



Recommendation ITU-R M.1184-3
(01/2018)

**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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| M | Mobile, radiodetermination, amateur and related satellite services |
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| 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, 2018

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RECOMMENDATION ITU-R M.1184-3

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 201-1/4)

(1995-2000-2003-2018)

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, should be considered 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 should be considered 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 should 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.

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, and China has deployed its mobile-satellite system to provide regional service in the 1.6/2.5 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. China is planning to deploy the future generation of mobile-satellite system to provide its global service in the 1.6/2.5 GHz bands.

2.1 Maritime mobile-satellite service

The Inmarsat Fleet Broadband (FBB) system which is based on IMT-2000 standards provides broadband data and voice, simultaneously, as well as ISDN data capability through a compact antenna on a global basis. 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

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 | G | H |
| <i>Polarization</i> | | | | | | | | |
| Feeder link | Linear | Linear | Linear | Linear | Circular | Linear | Circular | Circular |
| Service link | RHCP | RHCP | RHCP | RHCP | RHCP | Circular | LHCP | LHCP |
| <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 |
| <i>Frequency bands</i> | | | | | | | | |
| Feeder link (GHz) | 5 | 12 | 11 | 11 | 4 | 4, 11, 12 | 4 | 4 |
| Service link (GHz) | 1.6 | 1.6 | 1.6 | 2.0 | 2.0 | 1.6 | 1.6 | 1.6 |
| <i>Orbit</i> | | | | | | | | |
| Altitude (km) | 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 |
| Number of satellites | 3 | 2 | 1 | 1 | 4 to 6 | 1 or 2 | 5 to 8 | 5 to 8 |
| Orbital planes | 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 |
| <i>Satellite antennas</i> | | | | | | | | |
| Number of beams (service link) | 180 | 50 | 7 | 28 | 250 | Over 200 | 2 | 7 |
| Beam size (degrees) | 1 | 1 | 6 | 2 | * | 0.7 | 7 | 6 |
| Satellite coverage area | Global | Regional | North America, Alaska, Hawaii | North America, Alaska, Hawaii | Global | Regional | Regional | Regional |
| Average beam side lobes (dB) | * | -25 | -25 | -25 | * | -20 | -20 | -20 |
| Beam frequency reuse | 5 | 5 | 1.3 | 2 | * | 1 to 30 | * | * |

TABLE 1a (end)

| System Parameter | GSO | | | | | | | |
|---|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | A | B | C | D | E | F | G | H |
| <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 |
| EOC satellite G/T (dB(K ⁻¹)) | 10 | 11 | 3.0 | 9.8 | 11 | 15.7 | -3 | -1 |
| <i>Transmission parameters</i> | | | | | | | | |
| Modulation | QPSK | QPSK | QPSK | QPSK | QPSK | QPSK | BPSK | BPSK |
| Coding | FEC | FEC | * | * | FEC | FEC | FEC | FEC |
| Access scheme | CDMA | FDMA | FDMA | FDMA | FDMA/ TDMA | FDMA/ TDMA | CDMA | CDMA |
| Duplex scheme | * | FDD | FDD | FDD | FDD | FDD | FULL | FULL |
| Frame length | Not applicable | Not applicable | Not applicable | Not applicable | * | 40 | 20 to 200 | 20 to 1100 |
| Burst rate (kbit/s) | Not applicable | Not applicable | Not applicable | Not applicable | 32 | 46.8 | 8 | 4 to 16 |
| Chip rate (Mchip/s) | 8.33 | Not applicable | Not applicable | Not applicable | Not applicable | Not applicable | 4.1 | 4.1 |
| Voice activity factor | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | Not applicable | Not applicable |
| RF carrier spacing (MHz) | * | 0.006 | 0.006 | 0.006 | * | 0.03125 | Not applicable | Not applicable |
| RF channel spacing (MHz) | * | 0.006 | 0.006 | 0.006 | * | 0.03125 | Not applicable | Not applicable |
| Modulation bandwidth (MHz) | * | 0.0045 | 0.0047 | 0.0047 | * | 0.0234 | 8.2 | 8.2 |
| <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 |
| Data | 4.1 | 9.0 | 9.0 | 9.0 | * | 5.5 to 7.0 | 7.0 | 7.0 |
| <i>Maximum MES antenna discrimination towards the horizon (dBi)</i> | * | 7 | 7 | 7 | 1.0 | 7 to 19 | * | * |

