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| **US Radiocommunication Sector**  **FACT SHEET** | | | |
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| **Document Title:** Proposal of updates to Report ITU-R SA.2488, *Characteristics to be used for assessing interference to systems operating in the Earth exploration-satellite and meteorological-satellite services, and for conducting sharing studies*. | | | |
| **Authors**  Alfredo Mistichelli  NOAA  Tomasz Wojtaszek  NOAA  Edna Prado  NOAA  Botan Karim  NOAA  Christopher Hough  NOAA  Don Janksy | **Telephone**  240 624-0973  301 456-4574  301 628 5742  248 227-8895  301 323-8212  202 415-1834 | **E-Mail**  [alfredo.mistichelli@noaa.gov](mailto:alfredo.mistichelli@noaa.gov)  [tomasz.wojtaszek@noaa.gov](mailto:tomasz.wojtaszek@noaa.gov)  [edna.prado@noaa.gov](mailto:edna.prado@noaa.gov)  [botan.karim@noaa.gov](mailto:botan.karim@noaa.gov)  [christopher.hough@noaa.gov](mailto:christopher.hough@noaa.gov)  don@jansky-barmat.com | |
| **Purpose:** Propose updates to the EESS and MetSat system characteristics documented in Report ITU-R SA.2488. | | | |
| **Abstract:** WP 7B’s initial liaison statement to WP 5D contained in Document 5D/92 noted that some of the EESS and MetSat systems included in Annex 2 are also included in Report ITU-R SA.2488. However, some of the parameters reflected in the liaison statement are missing or are different from the Report because they are based on ITU filings of operational parameters. Updates to Report ITU-R SA.2488 will ensure consistency with operational parameters from ITU filings and facilitate any necessary sharing studies using this Report. | | | |
| **Fact Sheet Preparer:** Botan Karim, NOAA | | | |

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This contribution includes proposed revisions to Report ITU-R SA.2488-0. The proposed revisions, as highlighted in blue, update EESS and MetSat system characteristics in this Report and provide additional system characteristics. Updates to the Report are based on ITU filings of operational parameters.

**Attachment:** 1

Preliminary draft REVISION OF REPORT ITU-R SA.2488-0

Characteristics to be used for assessing interference to systems operating   
in the Earth exploration-satellite and meteorological-satellite services,   
and for conducting sharing studies

(202X)

**Summary of Revisions**

The revision includes updates to Earth exploration-satellite and meteorological-satellite system characteristics between 7 750 – 7 900 MHz and 8 025 – 8 400 MHz and introduces additional system characteristics.

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# 1 Introduction

This Report contains characteristics of systems, operating in the Earth exploration-satellite service (EESS)[[1]](#footnote-1) and meteorological‑satellite (MetSat) service, to be used to analyse potential interference from and to these systems, to achieve operational compatibility.

The different EESS and MetSat systems have been grouped into three categories according to functionalities of the links and the type of satellite orbits considered. The frequencies relevant to each category are listed below.

1 Space-to-Earth data transmission systems for non-GSO satellites (see § 3)

• 137-138 MHz

• 400.15-401 MHz

• 1 690-1 710 MHz

• 7 750-7 900 MHz

• 8 025-8 400 MHz

• 25.5-27 GHz

2 Raw data downlink and data dissemination systems for GSO satellites (see § 4)

• 1 670-1 698 MHz (space-to-Earth)

• 2 025-2 110 MHz (Earth-to-space)

• 7 450-7 550 MHz (space-to Earth) and 8 175-8 215 MHz (Earth-to-space)

• 25.5-27 GHz (space-to-Earth)

3 Data collection and platform interrogation systems (see § 5):

GSO satellites:

*Data collection systems*

• 401-403 MHz (Earth-to-space)

• 1 670-1 698 MHz (space-to-Earth)

*Interrogation systems*

• 460-470 MHz (space-to-Earth)

• 2 025-2 110 MHz (Earth-to-space)

Non-GSO satellites:

*Data collection systems*

• 401-403 MHz (Earth-to-space)

• 460-470 MHz (space-to-Earth)

• 1 697-1 699 MHz (space-to-Earth)

*Interrogation systems*

• 401-403 MHz (Earth-to-space)

• 460-470 MHz (space-to-Earth)

## 1.1 Description of the fields in the system characteristics tables

The tables in this Report provide data for frequency coordination analyses and contain information about individual EESS and MetSat systems. Tables 1 and 2 provide information on non-GSO and GSO satellite orbits, and Table 3 gives the coordinates for earth station locations. Satellite names are identified by a letter, and ground station names by a number. These are cross-referenced among table entries in the rest of the Report.

Table 5 and higher contain specific information intended for use in interference analysis. For ease of reading, the row elements are described below, following definitions of the EESS and MetSat data links.

EESS-MetSat data links

The definitions for types of EESS-MetSat data links are provided below in consistency with the definitions included in the MetSat Handbook (Section 2.1).

Data links from geostationary MetSat satellites

The raw data gathered by the instruments on-board geostationary MetSat satellites are permanently transmitted to a primary ground station of the operating agency, processed, and distributed to various national meteorological centres, to official archives and other users. These links are usually referred to as **raw data downlink or mission data acquisition**.

The processed data are either sent back to the MetSat satellite for re-transmission directly to user stations, referred to as **data dissemination**, or distributed to users by using alternative means of data dissemination, not covered in this Report.

Data links from non-geostationary EESS and/or MetSat satellites

Different to geostationary MetSat satellites, where the satellite is permanently in visibility of its ground stations, the raw data acquired by the instruments on non-geostationary EESS or MetSat satellites have to be gathered and stored on-board the satellite until they can be transmitted to a primary ground station of the operating agency when the satellite passes over such a ground station. These links are referred to as **stored mission data**.

The raw instrument data are then processed by the operating agency and provided to the users by different/various data dissemination mechanisms. To improve the latency of the data, a subset of the data acquired by the instruments are ‘broadcasted’ directly from the satellite and can be received by user stations when the satellite is in the visibility of such a user station which can be located anywhere. Such a service is called **direct read-out**.

Row elements for EESS and MetSat

**Function** – Column header for the operational parameters required to characterize EESS and MetSat services (Recommendation ITU-R SA.1021).

**Satellite** – Name of sending or receiving space station for the data link.

**Earth station** – Name of sending or receiving ground station for a data or communications link.

**Centre frequency** – Either the centre frequency of the transmitted emissions or the centre frequency of a broadband receiver, which is receiving signals from multiple narrowband transmitters.

**Information data rate** – Actual rate of transmitted information before any coding; the information data rate should be applied to the performance criterion.

**Necessary bandwidth** – From the ITU Radio Regulations No. **1.152**: “For a given *class of emission*, the width of the frequency band, which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.” Formulas for necessary bandwidths are found in Recommendation ITU-R SM.1138 and Recommendation ITU-R SM.853.

**Modulation** – The format of the signal used to transmit the data.

**Coding** – Name of the method used to code the information.

**Encoded data rate** – Actual symbol rate of the modulated signal, which includes coding. If packetizing and or error correction are used, this is the final bit rate in bits per second (bit/s). If a pseudorandom code is used to create a spread spectrum signal, this is the coding chip rate (cps).

**Minimum elevation angle** – Elevation angle above which the performance parameters are applied.

**Satellite antenna input power** – Power from the transmitter less line losses.

**Satellite antenna type** – Often satellite antennas have special radiation patterns for their function, identifiable by the antenna type.

**Satellite antenna radiation diagram/pattern** – Identity of reference source to get the diagram, formulas or tables to describe the antenna pattern. Details are provided in **Annex A**.

**Satellite antenna gain at nadir** – Peak gain on low-Earth-orbiting satellites is often optimized for some off-nadir angle, so the nadir gain is provided here. In cases where the spacecraft antenna is steerable, this value is variable and not relevant.

**Satellite antenna gain maximum gain** – This is the maximum gain, which may not occur at nadir. For low earth orbiting stations this may occur at angles where the earth station antenna’s elevation angle is low.

**Satellite antenna polarization** – The entries should specify whether the antenna polarization is linear or circular and whether dual polarization is used. In addition, the polarization direction should be included. For linearly polarized antennas, for example, it may be north to south (Linear N/S) or east to west (Linear E/W). For circularly polarized antennas it is either right hand circular (RHCP) or left hand circular (LHCP) or both.

**Earth station antenna diameter** – This assumes a parabolic dish antenna and can be used to calculate antenna gain.

**Earth station antenna gain toward satellite** – This is the maximum gain of the earth station antenna that is aimed toward the companion satellite.

**Earth station antenna polarization** – Does not necessarily match the satellite antenna.

**Earth station antenna radiation diagram/pattern** – Details are provided in Annex A.

**Earth station receiver noise temperature** – System noise includes the noise temperatures of the antenna, the receiver and the loss between the receiver and the feed expressed in degrees Kelvin (K).

## 1.2 Relevant ITU-R Recommendations SA-series

A complete description of EESS and MetSat systems can be found in the following ITU-R Handbooks:

– Handbook of [Earth Exploration-Satellite Service](https://www.itu.int/pub/publications.aspx?lang=en&parent=R-HDB-56) (2011).

– Handbook on the [Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction](https://www.itu.int/pub/publications.aspx?lang=en&parent=R-HDB-45) (2017).

The **interference criteria** to be used for studies involving different types of EESS and MetSat systems can be found in the following ITU-R Recommendations:

TABLE 1

ITU-R Recommendations providing interference criteria for EESS and MetSat services

|  |  |
| --- | --- |
| Rec. ITU-R | Topics addressed in the Recommendation |
| SA.514 | Interference criteria for command and data transmission systems |
| SA.1026 | Aggregate interference criteria for space-to-Earth data transmission systems using low-Earth satellites |
| SA.1027 | Sharing criteria for space-to-Earth data transmission systems using low‑Earth satellites |
| SA.1160 | Interference criteria for data dissemination and direct data readout systems using GSO satellites |
| SA.1161 | Sharing and coordination criteria for data dissemination and direct data readout systems using GSO orbit |
| SA.1163 | Interference criteria for service links in data collection systems |
| SA.1164 | Sharing and coordination criteria for service links in data collection systems |
|  | **Recommendations for specific bands** |
| SA.1258 | Sharing of the frequency band 401-403 MHz between the MetSat, EESS and MetAid services |
| SA.1277 | Sharing in the 8 025-8 400 MHz frequency band between the EESS, FS, FSS, MetSat and MS |
| SA.1745 | Use of the band 1 668.4-1 710 MHz by the meteorological aids service and meteorological-satellite service (space-to-Earth) |
| SA.1807 | System characteristics and interference criteria for MetSat systems operating around 18 GHz |
| SA.2044 | Protection criteria for non-GSO data collection platforms in the band 401‑403 MHz |

The **performance objectives** of the EESS and MetSat systems are prerequisites for the establishment of the associated interference criteria, and are provided in the following ITU-R Recommendations:

TABLE 2

ITU-R Recommendations providing performance objectives for EESS and MetSat services

|  |  |
| --- | --- |
| Rec. ITU-R | Topics addressed in the Recommendation |
| SA.1159 | Performance criteria for data dissemination, data collection and direct data readout systems in EESS and MetSat services |
| SA.1627 | Telecommunication requirements and characteristics of data collection and platform location systems |

Finally, the **methodologies** for determining the above interference and performance criteria in the EESS and MetSat services can be found in the following ITU-R Recommendations:

TABLE 3

ITU-R Recommendations providing methodologies for determining the interference and performance criteria for EESS and MetSat services

|  |  |
| --- | --- |
| Rec. ITU-R | Topics addressed in the Recommendation |
| SA.1020 | Hypothetical reference system for the EESS and MetSat services |
| SA.1021 | Methodology for determining performance objectives for systems in the EESS and MetSat services |
| SA.1022 | Methodology for determining interference criteria for systems in the EESS and MetSat services |
| SA.1023 | Methodology for determining sharing and coordination criteria for systems in the EESS and MetSat services |

# 2 Satellite orbit parameters and earth station locations

Table 4 provides a typical range of orbit parameters for current and future MetSat/EESS non-GSO satellites that use the frequency bands given in § 3 and in a portion of § 5 of this Report. Most satellites in Table 4 are in sun‑synchronous orbits. The purpose of the Table is to provide orbit information needed for conducting dynamic simulations.

TABLE 4

Typical Non-GSO satellite orbit parameters

| Non-GSO satellite name | Orbit altitude (km) | Inclination (degrees) | Longitude ascending node (degrees) or local time of equatorial crossing  (if in sun synchronous orbit) |
| --- | --- | --- | --- |
| Polar orbit (sun-synchronous) | About 400 to 870 | Close to 97° / 98° (linked to orbit altitude) | Systems specific |
| Other types of circular orbits (e.g. $ISS, Jason, …) | 400 to 1 336 | System specific | Systems specific |
| Other types of orbits (e.g. Highly elliptical, …) | System specific | Systems specific | System specific |

Detailed description of some of the corresponding non-GSO systems are given in Annex B.

Orbital parameters of current and future MetSat/EESS GSO satellites that use the frequency bands given in § 4 and in a portion of § 5 of this Report only relate to the longitudes of systems on the geostationary orbit.

Detailed description of some of the corresponding GSO systems are given in Annex B.

Finally, Annex B also provides a list of locations of representative specific earth stations and their locations that use the frequency bands given in §§ 3, 4 and 5.

It should be noted that all elements provided in Annex B (non-GSO, GSO systems and earth stations) are only a subset and cannot be taken as exhaustive.

