RECOMMENDATION ITU-R S.1328

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

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

(1997)

The ITU Radiocommunication Assembly,

*considering*

a) that the World Radiocommunication Conference (Geneva, 1995) (WRC-95), in Resolutions 116 and 117, allocated frequencies to the FSS for use by feeder links of non-GSO MSS systems;

b) that WRC-95, in Resolution 118, provided for parts of the 30/20 GHz bands in the FSS to be used by the non-GSO FSS without the restrictions of Radio Regulations (RR) No. 2613;

c) that WRC-95, in Resolution 120, provided for parts of the 30/20 GHz band in the FSS to be shared with feeder links of the non-GSO MSS;

d) that WRC-95, in Resolution 121, advocated the development of interference criteria and methodology for sharing between feeder links of the non-GSO MSS and networks of the GSO FSS,

*recommends*

**1** that, in the planning and development of new FSS networks, both GSO and non-GSO, and feeder links for MSS systems affecting the FSS allocations, the technical characteristics of existing and planned satellite systems in the Annexes 1 to 6 be taken into consideration;

**2** that, in studies pertaining to the development of sharing criteria between satellite systems, the technical characteristics of existing and planned systems in the Annexes 1 to 6 be used in interference analyses;

**3** that administrations planning modifications to these systems or proposing future satellite system networks in FSS bands are urged to submit their technical characteristics to the ITU-R to update this data source.

ANNEX 1

TABLE 1

**Technical characteristics of several LEO and GSO satellite networks**

| Parameters | Non-GSO MSS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | LEO A | LEO B | LEO C | LEO D | LEO E | | LEO F | LEO G |
| 1. *Orbital parameters* | | | | | | | | |
| Shape of orbit | Circular | Circular | Circular | Circular | Elliptical | Circular | Circular | Circular |
| Height (km) | 780 | 10 355 | 2 000 | 1 414 | 7 846 × 520 | 80-90 | 10 355 | 1 500 |
| Inclination angle (degrees) | 86 | 50 | 55 | 52 | 116.6 | 0 | 45 | 74 |
| Coherence (track repeat in h) | – | – | – | 47.5 | 3 | 4.8 | – | – |
| No. of satellites per plane | 11 | 4 | 5 | 6 | 5 | 7 | 5 | 12 |
| No. of orbital planes | 6 | 3 | 8 | 8 | 2 | 1 | 2 | 4 |
| Satellite separation (degrees) within plane | 32.7 | 90 | 45 | 60 | 72 | 51 | – | 30 |
| Satellite phasing between planes (degrees) | 31.6 (22) | 30 | – | 7.5 | 36 | – | 0 | 90 |
| 2. *Targeted frequency range and polarization* | | | | | | | | |
| Uplink frequency (GHz) | 29.1-29.3 | 29.1-29.5 | 5 091-5 250 | 5 091-5 250 | 15.45-15.65 | | 5 100-5 250 | 14 |
| Uplink polarization | RHCP | LHCP | RHCP/LHCP | LHCP/RHCP | – | | – | LHCP |
| Downlink frequency (GHz) | 19.4-19.6 | 19.3-19.7 | 6 875-7 075 | 6 875-7 055 | 6 875-7 075 | | 6 925-7 075 | 11 |
| Downlink polarization | LHCP | RHCP | RHCP/LHCP | LHCP/RHCP | – | | – | RHCP |
| 3. *Spectrum required in each direction* (MHz) | 200 | 400 | 200 | 159/180 | 200 | | 100 | 50 |
| 4. *Carrier transmission parameters* | | | | | | | | |
| Modulation type | FDMA/QPSK Rate ½, coded Rate 6.25 Mbit/s | CDMA | CDMA/FDMA | CDMA/FDMA | QPSK | QPSK | TDMA/QPSK | CDMA/FDMA |
| Number of service link beams | | – | 32 | 16 | 61 | 37 | 16.3 | – |
| No. of feeder-link segments/polarization | | – | 1 | 8 | 31 | 31 | – | – |
| Segment bandwidth (MHz) | | – | 12 | 16.5 | 12 | 12 | – | – |
| Receiver bandwidth (kHz) | 3 000 | 2 500 | 200 | 1 230 | 3 000/7 000 | 3 000/7 000 | 25 | 5 800 |
| Transmission bandwidth (kHz) | 4 370 | 2 500 | 2 500 | 1 230 | 3 000/7 000 | 3 000/7 000 | 25 | 5 800 |
| Overall ($C/N_0$) per user (dB(Hz)) or ($C/N$) (dB) | – | – | 44.7-46.6 | 44 | – | – | 48 | 42 ($E_b/N_0$) |