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

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

| Parameter \ System | GSO | | | | | | | |
|--------------------------------|----------------|----------------|-------------------------------|-------------------------------|----------------|----------------|----------------|----------------|
| | A | B | C | D | E | F | G | H |
| <i>Polarization</i> | | | | | | | | |
| Feeder link | Linear | Linear | * | * | Circular | Linear | Circular | Circular |
| Service link | RHCP | RHCP | * | * | RHCP | Circular | RHCP | RHCP |
| 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 |
| <i>Frequency bands</i> | | | | | | | | |
| Feeder link (GHz) | 6 | 14 | 13 | 13 | 6 | 6, 13, 14 | 6 | 6 |
| Service (GHz) | 2.5 | 1.5 | 1.5 | 1.9 | 2.2 | 1.5 | 2.5 | 2.5 |
| <i>Orbit</i> | | | | | | | | |
| Altitude (km) | 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 |
| Number of satellites | 3 | 2 | 1 | 1 | 4 to 6 | 1 or 2 | 5 to 8 | 5 to 8 |
| Orbital planes | 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 |
| <i>Satellite antennas</i> | | | | | | | | |
| Number of beams (service link) | 180 | 50 | 7 | 28 | 150 | Over 200 | 2 | 7 |
| Beam size (degrees) | 1 | 1 | * | * | * | 0.7 | 7 | 6 |
| Satellite coverage area | Global | Regional | North America, Alaska, Hawaii | North America, Alaska, Hawaii | Global | Regional | Regional | Regional |
| Average beam side lobes (dB) | * | -25 | -25 | -25 | * | -20 | -20 | -20 |
| Beam frequency reuse | 5 | 5 | 1.2 | 2 | * | 1 to 30 | * | * |

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TABLE 1b (continued)

| Parameter \ System | GSO | | | | | | | |
|---|----------------|----------------|----------------|----------------|----------------|------------------|----------------|----------------|
| | A | B | C | D | E | F | G | H |
| <i>Link characteristics</i> | | | | | | | | |
| Maximum e.i.r.p./beam (dBW) | 45.8 | 53.5 | 58.4 | 52.8 | * | * | 54 | 54 |
| Average gain/beam (dBi) | * | 44 | 32 | 41.1 | * | 44.5 | 27 | 27 |
| e.i.r.p./carrier (dBW) | 28.8 | 30 | 30 | 35.5 | 42 | 24.5 to 45.0 | 46 to 54 | 46 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 |
| 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 |
| User G/T (dB(K ⁻¹)) | -20 | -22 | -16 | -16 | -23 | -23.5 to -9.0 | -24 | -24 |
| Minimum elevation angle (degrees) | 5 | 5 | 5 | 5 | 10 | 20 | 10 | 10 |
| Lifetime (years) | 12 | 12 | 12 | 12 | 10 to 12 | 12 | 10 to 15 | 10 to 15 |
| Modulation | QPSK | QPSK | QPSK | QPSK | QPSK | QPSK | QPSK | QPSK |
| Coding | FEC | FEC | FEC | FEC | FEC | FEC | FEC | FEC |
| Access scheme | CDMA | FDMA/ TDMA | FDMA | FDMA | TDMA | FDMA/ TDMA | CDMA | CDMA |
| 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 |

TABLE 1b (end)

| Parameter \ System | GSO | | | | | | | |
|---|-----|---|---|---|---|------------|----------------|----------------|
| | A | B | C | D | E | F | G | H |
| <i>Required E_b/N_0 (dB)</i> | | | | | | | | |
| Voice | 2.5 | 9 | 9 | 9 | * | 3.5 | Not applicable | Not applicable |
| Data | 4.1 | 9 | 9 | 9 | * | 5.5 to 7.0 | 7 | 6 |
| <i>MES geographical distribution</i> | * | * | * | * | * | * | Regional | Regional |
| <i>Maximum permissible levels of interference power</i> | * | * | * | * | * | * | * | * |