# 3 Space-to-Earth data transmission systems for non-GSO satellites

This section provides the RF parameters needed to conduct interference assessments and sharing studies for space-to-Earth data transmission from typical non-GSO satellites. The information sent via these downlinks originate from instruments on the spacecraft.

## 3.1 137-138 MHz

The 137-138 MHz frequency band has a long history of providing data to private users using simple inexpensive receivers and data reading systems.

The Automatic Picture Transmission (APT) service continuously broadcasts low-resolution analogue data worldwide in this band from optical sensors. One sensor provides visible APT imagery during daylight, and another provides infrared imagery both day and night. The APT signal is transmitted continuously and can be received in real time by relatively unsophisticated, inexpensive ground station equipment while the satellite is within radio range. Thousands of APT receiving stations are in operation worldwide.

In contrast, the TIROS Information Processor (TIP) and the Low-Resolution Picture Transmission (LRPT) services using this band are digital. TIP provides low-resolution data from microwave sensors to users who do not intend to install the more complex equipment necessary to receive high‑resolution data. TIP multiplexes this data with that from other services and transmits it as an 8.32 kbit/s split phase signal. The LRPT service is envisaged for gradually replacing the APT service.

The LRPT data is Nyquist-filtered to minimize inter-symbol interference and coded to reduce its vulnerability to interference and noise. Table 5 lists some typical characteristics for non-GSO MetSat data dissemination systems in the frequency band 137-138 MHz.

TABLE 5

Non-GSO MetSat space-to-Earth parameters for data dissemination   
systems in the frequency band 137-138 MHz

| Function | APT | | TIP | LRPT |
| --- | --- | --- | --- | --- |
| Satellite | Satellites A and D | Satellite B | Satellite D | Satellite B |
| Earth station(s) | Worldwide |  | Stations 1 and 2 | Stations 13, 14 and 15 |
| Centre frequency (MHz) | A(137.5 and 137.62) D(137.1 and 137.9125 | 137.5 | 137.35 and 137.77 | 137.1 and 137.9125 |
| Information data rate (Mbits/s) | 0.038 | 0.0107 | 0.00832 | 0.144 |
| Necessary bandwidth (MHz) | 0.038 | 0.0568 | 0.046 | 0.144 |
| Modulation | Analogue FM-carrier AM 2.4 kHz subcarrier | FM | PM ± 67 deg. | QPSK |
| Coding | None | None | None | None |
| Encoded data rate |  |  |  |  |
| Minimum elevation angle (degree) | 25 | 5 | 25 | 5 |
| Satellite antenna input power (dBW) | 4.9 | 4 | −2.5 | 5 |
| Satellite antenna type | Quadrifilar Helix | Whip | Dipole | Whip |

TABLE 5 (*end*)

| Function | APT | | TIP | LRPT |
| --- | --- | --- | --- | --- |
| Satellite antenna radiation diagram | 3.7 dBi at nadir −0.25 dBi at horizon | see Fig. 1 | 5.8 dBi at nadir −6.0 dBi at horizon | see Fig. 1 |
| Satellite antenna gain at nadir (dBi) | 3.7 | 4 | 5.8 | 4 |
| Satellite antenna maximum gain (dBi) | 3.7 | 4 | 5.8 | 4 |
| Satellite antenna polarization | RHCP | RHCP | Linear | RHCP |
| Satellite antenna diameter (m) |  | 0.55 |  | 0.55 |
| Earth station antenna gain (dBi) | 2 (low-gain) 10 (high-gain) | 2.5 | 49.6 | 0 (low–gain) 10 (high-gain) |
| Earth station antenna polarization | RHCP | RHCP | Linear | RHCP |
| Earth station antenna radiation diagram | Crossed dipole or high gain Yagi | Rec. ITU-R S.580-6 | AP 7 Annex 3 | Crossed dipole or high gain Yagi |
| Earth station receiver noise temperature (K) | 1 000 | 450 | 300 | 300 |

Figure 1

Satellite antenna radiation diagram for Satellite B

Chart

Description automatically generated

## 3.2 400.15-401 MHz

The MetSat service has a primary allocation in the 400.15-401 MHz frequency band in the space‑to‑Earth direction and is currently used by non-geostationary satellites. Typical MetSat characteristics for this band are listed in Table 6. These characteristics are derived from Table 2 of Recommendation ITU-R SA.1026.

TABLE 6

Non-GSO MetSat space-to-Earth parameters for data dissemination systems   
in the band 400.15-401 MHz

|  |  |
| --- | --- |
| Function | MetSat |
| Satellite | Satellite Y |
| Centre frequency (MHz) | 400.15-401 |
| Information data rate (dB/Hz) | 49.5 |
| Necessary bandwidth (kHz) | 177.5 |
| Minimum elevation angle (degree) | 5 and 13 |
| Satellite antenna input power (dBW) | 11.1 |
| Satellite antenna gain at nadir (dBi) | 0.0 |
| Satellite antenna maximum gain (dBi) | 0.0 |
| Earth station antenna gain (dBi) | 0.0 |
| Polarization mismatch loss (dB) | 0.3 |
| Earth station antenna radiation diagram | Omni-directional (non‑tracking) |
| Earth station receiver noise temperature (K) | 400 |

## 3.3 1 690-1 710 MHz

These services provide real time data and images directly to the user customer. The High Rate Picture Transmission (HRPT) service has been a major source of high quality data from polar‑orbiting meteorological satellites at user stations throughout the world. HRPT transmitters operate continuously and data can be received by any user station. Hundreds of HRPT receiving stations worldwide are registered with the World Meteorological Organization (WMO). The data stream contains full resolution images in digital format from optical instruments as well as atmospheric information from a suite of sounding instruments. Through HRPT reception, the user site acquires data from three or more consecutive overpasses twice each day from each satellite, giving high-resolution data coverage of a region extending about 1 500 km radius from the user station. These are stored mission data systems when specific earth stations are indicated. Some typical characteristics for non-GSO MetSat direct readout systems in this band are found below in Tables 7 and 8 and typical characteristics for stored mission data in this band are found in Table 9.

TABLE 7

Non-GSO MetSat Space-to-Earth parameters for direct readout systems   
in the band 1 690-1 710 MHz

| Function | CHRPT | AHRPT | HRPT |
| --- | --- | --- | --- |
| Satellite | Satellite E and G | Satellite F | Satellite B |
| Earth station(s) | Various locations | | Russian territory |
| Carrier frequency (MHz) | 1 704.5 | 1 701.3 & 1 707 | 1 700 and 1 705 |
| Information Data rate (Mbits/s) | 4.2 | 3.5 | 1.33 |
| Necessary bandwidth (MHz) |  | 4.5 | 3 |
| Modulation | QPSK | QPSK | QPSK |
| Coding | Convolutional | Convolutional | Uncoded |
| Encoded data rate |  |  |  |
| Minimum elevation angle (degree) | 5 | 5 | 5 |
| Satellite antenna input power (dBW) | 10.5 | 6 | 9 |
| Satellite antenna type |  | Quadrifilar helix | Spiral |
| Satellite antenna radiation pattern |  |  | see Fig. 2 |
| Satellite antenna gain at nadir (dBi) |  |  | −7 |
| Satellite antenna maximum gain (dBi) |  | −4.5 | 4 |
| Satellite antenna polarization | RHCP | RHCP | RHCP |
| Earth station antenna diameter (m) |  | 1.8 | 7 3.7 1.5 |
| Earth station antenna gain toward satellite (dBi) | 30 | 28 | 40.0 34.0 26.0 |
| Earth station antenna polarization | RHCP | RHCP | RHCP |
| Earth station antenna radiation diagram | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 |
| Earth station receiver noise  temperature (K) | 280 | 200 | 150/200 |

TABLE 8

Non-GSO MetSat Space-to-Earth parameters for direct readout systems   
in the band 1 690-1 710 MHz

| Function | LRPT | Direct Data Broadcast  (DDB) | Direct Readout |
| --- | --- | --- | --- |
| Satellite | Satellite BF | Satellite BG  (Constellation of 8 to 16 satellites) | Satellites A and D |
| Earth station(s) | Stations 13, 14 and 15 | Worldwide | Stations 1 & 2 User stations |
| Carrier frequency (MHz) | 1703 | 1 701.3 or 1 707 | 1 698, 1 702.5 or 1 707 |
| Information data rate (Mbits/s) | 0.005 | 0.130 | 2.66 NRZ or 0.322 split phase |
| Necessary bandwidth (MHz) | 0.02 | 0.127 | 5.34 |
| Modulation | BPSK | QPSK | PM ±67 deg. |
| Coding | None | RS (255, 223) | None |
| Encoded data rate (Mbits/s) |  | 0.149 |  |
| Minimum elevation angle (degree) | 5 | 5 | 5 |
| Satellite antenna input power (dBW) | −4 | 6 | 8 |
| Satellite antenna type | Spiral |  | Quadrifilar helix |
| Satellite antenna radiation diagram/pattern | see Fig. 3 | Isoflux | Isoflux |
| Satellite antenna gain at nadir (dBi) | 16.2 | 0 | −10 |
| Satellite antenna maximum gain (dBi) | 16.2 | 0 | 0 dBi at ±60 degrees |
| Satellite antenna polarization | RHCP | RHCP | RHCP |
| Earth station antenna diameter (m) | 2.4 | 3 | 13 (stations 1  and 2)  1.2 (User stations) |
| Earth station antenna gain toward satellite (dBi) | 30 | 32 | 46.8 dBi (13 m)  24 dBi (1.2 m) |
| Earth station antenna polarization | RHCP | RHCP | RHCP |
| Earth station antenna radiation diagram/pattern | Rec. ITU-R S.580-5 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 |
| Earth station receiver noise  temperature (K) | 200 | 200 | 290 |

Figure 2

Satellite antenna radiation diagram for Satellite B

Diagram

Description automatically generated

NOTE – Typical non-GSO simple antenna radiation diagram to meet PFD requirements.

Figure 3

Satellite antenna radiation diagram for Satellite BF

Chart

Description automatically generated

TABLE 9

Non-GSO MetSat space-to-Earth parameters for Stored Mission Data systems   
in the band 1 690-1 710 MHz

| Function | Low rate data | Stored mission data |
| --- | --- | --- |
| Satellite | Satellite Y | Satellite BG  (Constellation of 8 to 16 satellites) |
| Earth station(s) | Worldwide | Station 5 and 18 |
| Carrier frequency (MHz) | 1 703 | 1 701.3 or 1 707 |
| Information data rate (Mbits/s) | 1.8 (max) | 1.53 |
| Necessary bandwidth (MHz) | 1.80 | 5.1 |
| Modulation | QPSK | QPSK |
| Coding | None | Concat.RS+Conv (1/2, 7) |
| Encoded data rate (Mbits/s) |  | 3.5 |
| Minimum elevation angle (degree) | 5 | 5 |
| Satellite antenna input power (dBW) | 7.6 | 6 |
| Satellite antenna type | Helix |  |
| Satellite antenna radiation diagram/pattern | Isoflux | Isoflux |
| Satellite antenna gain at nadir (dBi) | 7.3 | 0 |
| Satellite antenna maximum gain (dBi) | 7.3 | 0 |
| Satellite antenna polarization | RHCP | RHCP |

TABLE 9 (*end*)

| Function | Low rate data | Stored mission data |
| --- | --- | --- |
| Earth station antenna diameter (m) | 13 | Station 2: 1.8  Station 5: Digital Beamforming Network (DBFN) antenna |
| Earth station antenna gain toward satellite (dBi) | 47 | 28 |
| Earth station antenna polarization | RHCP | RHCP |
| Earth station antenna radiation diagram/pattern | Rec. ITU-R S.465-6 | Rec. ITU-R S.465‑6 |
| Earth station receiver noise temperature (K) | 290 | 290 |

## 3.4 7 750-7 900 MHz

Space-to-Earth parameters for systems in the frequency band 7 750-7 900 MHz are found in Table 10. Non‑geostationary (usually polar orbiting) MetSat systems use this band for two modes of data distribution:

– Raw data transmissions to dedicated earth stations usually located at high latitudes, labelled in Table 10 as “Stored Mission Data”. Transmissions take place in bursts as each satellite overpasses its station, with the transmitters switched off at other times.

– Continuous transmission of real time data to any ground station within line-of-sight, labelled in Table 10 as “Direct Readout”.