TABLE 1 *(continued)*

| Parameters | Non-GSO MSS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | LEO A | LEO B | LEO C | LEO D | LEO E | | LEO F | LEO G |
| 4. *Carrier transmission parameter (continued)* | | | | | | | | |
| Uplink e.i.r.p./carrier (dBW) | ARC 34.0 to 43.5 | 54.25 | 40.2 | 54 | 50 | 50 | 47.5 | 49 |
| Downlink e.i.r.p./carrier (dBW) | ARC 4.5 to 15.0 | 5.31 | –8.5 | –5 | – | – | 0 | –6 (nadir) |
| Type of satellite transponder | Regenerative | Transparent | Transparent | Transparent | Transparent | Transparent | – | – |
| 5. *Satellite antenna parameters* | | | | | | | | |
| Tx maximum gain (dBi) | 26.9, 2 dB axial ratio | 35.7 | 3 | 2 | 11 | 15 | 13 | 5 (nadir) |
| Rx maximum gain (dBi) | 30.1, 2 dB axial ratio | 38.5 | 3 | 2 | 11 | 15 | 10 | 5 (nadir) |
| Main lobes | RR AP 29 | – | –3 dB | ISO flux ± 2 dB | – | – | RR AP 30B | – |
| Side lobes | RR AP 29 | – | –3 dB | –14 dB | –16 dB | –16 dB | – | – |
| Back lobes | – | – | –10 dB | –35 dB | –38 dB | –38 dB | – | – |
| Steerable antenna or not | (Programmed Pointing) Steerable (4/SAT) | Steerable | No | No | No | No | No | No |
| 6. *Earth station antenna parameters* | | | | | | | | |
| Peak Tx gain (dBi) | 56.3 (beamwidth 0.24°) | 64.8 | 47.7 | 47.5 | 55.3 | | 47.8 | 41 |
| Peak Rx gain (dBi) | 53.2 (beamwidth 0.36°) | 60.8 | 50.2 | 50.0 | 48.2 | | 50.7 | 42 |
| Radiation pattern | RR AP 29 | Rec. ITU-R S.465 | Rec. ITU-R S.580 | Rec. ITU-R S.465 | – | | Rec. ITU-R S.580 | $32.3 - 25 \log \varphi$ |
| Minimum operating elevation angle (degrees) | 5° Acquisition 8.3° Service (Auto tracking) | 10 | 10 | 10 | 5 | | 5 | 10 |
| 7. *Number of earth stations and distribution* | 25 ww 7 USA | 8-12 | 50-100 | 100-200 | 20-40 | | 6-30 | 3 or more |
| 8. *Earth station switching strategy* | Nom. 10° minimum, make before break | ≥ minimum elevation angle | Highest elevation angle | Select highest elevation | Highest and 2nd highest elevation angle | | ≥ minimum elevation angle | |

