadband data and voice, simultaneously, through a compact antenna on a global basis. Another MMSS system provides store and forward data and telex using small and 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 GSO MSS satellite network characteristics

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

TABLE 1a

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

System Parameter	GSO								
	A	B	C	D	E	F	G	H	I
<i>Polarization</i>									
Feeder link	Linear	Linear	Linear	Linear	Circular	Linear	Circular	Circular	Linear
Service link	RHCP	RHCP	RHCP	RHCP	RHCP	Circular	LHCP	LHCP	Circular
<i>Direction of transmission</i>	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space
<i>Frequency bands</i>									
Feeder link (GHz)	5	12	11	11	4	4, 11, 12	4	4	4
Service link (GHz)	1.6	1.6	1.6	2.0	2.0	1.6	1.6	1.6	2
<i>Orbit</i>									
Altitude (km)	36 000	36 000	36 000	36 000	36 000	36 000	36 000	36 000	36 000
Satellite separation (degrees)	120	78	Not applicable	Not applicable	*	Not applicable	20 to 30	20 to 30	20 to 25
Number of satellites	3	2	1	1	4 to 6	1 or 2	5 to 8	5 to 8	3 or 5
Orbital planes	Not applicable	Not applicable	Not applicable	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	Not applicable	Not applicable	Not applicable
<i>Satellite antennas</i>									
Number of beams (service link)	180	50	7	28	250	Over 200	2	7	Over 100
Beam size (degrees)	1	1	6	2	*	0.7	7	6	0.75
Satellite coverage area	Global	Regional	North America, Alaska, Hawaii	North America, Alaska, Hawaii	Global	Regional	Regional	Regional	Regional

TABLE 1a (continued)

System Parameter	GSO								
	A	B	C	D	E	F	G	H	I
Average beam side lobes (dB)	*	−25	−25	−25	*	−20	−20	−20	−20
Beam frequency reuse	5	5	1.3	2	*	1 to 30	*	*	7
<i>Link characteristics</i>									
Nominal user e.i.r.p. (dBW)	6	0.5	12.5	10.9	−1 to +8	−7.5 to 3.5	5 to 12	3 to 10	1 to 25
EOC satellite G/T (dB(K ^{−1}))	10	11	3.0	9.8	11	15.7	−3	−1	14
<i>Transmission parameters</i>									
Modulation	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	BPSK	BPSK	BPSK/QPSK/ 8PSK
Coding	FEC	FEC	*	*	FEC	FEC	FEC	FEC	FEC
Access scheme	CDMA	FDMA	FDMA	FDMA	FDMA/ TDMA	FDMA/ TDMA	CDMA	CDMA	FDMA/ TDMA
Duplex scheme	*	FDD	FDD	FDD	FDD	FDD	FULL	FULL	FDD
Frame length	Not applicable	Not applicable	Not applicable	Not applicable	*	40	20 to 200	20 to 1100	Not applicable
Burst rate (kbit/s)	Not applicable	Not applicable	Not applicable	Not applicable	32	46.8	8	4 to 16	Not applicable
Chip rate (Mchip/s)	8.33	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	4.1	4.1	Not applicable
Voice activity factor	0.4	0.4	0.4	0.4	0.4	0.4	Not applicable	Not applicable	0.4
RF carrier spacing (MHz)	*	0.006	0.006	0.006	*	0.03125	Not applicable	Not applicable	0.0216
RF channel spacing (MHz)	*	0.006	0.006	0.006	*	0.03125	Not applicable	Not applicable	0.0216
Modulation bandwidth (MHz)	*	0.0045	0.0047	0.0047	*	0.0234	8.2	8.2	0.016

TABLE 1a (*end*)

System Parameter	GSO								
	A	B	C	D	E	F	G	H	I
<i>Required E_b/N_0 (dB)</i>									
Voice	2.5	9.0	9.0	9.0	4.0	3.5	Not applicable	Not applicable	−1 to 6.5
Data	4.1	9.0	9.0	9.0	*	5.5 to 7.0	7.0	7.0	3.1 to 11.6
<i>Maximum MES antenna discrimination towards the horizon (dBi)</i>	*	7	7	7	1.0	7 to 19	*	*	*

* Value requiring further study.