TABLE 10

Non-GSO MetSat space-to-Earth parameters for systems in the band 7 750-7 900 MHz

| Function | Stored mission data | | Direct readout | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Satellite | Satellite F | Satellites E and G | Satellites C  and S | Satellites AN | Satellite BF | Satellite BH |
| Earth station(s) | Station 5 |  | Worldwide | Worldwide | Stations 13, 14 and 15 | Worldwide |
| Carrier frequency (MHz) | 7 800 | 7 780 and 7820 | 7 812 | 7 825 | 7 865 | 7 812 |
| Information data rate (Mbits/s) | 70 | 60 | 13 | 80 | 30.7 | 21.8 |
| Necessary bandwidth (MHz) | 63 | 60 | 30 | 150 | 61.4 | 50 |
| Modulation | QPSK | QPSK | QPSK | QPSK | BPSK | OQPSK |
| Coding | Concatenated | Convolutional | Concatenated | Concatenated | None | Concatenated |
| Encoded data rate (Mbits/s) |  | 60 | 30 | 187 | - |  |
| Minimum elevation angle (degree) | 5 | 5 | 5 | 5 | 5 | 5 |
| Satellite antenna input power (dBW) | 6.5 | 14 | 9.6 | 19.4 | 10 | 11.7 |
| Satellite antenna type | Quadrifilar | Quadrifilar | Isoflux | Isoflux | Dish | Isoflux |

TABLE 10 (*end*)

| Function | Stored mission data | | Direct readout | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Satellite antenna radiation diagram | Isoflux | Isoflux | Isoflux | Isoflux | Rec. ITU-R  S.672 | Isoflux |
| Satellite antenna gain at nadir (dBi) |  |  | −2 |  |  |  |
| Satellite antenna maximum gain (dBi) | 6 | 5 | 9.4 | 6.8 | 38 | 6 |
| Satellite antenna polarization | RHCP |  | RHCP | RHCP | RHCP | RHCP |
| Earth station antenna diameter (m) | 10 | 12 | 3 | 3 | 5 | 3 |
| Earth station antenna gain toward satellite (dBi) | 55 | 57.2 | 44.9 | 44.3 | 50 | 44.9 |
| Earth station antenna polarization | RHCP | LHCP and RHCP | RHCP | RHCP | RHCP | RHCP |
| Earth station antenna radiation diagram | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 | Rec. ITU-R S.580 | Rec. ITU-R S.465-6 |
| Earth station receiver noise temperature (K) | 180 | 176 | 343 | 252 | 150 | 343 |

## 3.5 8 025-8 400 MHz

Functions in this band are similar to those of the 7 750-7 900 MHz band, i.e. transmission of direct readout data and of recorded data acquisition (stored mission data).

The band 8 025‑8 400 MHz is very heavily used by EESS payload data downlink, with more than 130 systems in operation (many of them involving multiple satellites) and this number is still increasing. The higher bandwidth available (375 MHz total) makes this band attractive to download stored mission data that requires data rates around 100 megabits/second and higher and is used by most Earth observation missions involving high‑resolution imaging or large instrument ensembles. Typically, the transmissions take place in bursts as each satellite overpasses its receiving station, with the transmitters switched off at other times.

Direct readout systems, typically requiring 15 to 20 Mbit/s, are also currently using this band. Direct readout systems typically maintain the transmitter on continuously.

Table 11 provides typical range of systems characteristics for both **stored mission data** and **direct read-out** applications.

Detailed description of some of the corresponding non-GSO systems are given in Annex C but cannot be taken as exhaustive.

TABLE 11

Typical system parameters for direct read-out and stored Mission Data services   
in the band 8 025-8 400 MHz

| Typical range of non‑GSO EESS space-to-Earth parameters for systems in the band 8 025‑8 400 MHz | Direct readout | Direct readout and stored mission data | Stored mission data |
| --- | --- | --- | --- |
| Earth station(s) | Specific, country territory or worldwide | Specific, country territory or worldwide | Specific |
| Carrier frequency (MHz) | Single or multiple frequency within the 8 025-8 400 MHz band | Single or multiple frequency within the 8 025-8 400 MHz band | Single or multiple frequency within the 8 025-8 400 MHz band |
| Information data rate (Mbits/s) | 3 to 320 | 60 to 300 | 4 to 800 |
| Necessary bandwidth (MHz) | 30 to 350 | 60 to 123 | 15 to 375 |
| Modulation and coding information | System specific  (see Annex C) | System specific  (see Annex C) | System specific  (see Annex C) |
| Minimum elevation angle (degree) | 5 | 5 | 5 |
| Satellite antenna input power (dBW) | 3 to 24 | 3 to 11 | 3.5 to 17 |
| Satellite antenna radiation diagram | Isoflux, Directional or specific | Isoflux, or steerable | Isoflux, Directional or horn |
| Satellite antenna gain at nadir (dBi) | −6 to 25 | −3.5 to 4 | −6 to 25 |
| Satellite antenna maximum gain (dBi) | 6 to 25 | 6.5 to 27.5 | 1 to 26 |
| Satellite antenna polarization | RHCP, LHCP or both | RHCP, LHCP or both | RHCP, LHCP or both |
| Earth station antenna gain toward satellite (dBi) | 41 to 57.6 | 48 to 53 | 54 to 60 |
| Earth station antenna polarization | RHCP, LHCP or both | RHCP, LHCP or both | RHCP, LHCP or both |
| Earth station antenna radiation diagram | Rec. ITU-R S.465 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 |
| Earth station receiver noise temperature (K) | 90 to 280 | 120 to 150 | 100 to 470 |
| Typical Orbital altitude (km) | 700 | 700 | 700 |
| Typical inclination angle (degree) | 98.2 | 98.2 | 98.2 |

## 3.6 25.5-27 GHz

The frequency band 25.5-27 GHz is used by systems with bandwidth requirements for raw data transmission and stored mission data exceeding the spectrum capacities provided in the bands 7 750-7 900 MHz and/or 8 025-8 400 MHz or which would face incompatibility with existing systems in those bands due to congestion/saturation. The characteristics for these systems can be found below in TABLE 12.

TABLE 12

System parameters for Stored Mission Data services in the band 25.5-27 GHz

| Function | Stored Mission Data | | | |
| --- | --- | --- | --- | --- |
| Satellite | Satellite C and other LEO Earth Observing Satellites | Satellites AN | Satellite AP (Generic) | Satellite AZ and other commercial LEO (Generic) |
| Earth stations | Stations 2, 4, 5, 18 and 63 | Stations 4 and 5 | Stations 5 and 18  Earth Stations in Central Europe (Generic) | Station 5, 6 and 18 Earth Stations worldwide  (Generic) |
| Carrier frequency (MHz) | 26 703.4 | 26 295 and 26 700 | 26 000 | 25 875 and 26 625 |
| Information data rate (Mbits/s) | 130 | 390.5 | 1 700 | Up to 1900 Mbit/s per channel (average VCM) one channel  @ 500 Msps)  (total: Up to 4 channels with frequency and polarization reuse) |
| Necessary bandwidth (MHz) | 300 | 2 × 366 MHz | 680 | 2 × 750 MHz |
| Modulation | SOQPSK-TG Shaped offset Quadrature PSK | OQPSK | 16/32-APSK | VCM (multiple modulations up to 64‑APSK) |
| Coding | Concatenated | RS (255,223) | SCCC | SCCC |
| Encoded data rate (Mbits/s) | 300 |  | up to 2 000 | Up to 2 000 (VCM dependant) |
| Minimum elevation angle (degree) | 5 | 5 | 5 | 5 |
| Satellite antenna input power (dBW) | 6.0 | 14.8 per carrier | 10.4 | 15 |
| Satellite antenna type | Steerable Parabolic | Steerable Parabolic | Steerable Parabolic | Steerable Parabolic |
| Satellite antenna radiation pattern | Pencil Beam | Pencil Beam | Pencil Beam | Pencil Beam |
| Satellite antenna gain toward nadir (dBi) | Varies with antenna pointing | Varies with antenna pointing | Varies with antenna pointing | Varies with antenna pointing |
| Satellite antenna maximum antenna gain (dBi) | 39.0 | 33.3 | 32 | 32 |
| Satellite antenna polarization | RHCP | RHCP | Circular | RHCP/LHCP |
| Earth station antenna diameter (m) | Station 2: 4 and 11.3  Station 4: 4  Station 5: 4, 7.3 and 11.3  Station 18: 7.3 Station 63: 11.3 | Station 4: 4  Station 5: 7.3 | Station 5: 4  Station 18: 7.3  Generic Station: 6.4 | Station 4: 4  Station 5: 6.4  Station 18: 7.3  Generic Station: 3 |

TABLE 12 (*end*)

| Function | Stored Mission Data | | | |
| --- | --- | --- | --- | --- |
| Earth station antenna gain toward satellite (dBi) | 55.4 dBi (4 m)  64.5 dBi (7.3 m)  67 dBi (11.3 m) | 55.4 dBi (4 m)  65 dBi (7.3m) | 55.4 dBi (4 m)  64.5 dBi (7.3 m) 63.1 dBi (6.4 m) | 55 dBi (3 m)  55.4 dBi (4 m)  63 dBi (6.4 m)  64.5 dBi (7.3 m) |
| Earth station antenna polarization | RHCP | RHCP | Circular | RHCP |
| Earth station antenna radiation diagram | Rec. ITU-R S.465-6 | Rec. ITU-R S.465‑6 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465‑6 |
| Earth station receiver noise temperature (K) | 363 | 395 | 363 | 395 |

# 4 Raw data downlink and data dissemination systems for GSO satellites

This section provides the RF parameters needed to conduct interference assessments and sharing studies for raw data downlink anddata dissemination for GSO satellite systems. The low and high data rate processed information is up‑linked to satellites in the 2 025-2 110 MHz band, and relayed, along with interfering signals entering the satellite in the same band, to the earth station receivers in the band 1 670-1 698 MHz via fixed-gain satellite transponders.

The ever-increasing bandwidth for raw data transmission requires gradual migration from the band 1 670-1 698 MHz to higher frequency bands (7 450‑7 550 MHz, 8 025-8 400 MHz, 18.1‑18.4 GHz (Regions 1 and 3), 18.0-18.3 GHz (Region 2) and 25.5-27 GHz). Recommendation ITU-R SA.1024-1 provides some guidance for band selection for the Earth exploration-satellite service indicating the use of higher bands for higher data rate applications.

## 4.1 1 670-1 698 MHz

The 1 670-1 698 MHz band is used for the downlinking of raw instrument data to specific ground stations of satellite operators. The sub-band 1 690-1 698 MHz is used for broadcasting data to the user. Data transmissions contain low- and high-resolution images including calibration and navigation information. Primary users are national meteorological centres, universities, private forecasters, and television broadcasters. Tables 13, 14, 15 and 16 lists some typical characteristics for systems in this band.

TABLE 13

GSO EESS space-to-Earth raw data downlink and data dissemination   
in the band 1 670-1 698 MHz

| Function | HRIT | | LRIT | | |
| --- | --- | --- | --- | --- | --- |
| Satellite | Satellite O | Satellite P | Satellite M | Satellite O | Satellite P |
| Earth station(s) | High rate user station | High rate user station | Low rate user station |  | Low rate user station |
| Carrier frequency (MHz) | 1 687.1 | 1 681 and 1 679 | 1 691 | 1 691 | 1697 |
| Information data rate (Mbits/s) |  | 11.6 and 9.3 | 0.128 |  | 0.09 |
| Necessary bandwidth (MHz) |  | 12 and 8 | 0.586 |  | 1 |
| Modulation | QPSK | QPSK | BPSK | BPSK | QPSK |
| Coding | Con-catenated | BCH+LDPC | Con-catenated | Con-catenated | BCH+LDPC |
| Encoded data rate (Mbits/s) |  | 7 and 5.6 |  |  | 0.09 |
| Minimum elevation angle (degree) |  | Fixed pointing | Fixed pointing |  | Fixed pointing |
| Satellite antenna input power (dBW) | e.i.r.p. 55 dBm | 13 | 10.2 | e.i.r.p. 55 dBm | 10 |
| Satellite antenna type |  | Planar Cup Dipole |  |
| Satellite antenna radiation pattern | Earth coverage | Earth coverage | Earth coverage |
| Satellite antenna gain at nadir (dBi) | 15.5 | 15.6 | 15.5 |
| Satellite antenna maximum gain (dBi) |  | 15.5 | 15.6 |  | 15.5 |
| Satellite antenna polarization |  | Linear V and H | Linear N/S |  | Linear V |
| Earth station antenna diameter (m) |  | 7.3 | 1 |  | 0.8 |
| Earth station antenna gain toward satellite (dBi) |  | 40 | 22.5 |  | 21 |
| Earth station antenna polarization | RHCP and LHCP | Linear N/S |  | Linear V |
| Earth station antenna radiation diagram | AP7-Annex 3 | AP7-Annex 3 |  | AP7-Annex 3 |
| Earth station receiver noise temperature (K) | 239 | 200 |  | 280 |

TABLE 14

GSO EESS space-to-Earth raw data downlink and data dissemination   
in the band 1 670-1 698 MHz

| Function | Processed data | GVAR | Raw data downlink | |
| --- | --- | --- | --- | --- |
| Satellite | Satellite P | Satellite M | Satellite M | Satellite P |
| Earth station |  | Station 16 | Station 1 | Station 8 |
| Carrier frequency (MHz) | 1 687.5 | 1 685.7 | 1 676.0 | 1 681.6 |
| Information data rate (Mbits/s) | 0.66 | 2.11 | 2.6 | 14 |
| Necessary bandwidth (MHz) |  | 4.22 | 5.2 |  |
| Modulation | DPSK | BPSK | QPSK | QPSK |
| Coding |  | Uncoded | Uncoded | Uncoded |
| Encoded data rate |  |  |  |  |
| Minimum elevation angle (degree) | 2 | 5 | 5 | 2 |
| Satellite antenna input power (dBW) | 10 | 14.5 | 6.9 | 10 |
| Satellite antenna gain at nadir (dBi) | 18.5 | 15.6 | 15.6 | 18.5 |
| Satellite antenna maximum gain (dBi) |  | 15.6 | 15.6 |  |
| Satellite antenna type |  | Planar Cup Dipole | Planar Cup Dipole |  |
| Satellite antenna polarization | Linear  Vertical | Linear N/S | Linear N/S | Linear  Vertical |
| Satellite antenna radiation diagram |  | 1st sidelobe of −6 dBi at 60 degrees | 1st sidelobe of −6 dBi at 60 degrees |  |
| Earth station antenna diameter (m) |  | 9.1 | 16.4 |  |
| Earth station antenna gain toward satellite (dBi) | 31.5 | 40.5 | 48.4 | 48.8 |
| Earth station antenna polarization | Linear  Vertical | Linear | Linear | Linear  Vertical |
| Earth station antenna radiation diagram |  | AP7- Annex 3 | AP7- Annex 3 |  |
| Earth station receiver noise temperature (K) | 80 | 199.5 | 156 | 96 |