TABLE 1 *(continued)*

| Parameters | Non-GSO/ MSS | GSO FSS | | | | | GSO MSS | Non-GSO FSS | FSS | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LEO | GSO 1 | GSO 2 | GSO 3 | GSO 13 | GSO 20 | | LEO SAT-1 | GSO 30 | QUASI-GSO 31 |
| 1. *Orbital parameters* | | | | | | | | | | |
| Shape of orbit | Circular | | | | Circular | Circular | Circular | Circular | Circular | Elliptical |
| Height (km) | 1 000 | 36 000 | 36 000 | 36 000 | 36 000 | 36 000 | 36 000 | 700 | 36 000 | 1 000-43 000 |
| Inclination angle (degrees) | 83 | – | – | – | 0 | – | – | 98.2 | – | 63 |
| Coherence (track repeat in h) | – | – | – | – | – | – | – | Not applicable | – | 12 |
| No. of satellites per plane | 1 | – | – | – | 17 | – | – | 40 | 1 | 1 |
| No. of orbital planes | 7 | – | – | – | 1 (GSO) | – | – | 21 | 12 | 8 |
| Satellite separation (degrees) within plane | – | – | – | – | At least 2° for co-channel sharing | – | – | 9 | – | – |
| Satellite phasing between planes (degrees) | 51.4 | – | – | – | Not applicable | – | – | Random | – | Varies |
| 2. *Targeted frequency range and polarization* | | | | | | | | | | |
| Uplink frequency (GHz) | 7 | 6 | 6 | 14 | 30 | 30 | 30 | 28.6-29.1 | 30 | 30 |
| Uplink polarization | RHCP | Circular | Circular | V and H | Circular with re-use | LHCP/RHCP | LHCP/RHCP | LHCP/RHCP | RHCP/LHCP | RHCP/LHCP |
| Downlink frequency (GHz) | 5 | 4 | 4 | 12 | 20 | 20 | 20 | 18.8-19.3 | 19 | 19 |
| Downlink polarization | LHCP | Circular | Circular | V and H | Circular with re-use | LHCP/RHCP | RHCP | LHCP/RHCP | RHCP/LHCP | RHCP/LHCP |
| 3. *Spectrum required in each direction* (MHz) | 50 up 66 down | 500 | 500 | 500 | 1 000-2 500 | 1 000 | 500 | 500 | 1 000-3 200 | 1 000-3 200 |
| *4. Carrier transmission parameters* | | | | | | | | | | |
| Modulation type | CDMA/FDMA | FM/TV | 64 kbit/s | FM/TV | FDMA up/ FDMA down | FDMA/QPSK | FDMA/QPSK | Shaped QPSK FDMA up/ TDMA down | Phase | Phase |
| No. of service link beams | – | – | – | – | 48 | 8 | 4 | < 49 pear satellite | – | – |
| No. of feeder-link segments/polarization | – | – | – | – | Not applicable | – | – | – | – | – |
| Segment bandwidth (MHz) | – | – | – | – | Not applicable | – | – | – | – | – |
| Receiver bandwidth (kHz) | 2 050 | 30 000 | 51.2 | 27 000 | 500 uplink/ 120 000 downlink | 241 up | 1 800 | 0.275-35.2 (MHz) | 3 200 | 3 200 |
| Transmission bandwidth (kHz) | 2 050 | 30 000 | 51.2 | 27 000 | 340 uplink/ 81 000 downlink | 1 800 down | 1 800 | 500 (MHz) | 3 200 | 3 200 |