TABLE 1b

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

System Parameter	GSO								
	A	B	C	D	E	F	G	H	I
<i>Polarization</i>									
Feeder link	Linear	Linear	*	*	Circular	Linear	Circular	Circular	Linear
Service link	RHCP	RHCP	*	*	RHCP	Circular	RHCP	RHCP	Circular
Direction of transmission	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth
<i>Frequency bands</i>									
Feeder link (GHz)	6	14	13	13	6	6, 13, 14	6	6	6
Service (GHz)	2.5	1.5	1.5	1.9	2.2	1.5	2.5	2.5	2.2
<i>Orbit</i>									
Altitude (km)	36 000	36 000	36 000	36 000	36 000	36 000	36 000	36 000	36 000
Satellite separation (degrees)	120	78	Not applicable	Not applicable	*	Not applicable	20 to 30	20 to 30	20 to 25
Number of satellites	3	2	1	1	4 to 6	1 or 2	5 to 8	5 to 8	3 or 5

TABLE 1b (continued)

System Parameter	GSO								
	A	B	C	D	E	F	G	H	I
Orbital planes	Not applicable	Not applicable	Not applicable	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	Not applicable	Not applicable	Not applicable
<i>Satellite antennas</i>									
Number of beams (service link)	180	50	7	28	150	Over 200	2	7	Over 100
Beam size (degrees)	1	1	*	*	*	0.7	7	6	0.75
Satellite coverage area	Global	Regional	North America, Alaska, Hawaii	North America, Alaska, Hawaii	Global	Regional	Regional	Regional	Regional
Average beam side lobes (dB)	*	−25	−25	−25	*	−20	−20	−20	−20
Beam frequency reuse	5	5	1.2	2	*	1 to 30	*	*	7
<i>Link characteristics</i>									
Maximum e.i.r.p./beam (dBW)	45.8	53.5	58.4	52.8	*	*	54	54	51.5
Average gain/beam (dBi)	*	44	32	41.1	*	44.5	27	27	44
e.i.r.p./carrier (dBW)	28.8	30	30	35.5	42	24.5 to 45.0	46 to 54	46 to 54	35 to 54
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	Not applicable	54	54	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	−141	−141	*
<i>Transmission parameters</i>									
Number of channels/satellite	*	5 000	2 000	10 000	5 000	20 000	2	7	5 000
User G/T (dB(K ^{−1}))	−20	−22	−16	−16	−23	−23.5 to −9.0	−24	−24	−29 to −20

TABLE 1b (*end*)

System Parameter	GSO								
	A	B	C	D	E	F	G	H	I
Minimum elevation angle (degrees)	5	5	5	5	10	20	10	10	10
Lifetime (years)	12	12	12	12	10 to 12	12	10 to 15	10 to 15	15
Modulation	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	BPSK/QPSK/8 PSK
Coding	FEC	FEC	FEC	FEC	FEC	FEC	FEC	FEC	
Access scheme	CDMA	FDMA/ TDMA	FDMA	FDMA	TDMA	FDMA/ TDMA	CDMA	CDMA	FDMA/ TDMA
Frame length (ms)	*	Not applicable	Not applicable	Not applicable	*	40	40	120	*
Burst rate (kbit/s)	Not applicable	Not applicable	Not applicable	Not applicable	32	46.8	Not applicable	Not applicable	*
Chip rate (Mchip/s)	8.33	Not applicable	Not applicable	Not applicable	*	Not applicable	4.1	8.2	*
Voice activity factor	0.4	0.4	0.4	0.4	0.4	0.5	Not applicable	Not applicable	0.4
<i>Required E_b/N_0 (dB)</i>									
Voice	2.5	9	9	9	*	3.5	Not applicable	Not applicable	−1 to 6.5
Data	4.1	9	9	9	*	5.5 to 7.0	7	6	3.1 to 11.6
<i>MES geographical distribution</i>	*	*	*	*	*	*	Regional	Regional	Regional

* Value requiring further study.

TABLE 2

GSO satellite network technical characteristics in the 1.6/1.5 GHz band overview

[illegible]

TABLE 2 (*end*)

	IDP	C	Hand held (GSPS)	Land		Maritime		Aeronautical	
				High gain	Low gain	High gain	Low gain	High gain	Low gain
Uplink channel spacing (nominal) (kHz)	2.5	5	50	200	200	200	200	200	200
Downlink channel spacing (nominal) (kHz)	2.5	5	200	200	200	200	200	200	200
Satellite peak antenna gain (dBi)	22	22	44	44	44	44	44	44	44
Satellite noise temperature (K)	630	630	630	630	630	630	630	630	630

* Value requiring further study.