TABLE 15

GSO EESS space-to-Earth raw data downlink and data dissemination  
in the band 1 670-1 698 MHz

| Function | GOES Rebroadcast | HRIT/EMWIN | EMWIN |
| --- | --- | --- | --- |
| Satellite | Satellite R | Satellite R | Satellite M |
| Earth station(s) | Various | Various | Ubiquitous user stations |
| Carrier frequency (MHz) | 1 686.6 | 1 694.1 | 1 692.7 |
| Information data rate (Mbits/s) | 15.5 | 0.400 | 0.0192 |
| Necessary bandwidth (MHz) | 9.79 or 10.90 | 1.21 | 0.027 |
| Modulation | QPSK or 8-PSK | QPSK | QPSK |
| Coding | DVB-S2 | Concatenated | Concatenated |
| Encoded data rate (Mbits/s) | 23.48017 or 17.332 | 0.927 |  |
| Minimum elevation angle (degree) | 5 | 5 | 5 |
| Power supplied to the input of satellite antenna (dBW) | 16 | 12.3 | 1.14 |
| Satellite antenna type | Horn | Horn | 15.6 |
| Satellite antenna radiation diagram/pattern | First sidelobe −26.7 dB @ 115 deg. | First sidelobe −2.5 dB @ 52 deg. | 15.6 |
| Satellite antenna gain at nadir (dBi) | 17.2 | 17.3 | Planar Cup Dipole |
| Satellite antenna maximum gain (dBi) | 17.2 | 17.3 | Linear N/S |
| Satellite antenna polarization | Dual RHCP/LHCP | Dual Linear | 1st sidelobe of −6 dBi at 60 degrees |
| Earth station antenna diameter (m) | 4.8 to 9.1 | 1 | 1 |
| Earth station antenna gain toward satellite (dBi) | 36.5 to 40.5 | 22.7 | 22.7 |
| Earth station antenna polarization | Dual RHCP/LHCP | V | Linear |
| Earth station antenna radiation diagram/pattern | First sidelobe  21.5 dBi @ 2.2 deg. | First sidelobe  10.5 dBi @ 20 deg. | AP7- Annex 3 |
| Earth station receiver noise temperature (K) | 150 | 160 | 160 |

TABLE 16

GSO EESS space-to-Earth Raw data downlink and data dissemination   
in the band 1 670-1 698 MHz

| Function | Multi-use Data Link | LRIT | Raw data downlink | LRIT, HRIT, Raw data downlink |
| --- | --- | --- | --- | --- |
| Satellite | Satellite M | Satellite N | Satellite N | Satellite Q |
| Earth station(s) | Stations 1, 21 and 22 | Stations 7 and 12 | Stations 7 & 12 | Stations 13, 14 and 15 |
| Carrier frequency (MHz) | 1 681.478 | 1 691 | 1 686.833 | 1 691.0 and 1 693.0 |
| Information data rate (Mbits/s) | 0.400 | 0.128 | 3.27 | 0.0025 to 1.0 Bandwidth 5 to  1 970 kHz |
| Necessary bandwidth (MHz) | 0.400 | 0.660 | 5.4 |  |
| Modulation | QPSK | BPSK | QPSK | BPSK and QPSK |
| Coding | Uncoded |  |  | Uncoded |
| Encoded data rate (Mbits/s) |  |  |  |  |
| Minimum elevation angle (degree) | 5 |  |  | 5 |
| Power supplied to the input of satellite antenna (dBW) | 8.2 | 8 | 0.9 | 9.7 |
| Satellite antenna type | Planar Cup Dipole |  |  |  |
| Satellite antenna radiation diagram/pattern | 1st sidelobe of −6 dBi at 60 degrees |  |  |  |
| Satellite antenna gain at nadir (dBi) | 15.6 | 13 | 13 | 12 |
| Satellite antenna maximum gain (dBi) | 17.2 |  |  |  |
| Satellite antenna polarization | Linear N/S |  |  | RHCP |
| Earth station antenna diameter (m) | 7.2 | 13 1.5 | 13 | 3.8 1.5 |
| Earth station antenna gain toward satellite (dBi) | 39 | 47.5 and 27.8 | 45.6 | 34.0 26.0 |
| Earth station antenna polarization | Linear |  |  | RHCP |
| Earth station antenna radiation diagram/pattern | AP7-Annex 3 |  |  | Rec. ITU-R S.465-6 |
| Earth station receiver noise temperature (K) | 160 | 135 and 140 | 135 | 150 |

**4.2 2 025-2 110 MHz**

The 2 025-2 110 MHz band is used for processed data uplinks for dissemination to the users. Performance of the composite circuit depends on the performance of each individual link. Characteristics of some typical systems can be found below in Tables 17 and 18.

TABLE 17

GSO MetSat Earth-to-space processed data in the band 2 025-2 110 MHz for data dissemination to the users

| Function | LRIT | Processed data | | EMWIN |
| --- | --- | --- | --- | --- |
| Satellite | Satellite M | Satellite M | Satellite P | Satellite M |
| Earth station(s) | Station 1 | Station 1 | Station 8 | User stations |
| Carrier frequency (MHz) | 2 033.0 | 2 027.7 | 2 047.5 | 2 034.7 |
| Information data rate (Mbits/s) | 0.128 | 2.11 | 1 | 0.0192 |
| Necessary bandwidth (MHz) | 0.586 | 4.22 | 2 | 0.027 |
| Modulation | BPSK | BPSK | QPSK | QPSK |
| Coding | Concatenated | Uncoded |  | Concatenated |
| Encoded data rate (Mbits/s) | 0.293 |  |  | 0.03494 |
| Minimum elevation angle (degree) | 5 | | 2 | 5 |
| Earth station antenna input power (dBW) | 10.4 | 21.2 | 20 | 3 |
| Earth station antenna gain toward satellite (dBi) | 49.5 | 49.5 | 50 | 49.5 |
| Earth station antenna polarization | Linear | Linear | Linear Vertical | Linear |
| Earth station antenna radiation diagram | Recommendation ITU-R S.465-6 | Recommendation ITU-R S.465-6 |  | Recommendation ITU-R S.465-6 |
| Satellite antenna gain (dBi) | 17 | 17 | 18.5 | 17 |
| Satellite antenna polarization | Linear (N/S) | Linear (N/S) | Linear  Vertical | Linear (N/S) |
| Satellite antenna radiation diagram | 1st sidelobe of  −13 dBi at 40 deg. | 1st sidelobe of  −13 dBi at 40 deg. |  | 1st sidelobe of −13 dBi at 40 deg. |
| Satellite receiver noise temperature (K) | 588 | 588 |  | 588 |

TABLE 18

GSO MetSat Earth-to-space processed data in the band 2 025-2 110 MHz for data dissemination to the users

| Function | HRIT/EMWIN | LRIT | | |
| --- | --- | --- | --- | --- |
| Satellite | Satellite R | Satellite N | Satellite P | Satellite P |
| Earth station | Stations 1 and 3 | Stations 7 and 12 | Stations 8 and 9 | |
| Carrier frequency (MHz) | 2 027.1 | 2 101.5 | 2 051 | 2 057 |
| Data rate (Mbits/s) | 0.400 | 0.128 |  | 0.256 |
| Necessary bandwidth (MHz) | 1.21 | 0.660 |  | |
| Modulation | PSK | QPSK | QPSK | |
| Coding | Concatenated |  | FEC | |
| Encoded data rate (Mbits/s) | 0.927 |  |  | |
| Minimum elevation angle (degree) | 5 |  | 2 |  |
| Earth station antenna input power (dBW) | 18.8 | 20 and 17 | 20 | 21 |
| Earth station antenna gain toward satellite (dBi) | 49.6 | 47.5 | 50 | 46 |
| Earth station antenna polarization | RHCP |  | Linear Vertical | CR |
| Earth station antenna radiation diagram | ITU-R S.465-6 |  |  | AP7-Annex 3 |
| Satellite antenna gain (dBi) | 17.3 | 3 | 18.5 | 13 |
| Satellite antenna polarization | RHCP |  | Linear Vertical |  |
| Satellite antenna radiation diagram | 1st sidelobe of  0.5 dBi at 38 deg. |  |  |  |
| Satellite receiver noise temperature (K) | 1 007 | 700 |  |  |

## 4.3 7 450-7 550 MHz and 8 175-8 215 MHz

The band 7 450-7 550 MHz is used for raw and processed data downlink (for dissemination to user stations) or specific ground stations of the satellite operator. The band 8 175-8 215 MHz is used for the uplink of processed data for dissemination to user stations. The characteristics for typical system in these bands are listed in Table 19.

TABLE 19

GSO MetSat for uplinking of processed data and data dissemination of to the users in the frequency bands 7 450-7 550 and 8 175-8 215 MHz

| Function | High rate data relay | | АРТ | High rate data relay | HRIT |
| --- | --- | --- | --- | --- | --- |
| Satellite | Satellite Q | | | Satellite P | |
| Earth station | Stations 13, 14 and 15 | | | Stations 8 and 9 | |
| Carrier frequency (MHz) | 7 475 (transmit) | 8 195 (receive) | 7 500 (transmit) | 7 500 (transmit) | 8 185 and 8 205 (receive) |
| Transmit (receive) data rate (Mbits/s) | 5.12; 30.72 | 0.331; 0.663; 1.31; 1.97; 5.12; 30.72 | 61.44 |  |  |
| Necessary bandwidth (MHz) |  |  |  |  |  |
| Modulation | ВPSK | PSK; QPSK | ВPSK | GMSK | QPSK |
| Coding | None | None | None | LDPC | LDPC |
| Encoded data rate |  |  |  |  |  |
| Satellite antenna input power (dBW) | 9.5 | - | 9.5 | 17 | 13 |
| Satellite antenna gain toward ES (dBi) | 36 | 36 | 36 | 30 | 30 |
| Satellite antenna polarization | Circular, CR | Circular, CL | Circular, CR | CL and CR | CR |
| Satellite antenna radiation diagram | Recommendation ITU-R S.672 | | |  |  |
| Earth station antenna gain toward satellite (dBi) | 47 (3.8 m) 50 (5 m) | 48 (3.8 m) 50 (5 m) | 47 (3.8 m) 50 (5 m) | 59 (13 m) | |
| Earth station antenna polarization | LHCP | LHCP | RHCP | LHCP & RHCP | RHCP |
| Earth station antenna radiation diagram | Recommendation ITU-R S.465-6 | | | AP7-Annex 3 | AP7-Annex 3 |
| Earth station receiver noise temperature (K) | 150 | | | 270 | 270 |
| Minimum elevation angle (degree) | 3 | | |  |  |

**4.4 8 025-8 400 MHz**

The band 8 025-8 400 MHz is used for raw data downlink to specific ground stations of the satellite operator. The characteristics for typical system in these bands are listed in Table 20.

TABLE 20

GSO EESS space-to-Earth raw data in the frequency bands 8 025-8 400 MHz

| Function | Raw Data Downlink:  Continuous real-time data feed |
| --- | --- |
| Satellite | Satellite R |
| Earth station(s) | Stations 1 and 3 |
| Carrier frequency (MHz) | 8 220 |
| Information data rate (Mbits/s) | 105 |
| Necessary bandwidth (MHz) | 130 |
| Modulation | QPSK |
| Coding | LDPC rate 7/8 |
| Encoded data rate (Mbits/s) | 130 |
| Minimum elevation angle (degree) | Fixed Pointing |
| Satellite antenna input power (dBW) | 10 |
| Satellite antenna radiation diagram/pattern | First sidelobe 9.9 dBi @ 4.5 deg. |
| Satellite antenna gain at nadir (dBi) | 0 dBi to −5 dBi |
| Satellite antenna maximum gain (dBi) | 35.9 |
| Satellite antenna polarization | Dual Linear |
| Earth station antenna diameter (m) | 16.4 |
| Earth station antenna gain toward satellite (dBi) | 61 |
| Earth station antenna polarization | Dual Linear |
| Earth station antenna radiation diagram/pattern | Rec. ITU-R S.465-6 |
| Earth station receiver noise temperature (K) | 150 |

## 4.5 25.5-27 GHz

The band 25.5-27 GHz is used by systems with bandwidth requirements for raw data transmission and stored mission data exceeding the spectrum capacities provided in the bands 7 750-7 900 MHz and/or 8 025-8 400 MHz or which would face incompatibility with existing systems in those bands due to congestion/saturation. Table 21 includes some typical characteristics for these systems. The mission data acquisition systems below are different from the non-GSO SMD 25.5-27.0 GHz systems in Section 3.6 because they do not require recorded data playback or recorded data acquisition where reception of data that has been collected and stored on the spacecraft and transmitted upon command. The systems in this section are in view of their associated ground stations almost all the time.