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

TABLE 2

Inmarsat GSO systems overview

| | IDP | C | Hand held (GSPS) | Land | | Maritime | | Aeronautical | |
|---|------------|---------------|------------------|----------------|----------------|----------------|----------------|------------------------|-----------------|
| | | | | High gain | Low gain | High gain | Low gain | High gain | Low gain |
| Service | LMSS | MMSS | LMSS | LMSS | LMSS | MMSS | MMSS | AMSS AMS(R)S | AMSS AMS(R)S |
| Typical mobile station antenna gain (dBi) | 0 | 0 | 2 | 12 | 9 | 16 | 9 | 12 | 6 |
| Antenna type (example) | Patch | Quad helix | Quad Helix | Phased array | Phased array | Phased array | Phased array | Phased array | Phased array |
| Typical antenna size | 5 cm | 5 cm diameter | 12 cm | 50 cm diameter | 30 cm diameter | 50 cm diameter | 30 cm diameter | 2 panels 60 × 60 cm | 20 × 15 cm |
| Mobile earth station figure of merit (G/T) (dB(K ⁻¹)) | -28 | -23 | -24 | -10 | -15.5 | -7.5 | -15.5 | -13 | -20 |
| Mobile earth station e.i.r.p./channel (dBW) | -3 | 11 | 5 | 18 | 15.1 | 22 | 15.1 | 20 | 15.1 |
| User data rate | 600 bits/s | 600 bit/s | Voice service | 500 kbit/s | 250 kbit/s | 500 kbit/s | 250 kbit/s | 500 kbit/s | 250 kbit/s |
| Modulation | 32ary FSK | BPSK | GMSK | 16-QAM | 16-QAM | 16-QAM | 16-QAM | 16-QAM | 16-QAM |
| Typical C/N_0 for communication channel (dB(Hz)) | 27 | 32 | 51 | 67 | 57 | 67 | 57 | 67 | 57 |
| Satellite e.i.r.p./channel (dBW) | 20 | 20 | 43 | 40.5 | 40.5 | 40.5 | 40.5 | 40.5 | 40.5 |
| Channel spacing (nominal) (kHz) | 5 | 5 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| Satellite peak antenna gain ⁽¹⁾ (dBi) | 18 | 18 | 41 | 41 | 41 | 41 | 41 | 41 | 41 |

⁽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 | $\pi/4$ 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 |
| pdf | * | * | * |

⁽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 – 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)

| System Parameter | A ⁽¹⁾ | B | C | D | E | | | F | G | | H | R | K | |
|--|--|---------------------------------|------------------|--|--|---|---------------------------------|--|---------------------|-----------------------|--|--|---|-----------------------|
| | | | | | | | | | Link 1 | Link 2 | | | I | M |
| <i>Polarization</i> | | | | | | | | | | | | | | |
| Feeder link | RHCP | RHCP | Circular | RHCP/ LHCP | RHCP/LHCP | | | Circular | RHCP | RHCP | LHCP | Circular | Circular | Circular |
| Service link | RHCP | LHCP | Circular | LHCP | RHCP | | | RHCP | LHCP | LHCP | RHCP | Circular | 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 | Earth-to-space | Earth-to-space | earth-to-space | Earth-to-space |
| <i>Frequency bands (GHz)</i> | | | | | | | | | | | | | | |
| 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 | 1.6 | 1.6 |
| Orbit | | ⁽²⁾ | | | Eccentric | Circular | Elliptical (alternate orbit) | | Circular | Circular | Circular | Circular | Circular | Circular |
| Altitude (km) | 780 | 10 355 | 2 000 | 1 414 | 520/7 846 | 7 846 | 4376/7846 | 10 355 | 1 500 | 1 500 | 1 000 | 700 | 36 000 | 21 500 |
| Satellite separation (degrees) | 32.7 | 90 | 45 | 60 | | | | 72 | 30 | 30 | 51.4 | 27.7 | 120 | 120 |
| Number of satellites | 66 | 12 | 40 | 48 | 4-5 | 6-8 | 6-8 | 10 | 48 | 48 | 7 | 91 | 3 to 9 | 14 to 27 |
| Orbital planes | 6 | 3 | 5 | 8 | 2 | 1 | 1 | 2 | 4 | 4 | 7 | 7 | 3 | 3 |
| Inclination angle (degrees) | 86 | 50 | 55 | 52 | 116.6 | 0 | 0 | 45 | 74 | 74 | 83 | 82 | 55 | 55 |
| <i>Satellite antennas</i> | | | | | | | | | | | | | | |
| 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 | 1 to 7 | 1 |
| 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 | 1.25 × 10 ⁷ to 8.5 × 10 ⁷ | 8.5 × 10 ⁷ |
| Average beam side lobes (dB) | -20 | -20 | To be determined | -15 | -15 and greater | | | -20 (peak) | -3 | -2 | -15 | -20 | -20 | -20 |
| Beam frequency reuse | 0.167 | 1 | 1 | 1 | N (where N: number of beams) | | | * | 1 | 0.6 | 0.11 | 3 | * | * |
| <i>Link characteristics</i> | | | | | | | | | | | | | | |
| 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 | 5 to 10 | 8 to 12 |
| 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 | -8.5 to -6 | -16.5 to -14.5 |