TABLE 1 *(continued)*

| Parameters | Non-GSO/ MSS | GSO FSS | | | | | GSO MSS | Non-GSO FSS | FSS | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LEO | GSO 1 | GSO 2 | GSO 3 | GSO 13 | GSO 20 | | LEO SAT-1 | GSO 30 | QUASI-GSO 31 |
| 4. *Carrier transmission parameters (continued)* | | | | | | | | | | |
| Overall ($C/N_0$) per user (dB(Hz)) or ($C/N$) (dB) | 63 | 17.7 | 12.7 | 17.7 | 8.0 up/ 5.0 down ($E_b/N_0$) | | | 63.3 (dB(Hz)) uplink $C/N_0$ 105.4 (dB(Hz)) downlink $C/N_0$ | – – | – – |
| Uplink e.i.r.p./carrier (dBW) | 42.1 | 85.4 | 48.3 | 86.3 | 32.8-40.8 | 39.0 | 62.0 | 15.2 (90° clear)-33.6 (40° minimum) | 110 | 110 |
| Downlink e.i.r.p./carrier (dBW) | –5.8 | 30.5 | 0.5 | 50.0 | 59.5 | 61.0 | 57.0 | 47.5 (90°), 48.6, 49.7 (40°) | 74 | 74 |
| Type of satellite transponder | – | – | – | – | Digital filtering/routing | On-board processing | On-board processing | On-board processing | On-board processing | On-board processing |
| 5. *Satellite antenna parameters* | | | | | | | | | | |
| Tx maximum gain (dBi) | 3 | | | | 46.5/35.0 | 48.9 | 40.9 | 29.8 (90°), 30.9, 32.0 (40°) | 55 | 55 |
| Rx maximum gain (dBi) | 3 | | | | 46.5/35.0 | 48.9 | 40.9 | 29.8 (90°), 30.9, 32.0 (40°) | 55 | 55 |
| Main lobes | – | | | | Report ITU-R S.558 | RR AP 30B | RR AP 30B | – | Report ITU-R S.558 | Report ITU-R S.558 |
| Side lobes | – | | | | Report ITU-R S.558 | – | – | – | Report ITU-R S.558 | Report ITU-R S.558 |
| Back lobes | – | | | | Report ITU-R S.558 | – | – | – | Report ITU-R S.558 | Report ITU-R S.558 |
| Steerable antenna or not | No | | | | No, fixed pointed array | Yes | Yes | 64 steerable beams | Yes | Yes |
| 6. *Earth station antenna parameters* | | | | | | | | | | |
| Peak Tx gain (dBi) | 43.1 | 57.8 | 51.6 | 62.3 | 44.5/53.3 | 34.0-43.5 | 37.5-43.5 | 36 | 70 | 70 |
| Peak Rx gain (dBi) | 48.5 | 54.0 | 47.7 | 60.2 | 44.5/53.3 | 30.5-40.0 | 34.0-40.0 | 33 | 70 | 70 |
| Radiation pattern | 29 – 25 log φ | – | – | – | 29 – 25 log φ | 32 – 25 log φ | 32 – 25 log φ | RR AP 29, Annex III | RR AP 29 | RR AP 29 |
| Minimum operating elevation angle (degrees) | 10 | – | – | – | 5 | 10 | 10 | 40 | 5 | 5 |
| 7. *No. of earth stations and distribution* | 4 or more | | | | Unlimited, through urban and suburban areas and certain rural areas | | | Up to 20 million, worldwide | Global | Global |
| 8. *Earth station switching strategy* | | | | | Not needed/used | Not applicable | Not applicable | Track nearest satellite | | |

ARC: Automatic Range Compensation

LHCP: left hand circular polarization

RHCP: right hand circular polarization

NOTE 1 – Ref. Based on Table 7 of CPM-95 Report.