TABLE 3

National/regional GSO satellite network overview

	Australia	Canada/ United States of America	Japan	Europe	East Asia Southeast Asia	Republic of Korea ⁽²⁾
Service	MSS	MSS	LMSS/ MMSS	AMSS	MSS	MSS
Frequency bands (GHz)	1.5/1.6	1.5/1.6	2.5/2.6	2/2.2	2/2.2	1.5/1.6
Typical mobile earth station antenna gain (dBi)	12	8 to 13 0 to 4	Up to 12	0 to 12	−2 to 13	16 to 21.2
Antenna type (example)	To be determined	– Electrically scanned phased array – Mast type	Phased array	– Electrically scanned phased array – Crossed-dipole	– Electrically scanned phased array – Crossed-dipole PIFA	Passive patch array or helical

TABLE 3 (*end*)

	Australia	Canada/ United States of America	Japan	Europe	East Asia Southeast Asia	Republic of Korea ⁽²⁾
Typical antenna size	To be determined	25 to 50 cm diameter	10 to 20 cm diameter	15 to 25 cm diameter	Up to 35 cm diameter	65 to 120 cm diameter
Mobile earth station figure of merit (G/T) (dB(K ⁻¹))	−13	−15 to −12 −23 to −18	Not available (N/A)	−11 to −23	−29 to −20	−6.5 to −1
Mobile earth station e.i.r.p./channel (dBW)	15	10 to 16	Up to 17	10 to 16	1 to 25	5 to 17
User data rate	2 400 bit/s	2.4 to 4.8 kbit/s 4 to 8 kbit/s, voice	Up to 1.5 Mbit/s	Up to 416 kbit/s	Up to 384 kbit/s	Up to 24 kbit/s
Communication channel rate and modulation	6.6 kbit/s	4.8 to 9.6 kbit/s, OQPSK TCM	BPSK/QPSK/16-QAM/64-QAM	1/5-9/10 coding rate BPSK/QPSK/8PSK/16APS K/32APSK	BPSK/QPSK/8PSK	QPSK
Typical C/N_0 for communication channel (dB(Hz))	48	45 to 51	Not available (N/A)	41 to 61	44 to 56.5	35 to 55
Satellite e.i.r.p./channel (dBW)	22	23 to 29	69.1 ⁽¹⁾	25 to 48	35 to 54	28 to 36 ⁽¹⁾
Channel spacing (nominal) (kHz)	7.5	5 to 10	1 200 to 10 000	2.5 to 200	21.6	2 to 50
Satellite peak antenna gain (dBi)	To be determined	32	49	35	44/47	19.2/19.9
pfd	*	*	*	*	*	*

⁽¹⁾ Satellite e.i.r.p. density (dB(W/1 MHz)).

⁽²⁾ For the feeder link in the bands 1.5 GHz (space-to-Earth) and 1.6 GHz (Earth-to-space), the e.i.r.p. density values for the satellite and earth station are 16 to 35 dBW/MHz and 43 to 56 dBW/MHz respectively, and the G/T values for the satellite and earth station are 15 to 20 dB/K and −9 to −6 dB/K respectively.

* Value requiring further study.

3 Non-GSO MSS satellite 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)

System Parameter	A ⁽¹⁾	B	C	D	E			F	G	
									Link 1	Link 2
Polarization										
Feeder link	RHCP	RHCP	Circular	RHCP/ LHCP	RHCP/LHCP			Circular	RHCP	RHCP
Service link	RHCP	LHCP	Circular	LHCP	RHCP			RHCP	LHCP	LHCP
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
Frequency bands (GHz)										
Feeder link	30	20	5	7		< 19		7	11	11
Service link	1.6	1.6	1.6	1.6		1.6		2	0.2	1.6
Orbit		(2)			Eccentric	Circular	Elliptical (alternate orbit)		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
Satellite separation (degrees)	32.7	90	45	60				72	30	30
Number of satellites	66	12	40	48	4-5	6-8	6-8	10	48	48
Orbital planes	6	3	5	8	2	1	1	2	4	4
Inclination angle (degrees)	86	50	55	52	116.6	0	0	45	74	74
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
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
Average beam side lobes (dB)	−20	−20	To be determined	−15	−15 and greater			−20 (peak)	−3	−2
Beam frequency reuse	0.167	1	1	1	N (where N: number of beams)			*	1	0.6
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
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

TABLE 4a (continued)