TABLE 21

GSO EESS space-to-Earth raw data downlink in the band 25.5-27 GHz

|  |  |  |  |
| --- | --- | --- | --- |
| Function | Mission Data Acquisition (MDA) | | |
| Satellite | Satellite AK | Satellite AL | Satellite P |
| Earth station(s) | Station 17 | Stations 35 and 36 | Stations 8 and 66 |
| Carrier frequency (MHz) | 26 500 | 26 360 and 26 760 | 26 600 |
| Information data rate (Mbits/s) | 150 | 164 (channel 1)  246 (channel 2) | 1 Gbit/s |
| Necessary bandwidth (MHz) |  | 287 MHz (Ch1) and  452 MHz (Ch 2) | 600 |
| Modulation | OQPSK | OQPSK | 8PSK |
| Coding | Convolutional ½ Reed-Solomon | Convolutional ½ Reed-Solomon 255/253 | LDPC rate 7/8 |
| Encoded data rate |  | 188 Msymbol/s (channel 1)  282 Msymbol/s (channel 2) | 400 Mbits/s |
| Minimum elevation angle (degree) |  | 10 |  |
| Satellite antenna input power (dBW) | −2.8 | 13 | 17 |
| Satellite antenna gain at nadir (dBi) | 43.5 | Steerable reflector, ±8.7 degrees | 43 |
| Satellite antenna maximum gain (dBi) | 43.5 | 42.5 | 43 |
| Satellite antenna polarization | LHCP and RHCP | RHCP or LHCP | RHCP and LHCP |
| Satellite antenna radiation diagram | 0.75 m reflector | 1m single reflector |  |
| Earth station antenna gain toward satellite (dBi) | 70.4 | 60.6 | 58 |
| Earth station antenna polarization | LHCP or RHCP | LHCP and RHCP | LHCP and RHCP |
| Earth station antenna radiation diagram |  | Rec. ITU-R S.580 | Rec. ITU-R S.580 |
| Earth station receiver noise temperature (K) | 460.3 | 200 | 330 |

# 5 Data collection systems

Data collection systems (DCS) in use are the Advanced Data Collection System (A-DCS) which transmits to GSO, HEO or LEO satellites. The satellites from several administrations and international agencies support programs that use the satellite transponders for relaying data from terrestrial platforms, which can be fixed terrestrial, mobile, buoys, or animals.

The programs are not always sponsored by the same agencies that provide the satellites and may not be the same administrations. The agencies who provide the satellite relay may assign time and frequency slots for data transmissions or the transmissions may be random. The technical characteristics for the terrestrial platforms are those of the various agencies that use the satellite relay and are not those of the satellite system directly. However, the transmitters on the platforms must conform to specifications of the satellite relay provider.

## 5.1 Non-GSO data collection systems

Non-GSO data collection system platform signals are uplinked in the band 401-403 MHz using signals through satellites in low-Earth or Highly elliptical orbits. The data rate ranges from 100 to 4 800 bit/s. The data collection platforms (DCP), operating with HEO satellites (ARCTICA-M) usually use a low-gain antenna (up to 6 dBi), maximum uplink e.i.r.p. would not exceed 16‑18 dBW. Bent-pipe transponder is used to relay the DCS data to associated Earth stations. For LEO systems DCP typically uses a low-gain antenna (up to 3 dBi maximum at 40-degree elevation angle), and can be a mobile or fixed platform. The non-GSO satellite DCS processor demodulates the uplink DCS data, multiplexes the data with other telemetry, and transmits the corresponding digital data to the ground. The power received from one DCP will differ from that received from another. Figure 4 provides statistics of the ARGOS DCS uplink power measured at the satellite receiver.

Figure 4

Statistical distribution of uplink signal levels from measurements: received signal power vs. time (%)

Chart, line chart

Description automatically generated

### 5.1.1 401-403 MHz

Tables 22 and 23 contain some of the DCP characteristics for the 401-403 MHz frequency band. Recommendation ITU-R SA.1627 has additional details.

TABLE 22

Non-GSO system parameters for platform uplinks in the band 401-403 MHz

| Function | ARGOS  Low data rate | ARGOS (HD-A3) High Data Rate | Brazilian DCS | ICARUS |
| --- | --- | --- | --- | --- |
| Satellite | Satellites A, D, F and AM | Satellites A, F and AM | Satellite Z | Satellite AO |
| Earth station | DCS platform | | | |
| Carrier frequency (MHz) | Multiple channels | Multiple channels | 401.62,  401.65 | 402.25 |
| Information data rate (Mbits/s) | 0.0004 | 0.0048 | 1.6 | 0.000521 |
| Necessary bandwidth (MHz) | 0.070 | 0.0096 |  | 1.2 |
| Modulation | BPSK | GMSK | BPSK | 8PSK/QPSK/BPSK |
| Coding | None | Convolutional 7, 3/4 | None | LDPC |
| Encoded data rate |  | 9 600 bit/s |  | 900 kcps |
| Minimum elevation angle (degree) | 5 | 5 | 5 | 40 |
| Earth station antenna input power (dBW) | See Fig. 1 for measurements of uplink signal level statistics at the satellite receiver in Rec. ITU-R SA.1627 | ≤ 7 | 3 | −25.76 |
| Earth station antenna gain toward satellite (dBi) | Nominal 2 dBi  Deployment dependent | −2 | max. 1.76 |
| Earth station antenna polarization | Linear | RHCP | Linear |
| Earth station antenna radiation diagram | Cardioid | Short dipole | Short dipole |
| Satellite antenna type | Helix | Helix | Phased array |
| Satellite antenna gain (dBi) | 4 | −6 (min)  −1.5 (max) | >10 dBi in target pattern |
| Satellite antenna polarization | Circular | RHCP | RHCP |
| Satellite antenna radiation diagram | Cardioid |  |  |
| Satellite receiver noise temperature (K) | 600 | 600 | 924 | 500 |

TABLE 23

Non-GSO system parameters for platform uplinks in the band 401-403 MHz

| Function | Low data rate | |
| --- | --- | --- |
| Satellite | Satellite B | Satellite BF |
| Earth station |  |  |
| Carrier frequency (MHz) | Multiple Channels | 401-403 MHz |
| Information data rate (bits/s) | 400; 1200 | 100; 1200 |
| Necessary bandwidth (kHz) | 1.6; 2.4 | 0.4; 2.4 |
| Modulation | PCM/PM; QPSK | BPSK/QPSK |
| Coding | None | None |
| Encoded data rate |  |  |
| Minimum elevation angle (degree) | 5 | 5 |
| Earth station antenna input power (dBW) | 10 | 12 |
| Earth station antenna gain toward satellite (dBi) | 2  Deployment dependent | 6 |
| Earth station antenna polarization | RHCP | RHCP |
| Earth station antenna radiation diagram | Non-Directional | Non-Directional |
| Satellite Antenna Type | Spiral | Spiral |
| Satellite antenna gain (dBi) | 4 | 15.8 |
| Satellite antenna polarization | RHCP | RHCP |
| Satellite antenna radiation diagram | See Fig. 4 | See Fig. 5 |
| Satellite receiver noise temperature (K) | 600 | 500 |

Figure 5

Satellite antenna radiation diagram for Satellite B

Diagram

Description automatically generated

NOTE – Typical non-GSO simple antenna radiation diagram to meet PFD requirements.

Figure 6

Satellite antenna radiation diagram for Satellite BF

Chart

Description automatically generated

### 5.1.2 460-470 MHz

The 460-470 MHz frequency band is used by the DCS to interrogate and command terrestrial platforms from GSO and non-GSO satellites. For operating DCS satellites that transmit a carrier frequency of 465.9875 MHz, Table 24 lists in-band technical characteristics of non-GSO DCS satellites.

In order to have reduced PFD levels on the ground, future satellites may implement spread spectrum multiple access (SSMA) transmission techniques.

Figure 7 graphically illustrates the maximum and minimum antenna gain patterns for the non-GSO DCPI system.

Similarly, for Icarus, which transmits a carrier frequency of 468.1 MHz, TABLE 25 lists in-band technical characteristics of non-GSO DCS satellites.

The Icarus antenna pattern is shown in Fig. 8.

TABLE 24

Non-GSO DCS technical characteristics (space-to-Earth)

| Parameter | Value |
| --- | --- |
| Satellite | Satellites Y, AN and AJ |
| Earth station | worldwide |
| Carrier frequency (MHz) | 465.9875 (±5 kHz) |
| Information data rate |  |
| Necessary bandwidth (MHz) | 1.00 |
| Modulation | SSMA/OQPSK |
| Coding | NRZ-M |
| Encoded data rate |  |
| Minimum elevation angle (degree) | 5 |
| Transmitter power (dBW) | 10 |
| Data bit rate (bit/s) | 977.52 |
| Chip rate (Msps) | 1 |
| Chip duration (seconds) | 1\*10-6 |
| Bandwidth (MHz) | 2 |
| Antenna gain (dBi) (1) | Maximum: −9.2 to 1.3 Minimum: −14 to -6.8 (90 to 5 degrees elevation angle) |

TABLE 25

Non-GSO ICARUS technical characteristics (space-to-Earth)

| Parameter | Value |
| --- | --- |
| Satellite | Satellite AO |
| Earth station(s) | Mobile; migratory animals tagged with transmitters |
| Carrier frequency (MHz) | 468.1 (±5 kHz) |
| Information data rate |  |
| Necessary bandwidth |  |
| Modulation | 8PSK/QPSK/BPSK |
| Coding |  |
| Encoded data rate |  |
| Minimum elevation angle (degree) |  |
| Transmitter power (dBW) | 5 |
| Data bit rate (kbit/s) |  |
| Symbol rate (Msps) | 0.03375 |
| Bandwidth (kHz) | 50 |
| Symbol duration (seconds) | 0.03 × 10−3 |
| Antenna gain(see Fig. 3) (dBi) | Max. 5 dBi at 46 degrees; 2.3 dBi at boresight |

Figure 7

Antenna gain patterns for non-GSO DCPI (DCS)

Chart, line chart

Description automatically generated

FIGURE 8

ICARUS antenna gain pattern

Chart, line chart

Description automatically generated

Table 26 presents an incumbent non-GSO EESS satellite BA characteristics, using the 460‑470 MHz for a system not related to DCS.

TABLE 26

Non-GSO EESS Satellite BA technical characteristics

|  |  |
| --- | --- |
| Parameter | Value |
| Satellite | Satellite BA |
| Orbit altitude (km) | 1 000 |
| Orbit inclination (degree) | 99.4 |
| Carrier frequency (MHz) | 465 |
| Emission class | 4M00G1D |
| Antenna power (dBW) | 10 |
| Power spectral density (dBW/Hz) | −55 |
| Maximum antenna gain (dBi) | 3.3 |
| Antenna pattern | See Fig. 4 |

Satellite BA antenna pattern in the specified frequency band is presented in Fig. 9.

Figure 9

Satellite BA antenna pattern

Chart

Description automatically generated

### 5.1.3 1 670-1 699 MHz

Data Collection Platforms (DCP) data include a number of environmental parameters that have an uplink in the 401-403 MHz band and a downlink in the 1 670-1 699 MHz band. Typical characteristics for downlink are listed in Table 27.

TABLE 27

System parameters for non-GSO DCS downlinks in the band 1 670-1 699 MHz

| Function | DCPR |
| --- | --- |
| Satellite | Satellite BF |
| Earth station(s) | Stations 13, 14 and 15 |
| Carrier frequency (MHz) | 1 697-1 699 |
| Information data rate (bits/s) | 100-1 200 |
| Necessary bandwidth (kHz) | 0.4-2.4 |
| Modulation | BPSK/QPSK |
| Coding | None |
| Encoded data rate | - |
| Minimum elevation angle (degree) | 5 |
| Satellite antenna input power (dBW) | 9 |
| Satellite antenna type | Spiral |
| Satellite antenna radiation pattern | See Fig. 6 |
| Satellite antenna gain at nadir (dBi) | 15 |

TABLE 27 (*end*)

| Function | DCPR |
| --- | --- |
| Satellite antenna maximum gain (dBi) | 15 |
| Satellite antenna polarization | RHCP |
| Earth station antenna gain toward satellite (dBi) | 41 |
| Earth station antenna polarization | RHCP |
| Earth station antenna radiation diagram | Rec. ITU-R S.580 |
| Earth station receiver noise temperature (K) | 150 |

Figure 10

Satellite antenna radiation diagram for Satellite BF

Chart, line chart

Description automatically generated

## 5.2 GSO Data Collection systems

Data Collection Platforms (DCPs) transmit Manchester-encoded PSK signals (DCP reports) in the 401‑403 MHz band to GSO meteorological satellites at a data rate of 300 bit/s. High rate DCPs can operate up to 1 200 bit/s. The satellite relays these DCP reports (DCPR) to a specific station of the satellite operator as well as user terminals in the 1 670‑1 698 MHz band. The satellite transponder, which is channelized to accommodate several hundred simultaneous DCPR transmissions, has an automatic gain control (AGC) that maintains the downlink DCPR e.i.r.p. constant regardless of the transponder input power.

Individual DCPs assigned to a given DCPR channel time-share that channel, the bandwidth of which is 750 Hz for 300 bit/s terminals and 2 250 Hz for 1 200 bit/s terminals for GOES NOP and the GOES-R series. For various reasons, the power radiated by one platform will differ from that radiated by another. Measurements of DCP e.i.r.p. in one GOES DCPR channel over a 24 h period have provided the statistics summarized in Table 21. In simulations, it can be assumed that all DCPs assigned to a given channel time-share the channel equally. To determine the total DCP e.i.r.p., the number of DCPR channels occupied simultaneously must be postulated. Assuming an average DCP e.i.r.p. of 15 dBW, and assuming that 100 DCPR channels are simultaneously active, the sum of the DCP e.i.r.p. values will be 35 dBW.