# ANNEX 2

TABLE 2

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

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

TABLE 3

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

| 1a. *Frequency band* (GHz) | 6/4 (Conv.) | | | | 6/4 (Allot) | 14/12 (Conv.) | | 14/12 (Allot) | 30/20 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1b. *System* | GSO 1 | GSO 2 | GSO 5 | GSO 6 | GSO 9 | GSO 3 | GSO 7 | GSO 10 | GSO 11 | GSO 12 | GSO 13 |
| No. of co-located satellites | 1 | | | | 1 | 1 | | 1 | 1 | 1 | 2 |
| No. of beams/satellite and polarization | 2 and RHCP + 2 and LHCP | | | | | V and H | | V and H | 7V and 7H | 1 circular polarization | 24 and RHCP + 24 and LHCP |
| 2. *Spectrum requirements in each direction* (MHz) | 500 | | | | 300 | 500 | | 500 | 800 | 1 000 | 1 000-2 500 |
| 3a. *Uplink carrier* | FM/TV | | 64 kbit/s IDR | | | FM/TV | 64 kbit/s | | 147 Mbit/s | 65 Mbit/s | 384 kbit/s |
| Beam identification?? | Global | Hemi | Global | Hemi | | Spot | Spot | | Spot | Spot | Spot (Global) |
| Occupied bandwidth (Hz) | 30 M | 30 M | 51.2 k | 51.2 k | | 27 M | 51.2 k | | 110 M | 110 M | 500 k |
| Minimum required $C/N$ or $E_b/N_0$ | | | | | | | | | | | 8 |
| 3b. *Downlink carrier* | Same as uplink | | | | Same as uplink | Same as uplink | | Same as uplink | Same as uplink | | Data mux |
| Occupied bandwidth (MHz) | Same as uplink | | | | Same as uplink | Same as uplink | | Same as uplink | Same as uplink | | 120 |
| Minimum required $C/N$ or $E_b/N_0$[(1)] (dB) | 17.7 | | 9.7 | | | 17.7 | 9.7 | | | | 5 |
| 4. *Uplink parameters* | | | | | | | | | | | |
| Transmitter power to antenna (dBW) | | | | | | | | | 20 | | –11.5 to –3.5 (power control) |
| Transmitting antenna size (m) | | | | | | | | | 5 | 11.5 | 0.66 |
| Transmitting antenna gain (dBi) | 57.8 | 57.8 | 51.6 | 51.6 | 52.5 | 62.3 | 55.5 | 50.7 | 61.9 | 69.0 | 44.3 |
| E.i.r.p. (dBW) | 85.4 | 87.8 | 48.3 | 46.1 | 6.6[(2)] | 86.3 | 40.9 | 14.6[(2)] | 81.9 | 91.0 | 32.8-40.8 (power control) |
| Peak system $G/T$ (dB($K^{-1}$)) | | | | | | | | | 21.8 | | 18.9 |
| Receiving antenna beamwidth (degrees) | | | | | | | | | | | 0.9 |
| Receiving antenna side-lobe pattern | | | | | | | | | | | |
| Steerable or not | | | | | | | | | | | No |
| 5. *Downlink parameters* | | | | | | | | | | | |
| Transmitter power to antenna (dBW) | | | | | | | | | 6 | | 12.5 |
| Peak transmitting antenna gain (dBi) | | | | | | | | | 49.5 | 33.0 | 46.5 |
| Peak e.i.r.p. (dBW) | 30.5 | 35.0 | 0.5 | 0.9 | –35.6[(2)] | 50.0 | 7.7 | –21[(2)] | 55.5 | 39.0 | 59 |
| Transmitting antenna beamwidth (degrees) | | | | | | | | | 0.44 | | 1.4 |
| Receiving antenna size (m) | | | | | | | | | 5 | | 0.66 |
| Peak receiving antenna gain (dBi) | 54.0 | 54.0 | 47.7 | 47.7 | 49.1 | 60.2 | 53.5 | 49.4 | 58.4 | 33.0 | 41.0 |
| 6. *Earth segment* | | | | | | | | | | | |
| No. of earth stations | | | | | | | | | | | 600 000 |
| Distribution of earth stations | | | | | | | | | | | Home and business location |

IDR: intermediate data rate

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

(2) E.i.r.p. is given in dB(W/Hz). The total e.i.r.p. is given in Annex 1 of Appendix 30B as the indicated e.i.r.p. density averaged over the necessary bandwidth..

ANNEX 3

TABLE 4

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

| Satellite system | A | A' | B | J | K | L | M | N | S | T | U |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *General parameters* | | | | | | | | | | | |
| Nominal frequency (GHz) | 20/30 | 20/30 | 20/30 | 20/30 | 20/30 | 20/30 | 20/30 | 20/30 | 20/30 | 20/30 | 20/30 |
| No. of transponders per satellite | 64 | 64 | 48 | 48 | 40 | | | | | | 48 |
| Transponder bandwidth (MHz) | 120 | 250 | 120 | 120 | 120 | 120 | 120 | 24 | 120 | 54 | 36 |
| Transponder high power amplifier (W) | 30 | 30 | 20 | 30 | 60 | | | 95 | | 40-60 | 60-90 |
| Satellite e.i.r.p. (dBW)(1) | 61 | 61 | 59 | 61 | 61 | 60 | 60.2 | 54 | 58 | 61 | 51-55 |
| Polarization(2) | Circular | Circular | Circular | Circular | Circular | Circular | Circular | Circular | Circular | Linear | Linear |
| *Downlink parameters* | | | | | | | | | | | |
| Modulation/access | TDM | CDMA | TDM | TDM | TDM | TDM | TDM | TDM | TDM | PSK/ MCPC | PSK/ MCPC |
| "Central" frequency (GHz) | 19.5 | 19.5 | 19.5 | 19.5 | 19.7 | 19.5 | 19.95 | 19.5 | 20.0 | 19.92 | 18.95 |
| Data rate (Mbit/s) | 92 | 95.04 | 92 | 155 | 92 | 155 | 130 | 40 | 90 | 51.84 | 38.88 |
| Digital service(3) | Narrow-band data | Narrow-band data | Narrow-band data | Narrow-band data | Narrow-band data | Narrow-band data | Narrow-band data | Narrow-band data | Narrow-band data | SC/TV | SC/TV |
| E.i.r.p. spectral density (dB(W/Hz)) | –23.6 | –26.6 | –21.3 | –25.9 | –20.8 | –20.8 | –20.9 | –22.0 | –22.6 | –16.3 | –18.0 |
| *Uplink parameters* | | | | | | | | | | | |
| "Central" frequency (GHz) | 29.5 | 29.5 | 29.5 | 29.5 | 29.5 | 29.5 | 29.75 | 29.5 | 30.0 | 29.72 | 28.75 |
| Modulation/access | CDMA | CDMA | FDM | FDM | FDM | FDM | FDM | FDM | FDM | TV/MCPC | TV/MCPC |
| Nominal rate (kbit/s) | 384 | 384 | 384 | 384 | 384 | 384 | 128 | 384 | 384 | 51 840 | 38 880 |
| Minimum earth station antenna diameter (m) | 0.66 | 0.66 | 0.66 | 0.66 | 0.70 | 0.70 | 0.65 | 0.75 | 0.70 | 4.6/0.6 | 4.6/0.6 |
| Up/down earth station (dB) antenna discrimination at 2° | 22.5/19 | 22.5/19 | 22.5/19 | 22.5/19 | 23/19.5 | 23/19.5 | 22.5/19 | 23.5/20 | 23/19.5 | 40/18 | 40/18 |
| Maximum power spectral density (dB(W/Hz)) | –61.7 | –70 | –60.5 | –58.9 | –57.9 | –57.9 | –65.9 | –63.7 | –58.9 | –61.1 | –61.9 |