System Parameter	H	R	K		N	O	P
			I	M			
Polarization							
Feeder link	LHCP	Circular	Circular	Circular	Circular	Circular	Circular
Service link	RHCP	Circular	LHCP	LHCP	Circular	Circular	Circular
Direction of transmission	Earth-to-space	Earth-to-space	earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space	Earth-to-space
Frequency bands (GHz)							
Feeder link	5.2	19	*	*	5.2	40	7
Service link	1.6	1.9, 2.6	1.6	1.6	1.9	1.6	1.6
Orbit	Circular	Circular	Circular	Circular	Circular	Circular	Circular
Altitude (km)	1 000	700	36 000	21 500	1 500	1 175	1 400/1 414
Satellite separation (degrees)	51.4	27.7	120	120	51.4	36	90
Number of satellites	7	91	3 to 9	14 to 27	28	12	12/48
Orbital planes	7	7	3	3	4	6	3/12
Inclination angle (degrees)	83	82	55	55	82,5	86.5	87/52
Satellite antennas							
Number of beams (service link)	9	37	1 to 7	1	*	52	256
Beam size (km ²)	2.6×10^5 to 2×10^6	7.6×10^4 to 3.5×10^5	1.25×10^7 to 8.5×10^7	8.5×10^7	*	9×10^5 to 1.4×10^6	3.8×10^4
Average beam side lobes (dB)	−15	−20	−20	−20	*		−15
Beam frequency reuse	0.11	3	*	*	*	4	1
Link characteristics							
Nominal user e.i.r.p. (dBW)	8	1.5	5 to 10	8 to 12	8 to 16	0 to 23	−7 to 11.6
EOC satellite <i>G/T</i> (dB(K ^{−1}))	−18	−12.6	−8.5 to −6	−16.5 to −14.5	−15.6	−32 to −15.5	−7.4

TABLE 4a (*continued*)

System Parameter	A ⁽¹⁾	B	C	D	E	F	G	
							Link 1	Link 2
Transmission parameters								
Modulation	QPSK	QPSK	QPSK	QPSK	OQPSK spreading modulation	QPSK	QPSK	QPSK
Coding	FEC	FEC	FEC	FEC	FEC rate 1/3, K= 9	FEC	FEC	FEC
Access scheme	FDMA/ TDMA	FDMA/ CDMA	FDMA/ CDMA	FDMA/ CDMA	CDMA	FDMA/ TDMA	FDMA/ CDMA	FDMA/ CDMA
Duplex scheme	TDD	FDD	FDD	FDD	Full	FDD	Full	Full
Transmission parameters (cont.)								
Frame length (ms)	90	Not applicable	Not applicable	Not applicable	320 and 25.86 (random access)	40	60	60
Burst rate (kbit/s)	50	Not applicable	Not applicable	Not applicable	0.3-9.6	36	Not applicable	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
Voice activity factor	0.4	0.5	0.4	0.4	0.4	0.4	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
RF channel bandwidth (MHz)	Not applicable	2.5	To be determined	1.2	Not applicable	0.025	0.5	5.8
Modulation bandwidth (MHz)	0.0315	2.5	To be determined	1.2	1.9 and/or 7.6	0.025	0.5	5.8
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
Maximum MES antenna gain towards the horizon (dBi)	0	0	To be determined	*	3 mobile 10 fixed 0 hand-held	2	1	1.2

TABLE 4a (*end*)

System Parameter	H	R	K		N	O	P
			I	M			
Transmission parameters							
Modulation	BPSK	QPSK	BPSK	BPSK	$\pi/4$ -DQPSK	QPSK	PSK
Coding	FEC	Convolutional code rate 1/2, $K = 7$	FEC	FEC	FEC	FEC	FEC
Access scheme	FDMA/ CDMA	FDMA/ CDMA	CDMA	CDMA	TDMA	FDMA/ CDMA	TDMA/FDMA/ CDMA
Duplex scheme	Full	FDD	Full	Full	FDD	FDD	FDD
Transmission parameters (cont.)							
Frame length (ms)	60	Not applicable	50 to 800	500 to 1500	*	*	*
Burst rate (kbit/s)	50	Not applicable	1 to 4	0.4 to 2	*	*	*
Chip rate (Mchip/s)	3	0.624	1.6 and/or 4.1	1.6	*	*	*
Voice activity factor	Not applicable	Not applicable	Not applicable	Not applicable	*	*	*
RF carrier spacing (MHz)	0.25	1.25	Not applicable	Not applicable	*	*	*
RF channel bandwidth (MHz)	2.05	1.25	*	*	*	0.125	*
Modulation bandwidth (MHz)	2.05	1.25	3.2 and/or 8.2	3.2	*	0.125	*
Required E_b/N_0 (dB)	16	6.5	7	7	*	5.5	*
Maximum MES antenna gain towards the horizon (dBi)	2	0	*	*	*	*	*

(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.