For the GOES-R series, the DCPR transponder has been designed to operate with 250 simultaneous channels with an average e.i.r.p. of 11 dBW. The maximum total uplink power would still be 35 dBW.

TABLE 28

GSO DCPR e.i.r.p. statistics

|  |  |  |
| --- | --- | --- |
| e.i.r.p. of a single DCP in the channel (dBW) | Number of DCPs having this e.i.r.p. in the channel | Number of DCPs having this e.i.r.p. or less |
| 4 | 0 | 0 |
| 5 | 3 | 3 |
| 6 | 1 | 4 |
| 7 | 4 | 8 |
| 8 | 0 | 8 |
| 9 | 5 | 13 |
| 10 | 17 | 30 |
| 11 | 12 | 42 |
| 12 | 12 | 54 |
| 13 | 16 | 70 |
| 14 | 28 | 98 |
| 15 | 36 | 134 |
| 16 | 46 | 180 |
| 17 | 34 | 214 |
| 18 | 5 | 219 |
| 19 | 1 | 220 |
| 20 | 0 | 220 |

### 5.2.1 401-403 MHz

Data Collection Platforms (DCP) data include a number of environmental parameters that have an uplink in the 401-403 MHz band and a downlink in the 1 670-1 698 MHz band. Typical characteristics for both the uplink and downlink are listed in Table 29 and in Tables 30 and 31 respectively.

TABLE 29

System parameters for GSO DCS platform uplinks in the band 401-403 MHz

| Function | DCPR | | | |
| --- | --- | --- | --- | --- |
| Satellite | Satellite M and R | Satellite N | Satellite P | Satellites Q and AY |
| Earth station | DCS Platform | DCS platform | DCS platform | DCS platform |
| Carrier frequency (MHz) | 401.7 to 402.1 Regional platforms operate between 401.7 and 402.0355 | 401.7-402.5 | 401.1-401.4  (100 channels) 402.0-402.1  (33 channels) | 401.5-402.5 |
| Information data rate (bit/s) | 300  1 200  0 CW Beacon | 300 (SRDCP)  1 200 (HRDCP)  0 CW Beacon |  | 400; 1 200 |
| Receiver bandwidth (kHz) | 480 | 750 |  | 1 000 |
| Modulation | 8PSK | PCM/SP-L/PM | BPSK | BPSK/QPSK |
| Coding | Trellis rate 2/3 | RS (255, 223) (for HRDCP) |  | None |
| Encoded data rate |  |  |  |  |
| Minimum elevation angle (degree) | Fixed pointing |  |  |  |
| Earth station antenna input power (dBW) | For GOES-NOP see Table 22 for measurements of platform uplink e.i.r.p. statistics. For GOES-R (GOES-16) the nominal e.i.r.p. is 11 dBW for 300 bit/s and e.i.r.p. of 17 dBW for 1 200 bit/s | up to 13 | 7 | 12 |
| Earth station antenna gain toward satellite (dBi) | Omni: 5.7  Yagi: 11 | 10 | 6 |
| Earth station antenna polarization | RHCP | RHCP | RHCP | RHCP |
| Earth station antenna radiation diagram | Yagi | Omni  Yagi |  |  |
| Satellite antenna type | Helix |  |  |  |
| Satellite antenna gain (dBi) | 14.0 | 3.9 | 10.6 | 12/15 |
| Satellite antenna polarization | RHCP | RHCP | RHCP | RHCP |
| Satellite antenna radiation diagram | 1st sidelobe of −2 dBi @50 degrees |  |  |  |
| Satellite receiver noise temperature (K) | 534 | 296 | 650 | 500/550 |

### 5.2.2 1 670-1 698 MHz

TABLE 30

System parameters for GSO DCS downlinks in the band 1 670-1 698 MHz

| Function | DCPR | | |
| --- | --- | --- | --- |
| Satellite | Satellite M | Satellite N | Satellite P |
| Earth station(s) | Station 1 | Station 7 & 12 | Station 8 |
| Carrier frequency (MHz) | 1 694.5 1 694.8 | 1 675.281 | 1 709.5 (1)) |
| Information data rate (bits/s) | 300 or 1 200 per channels | 300 (SRDCP)  1 200 (HRDCP)  per channel | 100 |
| Necessary bandwidth (kHz) | 0.3 or 1.2 | 750 (for all channels) |  |
| Modulation | 8PSK | PCM/SP-L/PM |  |
| Coding | Trellis |  |  |
| Encoded data rate |  |  |  |
| Minimum elevation angle (degree) | Fixed pointing |  |  |
| Satellite antenna input power (dBW) | 8 | −34 (per channel) |  |
| Satellite antenna type | Planar Cup Dipole |  |  |
| Satellite antenna radiation pattern | 1st sidelobe of −6 dBi at 60 degrees |  |  |
| Satellite antenna gain at nadir (dBi) | 15.6 | 11 |  |
| Satellite antenna maximum gain (dBi) | 15.6 | 11 |  |
| Satellite antenna polarization | Linear N/S | Linear  Horizontal | Linear Vertical |
| Earth station antenna gain toward satellite (dBi) | 38 | 45.5 | 48.8 |
| Earth station antenna polarization | Linear | Linear  Horizontal | Linear  Vertical |
| Earth station antenna radiation diagram | Rec. ITU-R S.465-6 |  |  |
| Earth station receiver noise temperature (K) | 200 | 141 | 96 |
| (1) The early FY-2 series satellite systems used this frequency outside of the 1 670-1 698 MHz band for the DCS downlink. | | | |

TABLE 31

System parameters for GSO DCS downlinks in the band 1 670-1 698 MHz

| Function | DCPR | | |
| --- | --- | --- | --- |
| Satellite | Satellite R | Satellite P | Satellites Q and AY |
| Earth station(s) | Stations 1 and 3 | Stations 8 and 9 | Stations 13, 14 and 15 |
| Carrier frequency (MHz) | 1 679.9  1 680.2 | 1 688 | 1 696-1 698 |
| Information data rate (bit/s) | 300/1 200  With coding 1 800 | 600 | 100-1 200 |
| Necessary bandwidth (kHz) | 400 | 4 000  (for all channels) | 0.4-2.4 (1 000 kHz for all channels) |
| Modulation | 8PSK | QPSK | BPSK/QPSK |
| Coding | Trellis | Convolutional | None |
| Encoded data rate |  |  |  |
| Minimum elevation angle (degree) | Fixed pointing |  | 5 |
| Satellite antenna input power (dBW) | 9 | –0.4 | 9.7/5.9 |
| Satellite antenna type | Horn |  |  |
| Satellite antenna radiation pattern | 1st sidelobe of  −2.5 dBi at 52 deg. |  |  |
| Satellite antenna gain at nadir (dBi) | 16.2 | 15.5 | 12/15 |
| Satellite antenna maximum gain (dBi) | 16.2 |  |  |
| Satellite antenna polarization | Linear | Linear Vertical | LRHCP |
| Earth station antenna gain toward satellite (dBi) | 47.5 | 44.3 | 44/39.6/35.7 |
| Earth station antenna polarization | Linear | Linear  Vertical | HRHCP |
| Earth station antenna radiation diagram | Rec. ITU-R S.465-6 |  | Rec. ITU‑R S.465-6 / S.580 |
| Earth station receiver noise temperature (K) | 200 | 200 | 150/200/250 |

## 5.3 GSO DCS interrogated systems

Geostationary satellites relay PSK-modulated DCP interrogations (DCPI) from a specific station of the satellite operator in the 2 025-2 110 MHz band to the DCPs in the 460‑470 MHz band.

Though the satellite DCPI transponder is hard-limiting rather than linear, downlink power sharing is much the same as it is for the DCPR transponder. Tables 32 and Table 33 include some typical characteristics for these bands.

### 5.3.1 2 025-2 110 MHz

TABLE 32

GSO system parameters for DCS uplinks in the band 2 025-2 110 MHz

| Function | DCPI | DCPI |
| --- | --- | --- |
| Satellite | Satellite M | Satellite R |
| Earth station | Station 1 | Stations 1 and 3 |
| Carrier frequency (MHz) | 2 034.8875  2 034.9000  2 034.9125 | 2 032.775  2 032.825 |
| Receiver bandwidth (kHz) | 11.0 | 44.5 |
| Modulation | BPSK | QPSK |
| Coding | None | DSSS |
| Encoded data rate (kcps) |  | 22.225 |
| Minimum elevation angle (degree) | Fixed pointing | Fixed pointing |
| Earth station antenna input power (dBW) | 4 | 3 |
| Earth station antenna gain toward satellite (dBi) | 47.6 | 49.6 |
| Earth station antenna polarization | Linear | RHCP |
| Earth station antenna radiation diagram | AP7-Annex 3 | AP7-Annex 3 |
| Satellite antenna type | Planar Cup Dipole | Planar Cup Dipole |
| Satellite antenna gain (dBi) | 12.9 | 16.5 |
| Satellite antenna polarization | Linear | Linear |
| Satellite antenna radiation diagram | Earth coverage | Earth coverage |
| Satellite receiver noise temperature (K) | 570 | 1 043 |

### 5.3.2 460-470 MHz

Systems in the 460-470 MHz band are used for transmitting commands and configuration data to Earth-based platforms. Using this service is optional for the platform owners. However, transmissions are continuous even without specific messages.

TABLE 33

GSO system parameters for DCS downlinks in the band 460-470 MHz

| Function | Interrogate platforms (DCPI) | Interrogate platforms (DCPC) |
| --- | --- | --- |
| Satellite | Satellite M | Satellite R |
| Earth station | DCS platform | DCS Platform |
| Carrier frequency (MHz) | 468.8125  468.8250  468.8375 | 468.775  468.825 |
| Information data rate (bit/s) | 5 500 | 350 |
| Necessary bandwidth (MHz) | 0.011 | 0.0445 |
| Modulation | BPSK | QPSK |
| Coding | None | DSSS |
| Encoded data rate (kcps) |  | 22.225 |
| Minimum elevation angle (degree) | 5 | 5 |
| Satellite antenna input power (dBW) | 5.2 | 5 |
| Satellite antenna type | Planar Cup Dipole | Planar Cup Dipole |
| Satellite antenna gain at nadir (dBi) | 10.6 | 14.5 |
| Satellite maximum antenna gain (dBi) | 10.6 | 14.5 |
| Satellite antenna polarization | RHCP | RHCP |
| Satellite antenna radiation diagram | Earth coverage | Earth coverage |
| Earth station antenna type | Yagi on land  Monopole on buoy | Yagi on land  Monopole on buoy |
| Earth station antenna radiation pattern | Yagi varies per installation  Monopole-Cardioid | Yagi varies per installation  Monopole-Cardioid |
| Earth station antenna gain toward satellite (dBi) | Land 13  Buoy 3 | Land 13  Buoy 3 |
| Earth station antenna polarization | RHCP | RHCP |
| Earth station receiver noise temperature (K) | 1 338 | 1 338 |

Annex A  
  
Antenna radiation diagrams/patterns

## A.1 Introduction

Although measured patterns are preferable, representative patterns have been developed by the ITU and references to them are used in this Report. This Annex presents and discusses the referenced antenna gain patterns.

## A.2 Earth station antennas

Pattern from ITU Radio Regulations Appendix 7, Annex 3 (see Note 1 below)

 (1)

 (2)

                    degrees

 (3)

NOTE 1 ‒ In cases where  is not given, it may be estimated from the expression 20 log ≈ Gmax − 7.7, where *Gmax* is the main lobe antenna gain (dBi).

Pattern from ITU Radio Regulations Appendix 8, Annex 3 (See Note 2 below)

a) for values of  (maximum gain ≥ 48 dBi approximately) (See Note 3 below):

*G*(φ) = *Gmax* − 2.5 × 10−3  for 0 < φ < φ*m*

*G*(φ) = *G*1 for φ*m* ≤ φ < φ*r*

*G*(φ) = 32 − 25 log φ for φ*r* ≤ φ < 48°

*G*(φ) = −10 for 48° ≤ φ <180°

where:

|  |  |  |
| --- | --- | --- |
| *D*: | antenna diameter | expressed in the same unit |
| λ: | wavelength |

φ: off-axis angle of the antenna, in degrees, equal to θ*t* or θ*g*, as applicable

*G*1: gain of the first sidelobe = 2 + 15 log .

          degrees

          degrees

b) for values of (maximum gain < 48 dBi approximately) (see Note 3 below):

*G*(φ) = *Gmax* − 2.5 × 10−3  for 0 < φ < φ*m*

*G*(φ) = *G*1 for φ*m* ≤ φ < 

*G*(φ) = 52 − 10 log  − 25 log φ for ≤ φ < 48°

*G*(φ) = 10 − 10 log  for 48° ≤ φ ≤ 180°

NOTE 2 ‒ These patterns are also described in Recommendation ITU-R F.699-8 (*recommends* 2.1.1 and 2.1.2).

NOTE 3 ‒ In cases where  is not given, it may be estimated from the expression 20 log ≈ *Gmax* − 7.7, where *Gmax* is the main lobe antenna gain (dBi).