TABLE 4a (end)

| System Parameter | A ⁽¹⁾ | B | C | D | E | F | G | | H | R | K | |
|--|------------------|----------------|------------------|--------------------|-------------------------------------|----------------|------------------|------------------|------------------|----------------------------------|----------------|----------------|
| | | | | | | | Link 1 | Link 2 | | | I | M |
| <i>Transmission parameters</i> | | | | | | | | | | | | |
| Modulation | QPSK | QPSK | QPSK | QPSK | OQPSK spreading modulation | QPSK | QPSK | QPSK | BPSK | QPSK | BPSK | BPSK |
| Coding | FEC | FEC | FEC | FEC | FEC rate 1/3, K=9 | FEC | FEC | FEC | FEC | Convolutional code rate 1/2, K=7 | FEC | FEC |
| Access scheme | FDMA/TDMA | FDMA/CDMA | FDMA/CDMA | FDMA/CDMA | CDMA | FDMA/TDMA | FDMA/CDMA | FDMA/CDMA | FDMA/CDMA | FDMA/CDMA | CDMA | CDMA |
| Duplex scheme | TDD | FDD | FDD | FDD | Full | FDD | Full | Full | Full | FDD | Full | Full |
| <i>Transmission parameters (cont.)</i> | | | | | | | | | | | | |
| Frame length (ms) | 90 | Not applicable | Not applicable | Not applicable | 320 and 25.86 (random access) | 40 | 60 | 60 | 60 | Not applicable | 50 to 800 | 500 to 1500 |
| Burst rate (kbit/s) | 50 | Not applicable | Not applicable | Not applicable | 0.3-9.6 | 36 | Not applicable | Not applicable | 50 | Not applicable | 1 to 4 | 0.4 to 2 |
| 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 | 1.6 and/or 4.1 | 1.6 |
| Voice activity factor | 0.4 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 | Not applicable | Not applicable | 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 | Not applicable | Not applicable |
| 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 | 3.2 and/or 8.2 | 3.2 |
| 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 | 7 | 7 |
| 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.

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

| Parameter \ System | A | B | C | D | E | F | G | | H | R | K | | | |
|--------------------------------|---|-------------------------------|------------------|--|--|----------------|---------------------------------|--|---------------------|-----------------------|--|--|---------------------|---------------------|
| | | | | | | | Link 1 | Link 2 | | | I | M | | |
| <i>Polarization</i> | | | | | | | | | | | | | | |
| Feeder link | RHCP | LHCP | Circular | RHCP/ LHCP | Dual circular | Circular | LHCP | LHCP | RHCP | Circular | Circular | Circular | | |
| Service link | RHCP | LHCP | Circular | LHCP | RHCP | RHCP | RHCP | RHCP | RHCP | Circular | 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 | Space-to-Earth | Space-to-Earth | Space-to-Earth | Space-to-Earth | | |
| <i>Frequency bands (GHz)</i> | | | | | | | | | | | | | | |
| 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 | 2.5 | 2.5 | | |
| Orbit | | ⁽²⁾ | | | Eccentric | Circular | Elliptical (alternate orbit) | | Circular | Circular | Circular | Circular | Circular | |
| Altitude (km) | 780 | 10 355 | 2 000 | 1 414 | 520/7 84 6 | 7 846 | 4 376/7 84 6 | 10 355 | 1 500 | 1 500 | 1 000 | 700 | 36 000 | 21 500 |
| Satellite separation (degrees) | 32.7 | 90 | 45 | 60 | – | – | – | 72 | 30 | 30 | 51.4 | 27.7 | 120 | 120 |
| Number of satellites | 66 | 12 | 40 | 48 | 4-5 | 6-8 | 6-8 | 10 | 48 | 48 | 7 | 91 | 3 to 9 | 27 |
| Orbital planes | 6 | 3 | 5 | 8 | 2 | 1 | 1 | 2 | 4 | 4 | 7 | 7 | 3 | 3 |
| Inclination angle (degrees) | 86 | 50 | 55 | 52 | 116.6 | 0 | 0 | 45 | 74 | 74 | 83 | 82 | 55 | 55 |
| <i>Satellite antennas</i> | | | | | | | | | | | | | | |
| 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 | 1 | 1 |
| 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 | 8.5×10 ⁷ | 8.5×10 ⁷ |
| Average beam side lobes (dB) | –20 | –20 | To be determined | –15 | –15 and greater | | | –20 (peak) | –3 | –2 | –15 | –20 | –20 | –20 |
| Beam frequency reuse | 0.167 | 1 | 1 | 1 | N (where N: number of beams) | | | * | 1 | 0.6 | 0.11 | 3 | * | * |