* Value requiring further study.

TABLE 4b

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

System Parameter	A	B	C	D	E			F	G	
									Link 1	Link 2
Polarization										
Feeder link	RHCP	LHCP	Circular	RHCP/ LHCP	Dual circular			Circular	LHCP	LHCP
Service link	RHCP	LHCP	Circular	LHCP	RHCP			RHCP	RHCP	RHCP
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
Frequency bands (GHz)										
Feeder link	20	30	6	5	< 19			5	14	14
Service	1.6	2.5	2.5	2.5	2.5			2.2	0.4	1.5
Orbit		(2)			Eccentric	Circular	Elliptical (alternate orbit)		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
Satellite separation (degrees)	32.7	90	45	60	–	–	–	72	30	30
Number of satellites	66	12	40	48	4-5	6-8	6-8	10	48	48
Orbital planes	6	3	5	8	2	1	1	2	4	4
Inclination angle (degrees)	86	50	55	52	116.6	0	0	45	74	74
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
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
Average beam side lobes (dB)	–20	–20	To be determined	–15	–15 and greater			–20 (peak)	–3	–2
Beam frequency reuse	0.167	1	1	1	N (where N: number of beams)			*	1	0.6

TABLE 4b (continued)

System Parameter	H	R	K		N	O	P
			I	M			
Polarization							
Feeder link	RHCP	Circular	Circular	Circular	Circular	Circular	Circular
Service link	RHCP	Circular	RHCP	RHCP	Circular	Circular	Circular
Direction of transmission	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth	Space-to-Earth
Frequency bands (GHz)							
Feeder link	7	15	*	*	7	40	7
Service	2.5	2.1	2.5	2.5	2.1	1.5	2.5
Orbit	Circular	Circular	Circular	Circular	Circular	Circular	Circular
Altitude (km)	1 000	700	36 000	21 500	1 500	1 175	1 400/1 414
Satellite separation (degrees)	51.4	27.7	120	120	51.4	36	90
Number of satellites	7	91	3 to 9	27	28	12	12/48
Orbital planes	7	7	3	3	4	6	3/12
Inclination angle (degrees)	83	82	55	55	82.5	86.5	87/52
Satellite antennas							
Number of beams (service link)	9	37	1	1	16	52	128
Beam size (km ²)	2.6 × 10 ⁵ to 2 × 10 ⁶	7.6 × 10 ⁴ to 3.5 × 10 ⁵	8.5 × 10 ⁷	8.5 × 10 ⁷	*	9 × 10 ⁵ to 1.4 × 10 ⁶	5.4 × 10 ⁴
Average beam side lobes (dB)	−15	−20	−20	−20	*	*	−15
Beam frequency reuse	0.11	3	*	*	*	4	1

TABLE 4b (continued)

System Parameter	A	B	C	D	E			F	G	
									Link 1	Link 2
<i>Link characteristics</i>										
Maximum e.i.r.p./beam (dBW)	*	~52	27.5	*	$\text{pdf} \leq -142 \text{ dB(W/(m}^2 \cdot 4 \text{ kHz))}$			52	-2	2.8
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
e.i.r.p./carrier (dBW)			To be determined					33	-15	-7.2
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
Shadowed user e.i.r.p. (dBW)	19-27	24.6	To be determined	0-5	Add 2.5 dB			*	Not applicable	Not applicable
e.i.r.p./CDMA channel (dBW)	Not applicable	*	-7 to 6	0 to 16		*		Not applicable	-5	-10.2
User G/T (dB(K ⁻¹))	-23	-22.2 to -24	-22	-23		-25 to -15		-24	-23.8	-14
Minimum elevation angle (degrees)	8.3	20	15	10		15		10	7	10
<i>Transmission parameters</i>										
Modulation	QPSK	QPSK	QPSK	QPSK	QPSK			QPSK	QPSK	QPSK
Coding	FEC	FEC	FEC	FEC	FEC rate 1/3, $K = 9$			FEC	FEC	FEC
Access scheme	FDMA/ TDMA	FDMA/ CDMA	FDMA/ CDMA	FDMA/ CDMA	CDMA			FDMA/ TDMA	FDMA/ CDMA	FDMA/ CDMA
Duplex scheme	TDD	FDD	FDD	FDD	FDD			FDD	Full	Full
Frame length (ms)	90	*	Not applicable	*	320			40	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