Pattern from Recommendation ITU-R S.465-6

*G*  32 – 25 log  dBi for *min*    48° (4)

G  −10 dBi for 48°    180°

where:

*min*  1° or 100 λ/*D* degrees, whichever is the greater, for *D*/λ≥ 50

*min* = 2° or 114 (D/λ)–1.09 degrees, whichever is the greater, for *D/*λ< 50

This pattern does not contain representation of the main lobe. The mainlobe pattern from RR Appendix **7** Annex 3 can be considered.

**Pattern from Recommendation ITU-R S.580-6**

This Recommendation provides design objectives for antennas of earth stations operating with geostationary satellites:

1That new antennas of an earth station operating with a geostationary satellite should have a design objective such that the gain, *G*, of at least 90% of the side-lobe peaks does not exceed:

(5)

(*G* being the gain relative to an isotropic antenna and  being the off-axis angle in the direction of the GSO referred to the main-lobe axis).

This requirement should be met for  between 1° or (100 *D*) whichever is the greater and 20° for any off‑axis direction that is within 3° of the GSO.

2 For an off-axis angle, , greater than the limits specified above, Recommendation ITU‑R S.465 should be used as a reference.

Sidelobe level specification

Several of the entries provide the offset angle and absolute gain of the first antenna sidelobe (e.g. First sidelobe 9.9 dBi @ 0.26 deg). Figure A-1 below provides a sample pattern for large parabolic antennas. The first sidelobe is indicated by the diamonds. The sample antenna pattern is for a 13‑metre antenna used in S-band.

Figure A-1

Antenna pattern at 2 247.5 MHz for a 13-metre antenna (50 dBi)

*Diagram

Description automatically generated with low confidence*

## A.3 Space station antennas

### A.3.1 Geostationary satellites

#### A.3.1.1 Earth coverage

From the geostationary orbit the Earth subtends only 18 degrees. Antennas with beamwidth of 20 degrees or more will have a fairly constant gain across the Earth’s visible surface.

#### A.3.1.2 Recommendation ITU-R S.672-4

This antenna pattern is a design objective of satellite antennas used in the fixed-satellite service employing geostationary satellites. For more details, see the Recommendation.

### A.3.2 Low earth orbiting satellites

#### A.3.2.1 Isoflux pattern

The term Isoflux as used in this document refers to an antenna gain pattern used by low earth‑orbiting satellites, which provides its maximum gain toward the horizon and attempts to provide a constant power flux density at all locations within the field of view of the spacecraft.

Antennas that approximate this pattern are sometimes referred to as Isoflux antennas but the actual antenna may be a quadrifiler or some other antenna.

A generic isoflux radiation pattern that can be assumed is presented below:

where *k* is the maximum gain in dBi and θis the antenna boresight angle from nadir. Tables in this Report refer to this pattern as the ‘Isoflux’. A sample Isoflux pattern (7 dBi max gain) is shown in Fig. A‑2.

Figure A-2

Representative isoflux antenna pattern

Chart, line chart

Description automatically generated

#### A.3.2.2 Pencil beam

There is no specific pattern associated with this term. It might be assumed that the pattern is similar to Recommendation ITU-R S.672-4.

#### A.3.2.3 Cardioid

Satellite antennas that are not specifically designed for Isoflux type coverage will likely have their maximum gain at nadir and a cardioid rolloff pattern. A sample Cardioid pattern is shown in Fig. A‑3.

Figure A-3

Representative cardioid antenna pattern

Chart, radar chart

Description automatically generated

#### A.3.2.4 ND

This term means non-directional. This is an ideal. The actual pattern is likely to be a cardioid but can be modelled as an Omni-directional antenna.

Annex B  
(for information only)  
  
Typical orbit parameters and earth station locations

This Annex provides reference information on typical orbit parameters for non-GSO and GSO systems as well as earth station locations. It should be noted that these elements are only a subset and cannot be taken as exhaustive (e.g. this is not an active database of all current and planned missions). It is not comprehensive lists but rather list of systems as added from several administrations over the course of development of this document. In addition, this annex is provided only for information and as a reference for any future updates to this Report containing representative characteristics.

Table B-1 lists typical orbit parameters for current and future MetSat/EESS non-GSO satellites that use the frequency bands given in § 3 and in a portion of § 5 of this Report. Most satellites in Table B-1 are in sun‑synchronous orbits. The purpose of the Table is to provide orbit information needed for conducting dynamic simulations. Table B-2 lists typical longitudes of current and future MetSat/EESS GSO satellites that use the frequency bands given in § 4 and in a portion of § 5 of this Report. Table B-3 lists locations of representative specific earth stations and their locations that use the frequency bands given in §§ 3, 4 and 5, however, this is not an exhaustive list of locations.

TABLE B-1

Non-GSO satellite orbit parameters

| Non-GSO satellite name | Orbit altitude (km) | Inclination (degrees) | Longitude ascending node (degrees) or local time of equatorial crossing  (if in sun synchronous orbit) |
| --- | --- | --- | --- |
| Satellite A (NOAA KLM (NOAA‑15 through -17)) | 812 | 98.5 | 140 deg. |
| Satellite B (Meteor-3M) | 835 | 98.85 | 8:00 LTDN |
| Satellite C (JPSS-1 (NOAA-20)) | 824 | 98.7 | 13:30 LTAN |
| Satellite D (NOAA N and N’ (NOAA-18 and -19)) | 854 870 | 98.7 | 17:30 LTAN  14:30 LTAN |
| Satellite E (FY-3A) | 824 | 98.73 | 306.24 deg. |
| Satellite F (Metop) | 833 | 98.7 | 9:30 LTDN |
| Satellite G (FY-3B) | 824 | 98.73 | 224.93 deg. |
| Satellite H (AQUA) | 705 | 98.2 | 13:30 LTAN |
| Satellite I (Landsat-7) | 705 | 98.2 | 22:00 LTAN |
| Satellite I1 (Landsat-8) | 705 | 98.2 | 22:00 LTAN |
| Satellite J (TERRA) | 705 | 98.2 | 22:30 LTAN |
| Satellite K (Resurs-P) | 475 | 97.5 | 22:00 LTAN |
| Satellite L (AMAZONIA-1) | 753 | 98.4 | 10 30 LTDN |
| Satellite S (Suomi-NPP) | 824 | 98.74 | 10 30 LTDN |
| Satellite T (KANOPUS-V) | 510 | 97.0 | 23:30 LTDN |
| Satellite U (Resurs-PM) | 450-730 | 97-99 | Not launched yet |
| Satellite V (BIOMASS) | 661 | 98.07 | 06:00 LTAN |
| Satellite W (PROBA-V) | 820 | 98.6 | 21:00 LTAN |
| Satellite X (Jason) | 1 336 | 66 | Jason-3 – Non sun‑synchronous orbit  Jason-CS (Sentinel-6), Non sun‑synchronous orbit |
| Satellite Y (CDARS) | 750 | 98.32 | Sun-synchronous orbit  17:30 LTAN |
| Satellite Z (CBERS-04A) | 628 | 97.9 | 10:30 LTDN |
| Satellite AA (ADM-AEOLUS) | 300 | 97.0 | 18:00 LTAN |
| Satellite AB (ALOS-2) | 628 | 97.9 | 24 00 local time |
| Satellite AC (CRYOSAT-2) | 698 | 92.0 | Non sun‑synchronous orbit. Nodal regression of 0.25 deg per day. |
| Satellite AD (SMOS) | 748 | 98.4 | 06:00 LTAN |

TABLE B-1 (*cont.*)

| Non-GSO satellite name | Orbit altitude (km) | Inclination (degrees) | Longitude ascending node (degrees) or local time of equatorial crossing  (if in sun synchronous orbit) |
| --- | --- | --- | --- |
| Satellite AE (EARTHCARE) | 398 | 97.0 | 02:00 LTAN |
| Satellite AF (EnMap) | 675 × 660 | 97.96 | Not yet launched |
| Satellite AG (AURA) | 705 | 98.2 | 13:38 LTAN |
| Satellite AH (SENTINEL-5P) | 819 | 98.6 | 13:35 LTAN |
| Satellite AI (Formosat-5) | 718 | 98.28 | 10 00 LTDN |
| Satellite AJ (OCEANSAT-3) | 738 | 98.3 | 0:00 LTAN |
| Satellite AM (SARAL) |  |  |  |
| Satellite AN (Metop-SG) | 830 | 98.7 | 09 30 LTDN |
| Satellite AO (International Space Station, ISS) | 410 × 420 | 51.65 | Non sun‑synchronous orbit.  Multiple payload |
| Satellite AP (TerraSAR-X) | 514 | 97.4 | 18 00 LTAN |
| Satellite AQ (TanDEM-X) | 514 | 97.4 | 18 00 LTAN |
| Satellite AR (HRWS) | 514 | 97.4 | Not yet launched (probably 18 00) |
| Satellite AS (TET-1) | 550 | 97.5 |  |
| Satellite AT (BIROS) | 505 | 97.4 | 09:30 LTDN |
| Satellite AU (High Resolution Radar Satellite) (generic) | 750 | 98.4 |  |
| Satellite AV (Sentinel 1A/1B) | 693 | 98.18 | 18:00 LTAN  System with two satellite in same orbital plane (180º phasing) |
| Satellite AW (Sentinel 2A/2B) | 786 | 98.5 | 22:30 LTAN  System with two satellite in same orbital plane (180º phasing) |
| Satellite AX (Sentinel 3A/3B) | 815 | 98.6 | 22:00 LTAN  System with two satellite in same orbital plane (180º phasing) |
| Satellite AZ (Copernicus Evolution, and other commercial LEO, generic) | 600 to 900 | Typically polar orbits |  |
| Satellite BA (GEO-IK) | 1000 | 99.4 |  |
| Satellite BB (RADARSAT-2) | 798 | 98.6 | 18:00 LTAN |
| Satellite BC (Radarsat Mission Constellation, RCM) | 586 to 615 | 97.7 | 18:00 hours ±15 minutes LTAN  System with three satellites in the same orbital plane. |
| Satellite BD (Obzor-R) | 650-850 | 97-99 | Non sun‑synchronous orbit |
| Satellite BE (Kondor-FKA) | 510-520 | 97.4-97.5 | 6:30 LTAN (initial, as has a temporal drift) |

TABLE B-1 (*end*)

| Non-GSO satellite name | Orbit altitude (km) | Inclination (degrees) | Longitude ascending node (degrees) or local time of equatorial crossing  (if in sun synchronous orbit) |
| --- | --- | --- | --- |
| Satellite BF (ARCTICA-M) | 40 000 (apogee)  3 000 (perigee) | 62.8 | Non sun‑synchronous orbit |
| Satellite BG (AWS) | 600 | 97.79 | Constellation of 8 to 16 satellites  Non sun‑synchronous orbit |
| Satellite BH (JPSS-2 (NOAA-21)) | 824 | 98.7 | 13:25 LTAN |

TABLE B-2

GSO Sub-satellite longitudes

|  |  |
| --- | --- |
| GSO satellite | Longitude (degrees) |
| Satellite M (GOES-NOP) | 60 W, 75 W, 89.5 W, 105 W and 135 W |
| Satellite N (Meteosat) | 45.5 E, 41.5 E, 9.5 E, 3.5 E, 0 E, 3.4 W |
| Satellite O (MTSAT) | 140 E and 145 E |
| Satellite P (FY-2 & FY-4) | 133 E, 123.5 E, 112 E, 105 E, 99.5 E, 86.5 E and 79 E |
| Satellite Q (GOMS with Elektro-L) | 76 E, 14.5 W and 165.8 E |
| Satellite R (GOES-R Series) | 75.2 W, 89.5 W, 105 W and 137 W |
| Satellite AK (SDO) | 102 W |
| Satellite AL (MTG) | 0 E, 3.5 E, 9.5 E and 3.4 W |
| Satellite AY (Luch-5A, 5B, 5V) | 16 W, 95 E and 167 E |

TABLE B-3

Non-GSO and GSO specific earth station locations

| Non-GSO and GSO earth stations | Longitude (degrees) | Latitude (degrees) |
| --- | --- | --- |
| Station 1 (Wallops CDA, VA, USA) | 75.5 W | 37.9 N |
| Station 2 (Fairbanks, AK, USA) | 147.5 W | 65.0 N |
| Station 3 (Fairmont, WV, USA) | 80.2 W | 39.4 N |
| Station 4 (McMurdo Station, Antarctica) | 166.7 E | 77.8 S |
| Station 5 (Svalbard, Norway) | 15.5 E | 78.2 N |
| Station 6 (Kiruna, Sweden) | 21.1 E | 67.9 N |
| Station 7 (Cheia, Romania) | 25.93 E | 45.46 N |
| Station 8 (Beijing, CHN) | 116.3 E | 40.1 N |
| Station 9 (Guangzhou, CHN) | 113.3 E | 23.2 N |
| Station 10 (Prudhoe Bay, AK) | 148.5 W | 70.2 N |
| Station 11 (Usingen, Germany) | 8.48 E | 50.33 N |
| Station 12 (Fucino, Italy) | 13.6 E | 41.98 N |
| Station 13 (Moscow, Russia) | 37.3 E | 55.8 N |