MCPC: multi-channel per carrier
SC: single carrier
(1) Estimated peak e.i.r.p. values of spot beams, with edge of coverage of spot beams from 3 to 5 dB below peak.
(2) Left- and right-hand circular polarization used for up and downlinks.
(3) Narrow-band digital data rates may include mixtures of 64, 128, 384, and 1 544 kbit/s.

TABLE 4 *(continued)*

| Satellite system | V | W | X | Y | Z |
|---|---|---|---|---|---|
| *General parameters* | | | | | |
| Nominal frequency (GHz) | 20/30 | 20/30 | 20/30 | 20/30 | 20/30 |
| No. of transponders per satellite | | | | | 360(1) |
| Transponder bandwidth (MHz) | 125 | | | | 25-120 |
| Transponder high power amplifier (W) | 40 | | | | |
| Satellite e.i.r.p. (dBW)(2) | 60-62 | 22.6 | 62.8 | | 70(3) |
| Polarization(4) | Circular | | | | Linear |
| *Downlink parameters* | | | | | |
| Modulation/access | TDM | TDM | FDM | | TDM/FDM/CDMA |
| "Central" frequency (GHz) | 20 | 20 | 20.2 | 17.7-20.2 | (5) |
| Data rate (Mbit/s) | 92.16 | 0.064 | 1.544/0.384 | | To be determined |
| Digital service(6) | Narrow-band data | Narrow-band data | Narrow-band data/video | | |
| E.i.r.p. spectral density (dB(W/Hz)) | –19.1 | –25.5 | –23.1/–16.0 | –63/–38 | –4.1 |
| *Uplink parameters* | | | | | |
| "Central" frequency (GHz) | 30 | 30 | 30 | 27.5-30.0 | (5) |
| Modulation/access | FDM | FDM | FDM | | TDM/FDM/CDMA |
| Nominal rate (kbit/s) | 384 | 64 | 1 544/384 | | |
| Minimum earth station antenna diameter (m) | 0.70 | 0.60 | 1.0/0.3 | | 0.3-12.0 |
| Up/down earth station (dB) antenna discrimination at 2° | 23/19.5 | 21.5/18 | 26/12 | | Rec. ITU-R S.580 |
| Maximum power spectral density (dB(W/Hz)) | –58.8 | –45.1 | –65.9/–56.8 | –40 | –44.0 |

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

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

(3) In compliance with RR No. 2578.

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

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

Downlink frequency: 21.9-22.0(7), 21.4-21.9(7)/18.2-21.2.