TABLE 4b (continued)

System Parameter	H	R	K		N	O	P
			I	M			
Link characteristics							
Maximum e.i.r.p./beam (dBW)	19	31.7	36	32	25	28	*
Average gain/beam (dBi)	10	31.7	*	*		*	*
e.i.r.p./carrier (dBW)	15	31.7	36	32		*	*
Unshadowed user e.i.r.p. (dBW)	Not applicable	Not applicable	*	*	*	*	*
Shadowed user e.i.r.p. (dBW)	Not applicable	Not applicable	Not applicable	Not applicable	*	*	*
e.i.r.p./CDMA channel (dBW)	15 to 19	31.7	36	32	*	*	*
User G/T (dB(K ⁻¹))	−24	−18	−24	−24	−19.7 to −11.7	−32 to −15.5	−23
Minimum elevation angle (degrees)	10	10	10	10		10	10
Transmission parameters		(2)					
Modulation	QPSK	QPSK	QPSK	QPSK	$\pi/4$ -DQPSK	QPSK	PSK
Coding	FEC	Convolutional code rate 1/2, $K = 7$	FEC	FEC	FEC	FEC	FEC
Access scheme	FDMA/ CDMA	FDMA/ CDMA	CDMA	CDMA	TDMA	FDMA/ TDMA	TDMA/ FDMA/ CDMA
Duplex scheme	Full	FDD	Full	Full	FDD	FDD	FDD
Frame length (ms)	Not applicable	Not applicable	1000	1000	*	*	*
Burst rate (kbit/s)	Not applicable	Not applicable	Not applicable	Not applicable	*	*	*

TABLE 4b (continued)

System Parameter	A	B	C	D	E	F	G	
							Link 1	Link 1
<i>Transmission parameters (cont.)</i>								
Chip rate (Mchip/s)	Not applicable	~2	2.56	1.228	1.9 and/or 7.6	Not applicable	0.15	2.4
Interleaving	*	*	*	*	Varies	None	None	None
Voice activity factor	0.4	0.5	0.4	0.4	0.4	0.4	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
MES geographical distribution	Worldwide	Worldwide	To be determined	*	Varies	*	Multi-country	Multi-country
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

TABLE 4b (*end*)

System Parameter	H	R	K		N	O	P
			I	M			
Transmission parameters (cont.)		(2)					
Chip rate (Mchip/s)	6	7.5	8.1	8.1	*	*	*
Interleaving	None	Not applicable	Not applicable	Not applicable	*	*	*
Voice activity factor	Not applicable	Not applicable	Not applicable	Not applicable	*	*	*
Required E_b/N_0 (dB)	−8	6.5	7	7	*	*	*
MES geographical distribution	Mulit-country	Worldwide	Regional	Worldwide	*	*	*
Range of pfd (dB(W/(m ² · 4 kHz)))	To be determined	Minimum: −144.8 Maximum: −132.0	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⁾ For system R, RF carrier spacing is 7.5 MHz and RF channel bandwidth 15 MHz.

⁽³⁾ Includes effect of feeder link.

* Value requiring further study.

Annex 2

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

TABLE 5

Parameters of several non-GSO MSS satellite 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
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

TABLE 5 (continued)

System	L		M	N	P	Q		S
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	$T = 1\,565\text{ K}$	$T = 505\text{ K}$	−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	$E_b/(N_0 + I_0) = 3.7\text{ dB}$	$E_b/N_0 = 13.5\text{ dB}$		$E_b/N_0 = 13.4\text{ dB}$
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	$T = 1\,565\text{ K}$	$T = 505\text{ K}$	-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	$C/(N_0 + I_0) = 3.7\text{ dB(Hz)}$	$E_b/N_0 = 13.5\text{ dB}$		$E_b/N_0 = 13.4\text{ dB}$
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	$T = 940\text{ K}$		-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	$C/(N_0 + I_0) = 42.5\text{ dB(Hz)}$	$E_b/N_0 = 13.5\text{ dB}$		$E_b/N_0 = 13.4\text{ dB}$

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