TABLE 4b (end)

| System Parameter | A | B | C | D | E | F | G | | H | R | K | |
|--|------------------|------------------|------------------|--------------------|--------------------|------------------|------------------|------------------|------------------|------------------------------------|------------------|------------------|
| | | | | | | | Link 1 | Link 1 | | | I | M |
| <i>Transmission parameters (cont.)</i> | | | | | | | | | | (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 | 8.1 | 8.1 |
| Interleaving | * | * | * | * | Varies | None | None | None | None | Not applicable | Not applicable | 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 | 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 | 7 | 7 |
| MES geographical distribution | Worldwide | Worldwide | To be determined | * | Varies | * | AAB | AAB | AAB | Worldwide | Regional | 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 | 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.

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

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 |
|---|------------------------------------|----------------|---|---------|---------------------------|----------------------------|---------------------------|-------|---------------------|
| <i>Orbital parameters</i> | | | | | | | | | |
| 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 |
| <i>Subscriber uplink</i> | | | | | | | | | |
| 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 | | | $10 \log (\cos 2 \theta)$ | $10 \log (\cos 2 \theta)$ | 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 |

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TABLE 5 (continued)

| System | L | | M | N | P | Q | | S |
|--|---------------------|------------|-------------------|---------------|-----------------------------|-----------------------------------|------------------------|----------------------|
| <i>Subscriber downlink</i> | | | | | | | | |
| 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 | $E_b/(N_0 + I_0) = 3.7\ dB$ | $E_b/N_0 = 13.5\ dB$ | | $E_b/N_0 = 13.4\ dB$ |
| <i>Gateway downlink</i> | | | | | | | | |
| 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 |
|---|------------|-------------------|---------------------|--------------------------------|------------------------------------|--------------|
| <i>Gateway downlink (cont.)</i> | | | | | | |
| Channel bandwidth (kHz) | 60 | 50 | 30-85 | 855 | 175 | 45 |
| Rate (kbit/s) | 50/OQPSK | 57.6/OQPSK | 9.6, 19.2, 38.4/FSK | Regenerated | 112/GMSK | 30/GMSK |
| Polarization (Tx wave) | RHCP | | | LHCP | RHCP | |
| Gateway Rx G/T (dB(K ⁻¹)) | -18.3 | -12.8 | -9.6 | -21.2 | $T = 1\ 565\ K$ | $T = 505\ K$ |
| Maximum Rx antenna gain (dBi) | 5.7 | 17, RHCP | 14 | 7.6 | 12 | |
| $C/(I + N)$ (dB) | 8.5 | Rec. ITU-R M.1232 | 8 | $C/(N_0 + I_0) = 3.7\ dB(Hz)$ | $E_b/N_0 = 13.5\ dB$ | |
| <i>Gateway uplink</i> | | | | | | |
| 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 | $T = 940\ K$ | |
| Maximum Rx antenna gain (dBi) | 16 | 0, RHCP | 0 | 5.7 | 6 maximum, isoflux, -3 at nadir | |
| $C/(I + N)$ (dB) | 8.5 | 10.6 | 8 | $C/(N_0 + I_0) = 42.5\ dB(Hz)$ | $E_b/N_0 = 13.5\ dB$ | |

⁽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.