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

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

TABLE 5

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

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

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

TABLE 6

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

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

PFMO: pulse frequency modulation (offset)

UPC: upward power control

APPENDIX 1
TO ANNEX 3

TABLE 7

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

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

# ANNEX 4

TABLE 8

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

| Satellite system | R-1 | R-2 | R-3 | R-4 | R-5 | R-6 |
|---|---|---|---|---|---|---|
| *General parameters* | | | | | | |
| Nominal frequency (GHz) | 20/30 | | | | | |
| No. of transponders per satellite(1) | 10 | | | | | |
| Transponder bandwidth (MHz) | 100 | | | | | |
| Transponder high power amplifier (W) | 29 | | | | | |
| Satellite e.i.r.p. (dBW)(2) | 55 | | | | | |
| Polarization | Circular | | | | | |
| *Downlink parameters* | | | | | | |
| Modulation/access | TDM | FDM | FDM | FDM | FDM | FM |
| "Central" frequency (GHz)(3) | | | | | | |
| Data rate (Mbit/s) | 20.4 | 0.032 | 0.032 | 1.544 | 7.2 | Not applicable |
| Digital service | Voice, data and fax | Voice, data and fax | Voice, data and fax | Voice, data and fax | Digital video | TV/FM |
| E.i.r.p. spectral density (dB(W/Hz)) | –9.1 | –3.1 | –5.3 | –14.6 | –17.0 | –3.9(4) |
| *Uplink parameters* | | | | | | |
| "Central" frequency (GHz)(3) | | | | | | |
| Modulation/access | TDMA | FDMA | FDMA | FDMA | FDMA | FM |
| Nominal rate (Mbit/s) | 20.4 | 0.032 | 0.032 | 1.544 | 7.2 | Not applicable |
| Minimum earth station antenna diameter (m) | 7.6 | 1.4 | 3.6 | 3.6 | 1.4 | 3.0 |
| Up/down earth station (dB) antenna discrimination at 2° | Rec. ITU-R S.465 | | | | | |
| Maximum power spectral density (dB(W/Hz)) | –31.1 | –23.3 | –25.3 | –27.6 | –28.2 | –14.0(4) |

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

ANNEX 5

TABLE 9

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

| | Non-GSO | | | |
|---|---|---|---|---|
| | FSAT-MULTI 1-B | | | |
| 1. *Orbital parameters* | | | | |
| Shape of orbit | Circular | | | |
| Height (km) | 1 457 | | | |
| Inclination angle (degrees) | 55 | | | |
| Coherence (track repeat (h)) | 665 | | | |
| No. of satellites per plane | 4 | | | |
| No. of orbital planes | 16 | | | |
| Satellite separation (degrees) within plane | 90 | | | |
| Satellite phasing between planes | Not applicable | | | |
| 2. *Targeted frequency range and polarization* | | | | |
| Uplink frequency (GHz) | 13-14 | | | |
| Uplink polarization | Circular | | | |
| Downlink frequency (GHz) | 11-12 | | | |
| Downlink polarization | Circular | | | |
| 3. *Spectrum required in each direction* (MHz) | 1 000 within the above frequency range | | | |
| 4. *Carrier transmission parameter* | | | | |
| Modulation type | SSMA | | | |
| No. of service link beams | < 45 | | | |
| No. of feeder-link segments/polarization | – | | | |
| Segment bandwidth (MHz) | – | | | |
| Receiver bandwidth (kHz) | Forward: 41 000; Return: 5 200 | | | |
| Transmission bandwidth (kHz) | Forward: 41 000; Return: 5 200 | | | |
| Overall ($C/N_0$) per user (dB(Hz)) or ($C/N$) (dB) | 4 dB ($E_b/N_0$) | | | |
| Uplink e.i.r.p./carrier (dBW) | 63.8[1] 68[1] (13.75-14 GHz) 35.5[2] | | | |
| Downlink e.i.r.p./carrier (dBW) | 90°: 17.5[2] 4.8[1] | 75°: 19.7[2] 7.1[1] | 50°: 21.2[2] 8.6[1] | 32°: 23.1[2] 10.2[1] |
| Type of satellite transponder | Transparent | | | |
| 5. *Satellite antenna parameters* | | | | |
| Tx maximum gain (dBi) | 90°: 17.2 | 75°: 19.8 | 50°: 21.7[2] | 32°: 23 |
| Rx maximum gain (dBi) | 90°: 16.9 | 75°: 19.5 | 50°: 21.4 | 32°: 22.7 |
| Main lobes | – | | | |
| Side lobes | – | | | |
| Back lobes | – | | | |
| Steerable antenna or not | Yes+ | | | |
| 6. *Earth station antenna parameters* | | | | |
| Peak Tx gain (dBi) | 51.6[1] | 54.1[1] (13.75-14 GHz) | | 33[2] |
| Peak Rx gain (dBi) | 50.5[1] | 53[1] (13.75-14 GHz) | | 31.8[2] |
| Radiation pattern | Rec. ITU-R S.580 | Rec. ITU-R S.580 | | – |
| Minimum operating elevation angle (degrees) | 5 | 5 | | 10 |
| 7. *No. of earth stations and distribution* | Up to 20 million | | | |
| 8. *Earth station switching strategy* | Track best elevation satellite within the operating range | | | |

(1) Feeder link/gateway.

(2) Service link/user station.

TABLE 10

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

**a) Orbital parameters**

The satellites are distributed between two types of plane, as shown in the following table:

| | |
|---|---|
| Number of plane | 161 |
| Number of satellites per plane | 1 |
| Right ascension node (degrees) | $0 + 1\,315\ i$ for $i = 0\text{-}160$ |
| Altitude (km) | 1 675 |
| Eccentricity | 0 |
| Inclination (degrees) | 87 1133 |

**b) Communications parameters**

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

ANNEX 6

TABLE 11

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

| | FS MSS | FL FSS | FSS |
|---|---|---|---|
| 1. *Orbital parameters* | | | |
| Shape of orbit | | Circular | |
| Height (km) | | 1 500 | |
| Inclination angle (degrees) | | 74 | |
| Satellites per plane | | 12 | |
| No. of orbital planes | | 4 | |
| Satellite separation within plane (degrees) | | 30 | |
| Satellite phasing between planes (degrees) | | 90 | |
| 2. *Targeted frequency range and polarization* | | | |
| Uplink frequency (GHz) | 19.3-19.6 | 28.6-29.1 | 28.6-29.1 |
| Uplink polarization | LHCP | LHCP | LHCP |
| Downlink frequency (GHz) | 15.45-15.65 | 18.8-19.3 | 18.8-19.3 |
| Downlink polarization | RHCP | RHCP | RHCP |
| 3. *Spectrum required in each direction* (MHz) | 200 | 300 | 200 |
| 4. *Carrier transmission parameters* | | | |
| Receiver bandwidth (kHz) | 48 000 | 64 000 | 32 000 |
| Transmission bandwidth (kHz) | 48 000 | 64 000 | 32 000 |
| Overall $C/N_0$ per user (dB(Hz)) | 46 | 46 | 46 |
| Uplink e.i.r.p./carrier (dBW)<br>Maximum<br>Minimum | <br>67<br>29.6 | <br>63.9<br>28.2 | <br>60.9<br>28.2 |
| Downlink e.i.r.p./carrier (dBW)<br>Maximum<br>Minimum | <br>24.9<br>–3.8 | <br>29.1<br>2.0 | <br>29.7<br>5.6 |
| 5. *Satellite antenna parameters* | | | |
| Tx maximum gain (dBi) | 22 | 30 | 30 |
| Rx maximum gain (dBi) | 22 | 30 | 30 |
| Main, side and back lobes | Fig. 1 | Fig. 2 | Fig. 2 |
| Steerable antenna or not | Yes | Yes | Yes |
| 6. *Earth station antenna parameters* | | | |
| Peak Tx gain (dBi) | 49 | 49 | 45 |
| Peak Rx gain (dBi) | 49 | 49 | 45 |
| Radiation pattern | Fig. 3 | Fig. 4 | Fig. 5 |
| Minimum operating elevation angle (degrees) | 10 | 10 | 10 |
| 7. *Number of earth stations and distribution* | 6 or more | 6 or more | Multiple |
| 8. *Earth station switching strategy* | ≥ minimum elevation angle | | |