TABLE B-3 (*cont.*)

| Non-GSO and GSO earth stations | Longitude (degrees) | Latitude (degrees) |
| --- | --- | --- |
| Station 14 (Novosibirsk, Russia) | 83.0 E | 55.0 N |
| Station 15 (Khabarovsk, Russia) | 135.2 E | 48.5 N |
| Station 16 (Suitland, Maryland, USA) | 76.9 W | 38.9 N |
| Station 17 (White Sands, New Mexico, USA) | 106.6 W | 32.5 N |
| Station 18 (Troll, Antarctica) | 2.5 E | 72.0 S |
| Station 19 (Cachoeira Paulista, Brazil) | 45.00 W | 22.68 S |
| Station 20 (Cuiabá, Brazil) | 56.04 W | 15.33 S |
| Station 21 (Greenbelt, Maryland, USA) | 76.84 W | 39.00 N |
| Station 22 (Boulder, Colorado, USA) | 105.26 W | 39.99 N |
| Station 23 (Laurel, Maryland USA) | 76.90 W | 39.33 N |
| Station 24 (North Pole, Alaska, USA) | 147.5 W | 64.80 N |
| Station 25 (South Point, Hawaii, USA) | 155.60 W | 19.00 N |
| Station 26 (Goldstone, California, USA) | 116.98 W | 35.42 N |
| Station 27 (Xinjiang, CHN) | 87.4 E | 43.8 N |
| Station 28 (Jiamusi, CHN) | 130.3 E | 46.7 N |
| Station 29 (Perth, Australia) | 115.86 E | 31.93 S |
| Station 30 (T’ainai, Taiwan, CHN) | 120.19 E | 22.93 N |
| Station 31 (Chung-li,Taiwan, CHN) | 121.19 E | 24.97 N |
| Station 32 (Hsin-Chu, Taiwan, CHN) | 120.98 E | 24.81 N |
| Station 33 (Cheia, Romania) | 25.93 E | 45.46 N |
| Station 34 (Maspalomas, Spain) | 15.63 W | 27.76 N |
| Station 35 (Lario, Italy) | 9.38 E | 46.17 N |
| Station 36 (Leuk, Switzerland) | 7.65 E | 46.32 N |
| Station 37 (Katsuura, Japan) | 140.30 E | 35.21 N |
| Station 38 (Barrow, Alaska, USA) | 159.6 W | 71.3 N |
| Station 39 (Villafranca, Spain) | 3.95 W | 40.45 N |
| Station 40 (Neustrelitz, Germany) | 13.07 E | 53.33 N |
| Station 41 (Sagamihara, Japan) | 139.49 E | 35.71 N |
| Station 42 (Jeju, Rep. of Korea) | 126.81 E | 33.37 N |
| Station 43 (Sioux Falls, SD, USA) | 96.62 E | 43.73 N |
| Station 44 (Alice Springs, Australia) | 133.87 E | 23.70 S |
| Station 45 (Cordoba, Argentina) | 64.46 W | 31.52 S |
| Station 46 (Gatineau, Canada) | 75.80 W | 45.58 N |
| Station 47 (Prince Albert, Canada) | 105.93 W | 53.21 N |
| Station 48 (KaShi, CHN) | 75.93 E | 39.50 N |
| Station 49 (Parepare, Indonesia) | 119.63 E | 3.98 S |
| Station 50 (Rumpin, Indonesia) | 106.60 E | 6.37 S |
| Station 51 (Matera, Italy) | 16.70 E | 40.65 N |
| Station 52 (Kumamoto, Japan) | 130.87 E | 32.53 N |

TABLE B-3 (*end*)

| Non-GSO and GSO earth stations | Longitude (degrees) | Latitude (degrees) |
| --- | --- | --- |
| Station 53 (Hartebeestoek, South Africa) | 27.71 E | 25.88 S |
| Station 54 (Bangkok, Thailand) | 100.79 E | 13.73 N |
| Station 55 (Si Racha, Thailand) | 100.93 E | 13.10 N |
| Station 56 (Hatayoma, Japan) | 139.33 E | 36.02 N |
| Station 57 (Weilheim, Germany) | 11.08 E | 47.88 N |
| Station 58 (Inuvik, Canada) | 133.54 W | 68.32 N |
| Station 59 (O´Higgins, Antarctica) | 57.9 W | 63.32 S |
| Station 60 (Libreville, Gabon) | 9.60 E | 0.39N |
| Station 61 (Riyadh, Saudi Arabia) | 46.63 E | 24.72 N |
| Station 62 (Shadagar, India) | 78.19E | 17.03N |
| Station 63 (Punta Arenas, Chile) | 70.87 W | 52.93 S |
| Station 64 (Sanya, CHN) | 109.28 E | 18.28 N |
| Station 65 (Sodankyla, FIN) | 26.63 E | 67.37 N |
| Station 66 (Neimeng, CHN) | 111..65 E | 41.55 N |
| Station 67 (Clewiston, Florida, USA) | 80.99 W | 26.75 N |
| Station 68 (Kapolei, Hawaii, USA) | 158.09 W | 21.34 N |
| Station 69 (Dublin, Ohio, USA) | 83.2 W | 40.1 N |
| Station 70 (Boardman, Oregon, USA) | 119.632 W | 45.86 N |
| Station 71 (Green River, Wyoming, USA) | 109.4 W | 41.5 N |
| Station 72 (Tromsø, Norway) | 18.94 E | 69.66 N |
| Station 73 (Vasteras, Sweden) | 16.58 E | 59.65 N |
| Station 74 (Dublin, Ireland) | 6.23 W | 53.41 N |
| Station 75 (Dubai, UAE) | 55.47E | 25.29 N |
| Station 76 (Zallaq, Bahrain) | 50.5 E | 26.05 N |
| Station 77 (Canary Islands) | 15.636 E | 27.767 N |
| Station 78 (Mauritius) | 57.45 E | 20.5 S |
| Station 79 (Cape Town, South Africa) | 18.72 E | 34.03 S |
| Station 80 (Bangalore, India) | 77.54 E | 12.91 N |
| Station 81 (Singapore) | 103.83 E | 1.4 N |
| Station 82 (Seoul, Rep. of Korea) | 127.138 E | 37.31 N |
| Station 83 (Hokkaido, Japan) | 142.62 E | 43.28 N |
| Station 84 (Dongara, Australia) | 115.43 E | 29.19 S |
| Station 85 (Sydney, Australia) | 150.77 E | 34.04 S |

Annex C  
  
System characteristics of non-GSO systems in the 8 025-8 400 MHz band

TABLE C-1

Non-GSO EESS space-to-Earth parameters for systems in the band 8 025-8 400 MHz

| Function | Direct readout | | | | |
| --- | --- | --- | --- | --- | --- |
| Satellite | Satellite H | Satellite J | Satellite B | Satellite K | Satellites E  and G |
| Earth station(s) | Worldwide | | Russian territory | Worldwide | Station 8 |
| Carrier frequency (MHz) | 8 160 | 8 212.5 | 8 128 and 8 320 | 8 192 and 8 335 | 8 212.5 |
| Information data rate (Mbits/s) | 15 | 13.5 | 3  15.36, 122.88 | 76.8  153.6 | 225 |
| Necessary bandwidth (MHz) |  |  | 30.7 & 123 | 58 & 115 |  |
| Modulation |  |  |  |  | QPSK |
| Coding |  |  |  |  | RS(233,255)+CONV(3/4,7) |
| Encoded data rate |  |  |  |  | 300 |

TABLE C-1 (*end*)

| Function | | Direct readout | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Minimum elevation angle (degree) | 5 | | 5 | 5 | |  |
| Satellite antenna input power (dBW) | 11.18 | | 10.6 | 9 | 23.8 | 14 |
| Satellite antenna radiation diagram | Isoflux | | Isoflux | Isoflux | S.672/ Pointed | Isoflux |
| Satellite antenna gain at nadir (dBi) | −4.1 | | −6 | 24 | 25 | 5 |
| Satellite antenna maximum gain (dBi) | 6.8 | | 6 | 8.5 | 25 | 5 |
| Satellite antenna polarization | RHCP | | RHCP | RHCP | RHCP and LHCP | RHCP |
| Earth station antenna gain toward satellite (dBi) | 45.6 | | 45.6 | 57 53 48 43 | 54.6  50  47  45 | 56 |
| Earth station antenna polarization | RHCP | | RHCP | RHCP | RHCP and LHCP | RHCP |
| Earth station antenna radiation diagram | Rec. ITU-R S.465-6 | | | Rec. ITU-R S.465-6 | | Rec. ITU-R S.465-6 |
| Earth station receiver noise temperature (K) | 125 | | 190 | 100/185 | 150 | 280 |

TABLE C-2

Non-GSO EESS space-to-Earth parameters for systems in the band 8 025-8 400 MHz

|  |  |  |
| --- | --- | --- |
| Function | Direct Readout | |
| Satellite system | Satellite AF | Satellite AP |
| Earth station(s) | Station 40 | World-wide |
| Carrier frequency (MHz) | 8 200 | 8 150 |
| Information data rate (Mbits/s) | 320 | 300 |
| Necessary bandwidth (MHz) | 350 | 225 |
| Modulation |  |  |
| Coding |  |  |
| Encoded data rate |  |  |
| Minimum elevation angle (degree) | 5 | 5 |
| Satellite antenna input power (dBW) | 3.2 | 17.5 |
| Satellite antenna radiation pattern | Directional | Isoflux |
| Satellite antenna gain toward nadir (dBi) | 20.9 | 0 |
| Satellite antenna maximum gain (dBi) | 20.9 | 7 |
| Satellite antenna polarization | LHCP | LHCP/ RHCP |
| Earth station antenna gain toward satellite (dBi) | 41 | 57.6 |
| Earth station antenna polarization | RHCP/LHCP | RHCP/ LHCP |
| Earth station antenna radiation diagram | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 |
| Earth station receiver noise temperature (K) | 226 | 92 |

TABLE C-3

Non-GSO EESS space-to-Earth parameters of systems in the band 8 025-8 400 MHz

| Function | Direct Readout and Stored Mission Data | | | | |
| --- | --- | --- | --- | --- | --- |
| Satellite | Satellite U | Satellite T | Satellite AO | Satellite BD | Satellite BE |
| Earth station(s) | Worldwide | Worldwide | Worldwide | Russian territory | Russian territory |
| Carrier frequency (MHz) | 8077.5  8167.5  8257.5  8347.5 | 8 128.0; 8 320.0 | 8 225.0 | 8 192 and 8 335 | 8 128.0; 8 320.0 |
| Information data rate (Mbits/s) | 150; 300 | 123 | 1525 | 150; 300 | 61.44; 122.88 |
| Necessary bandwidth (MHz) | 62.9; 78.6; 94.4 | 123 | 270 | 62.9; 78.6; 105 | 123 |
| Modulation |  |  |  |  |  |
| Coding |  |  |  |  |  |
| Encoded data rate |  |  |  |  |  |
| Minimum elevation angle (degree) | 5 | 5 | 5 | 5 | 5 |
| Power supplied to the input of satellite antenna (dBW) | 7-2 | 11.2 | 7 | 3.5 | 4.5 |
| Satellite antenna radiation diagram/pattern | ITU-R S.672  (steerable) | isoflux | ITU-R S.672  (steerable) | ITU-R S.672  (steerable) | ITU-R S.672  (steerable) |
| Satellite antenna gain at nadir (dBi) | 4 | −3.5 | 0 |  |  |
| Satellite antenna maximum gain (dBi) | ±27.5 | ±67 degrees from nadir +6.5 | ±15 | 25 | 23.3 |
| Satellite antenna polarization | RHCP/ LHCP | Circular Right | RHCP/ LHCP | RHCP/ LHCP | Circular Right |
| Earth station antenna gain toward satellite (dBi) | 48.0 (3.8 m) 53.0 (7 m) | 48.0 (3.8 m) 53.0 (7 m) | 48.0 (3.8 m) 53.0 (7 m) | 50 | 49.4 |
| Earth station antenna polarization | RHCP/ LHCP | Circular Right | RHCP and LHCP | RHCP/ LHCP | RHCP |
| Earth station antenna radiation diagram/pattern | Rec. ITU-R  S.465-6 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 |
| Earth station receiver noise temperature (K) | 120 (3.8 m) 130 (7 m) | 120 (3.8 m) 130 (7 m) | 120 (3.8 m) 130 (7 m) | 150 | 150 |

TABLE C-4

Non-GSO EESS space-to-Earth parameters for systems in the band 8 025-8 400 MHz

| Function | Stored mission data | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Satellite system | Satellite AA | Satellite AC | Satellite AE | Satellite V | Satellite W | Satellite AD |
| Earth station(s) | Stations 1, 5, 6 and 18 | Stations 6 and 58 | Stations 5, 6 and 18 | Stations 5, 6, 10, 18, 58 and 65 | Stations 2, 5 and 6 | Stations 5 and 39 |
| Carrier frequency (MHz) | 8 040 | 8 100 | 8 100 | 8170 | 8090 | 8150 |
| Information data rate (Mbits/s) | 4.4 | 87.4 | 131 | 468 | 84.4 | 16.8 |
| Necessary bandwidth (MHz) | 15 | 75 | 120 | 270 | 100 | 18 |
| Modulation | Filtered OQPSK | QPSK | Filtered OQPSK | Filtered 8PSK | Filtered OQPSK | 8PSK |
| Coding | RS (255, 223) + Conv (1/2) | R-S (255,223) (I=5) | R-S (255,223) | RS (255,239) |  | RS (255,239) |
| Encoded data rate | 10 | 100 | 150 | 500 |  | 18 |
| Minimum elevation angle (degree) | 5 | 5 | 5 | 5 | 5 | 5 |
| Satellite antenna input power (dBW) | 3.5 | 14 | 6.2 | 16.2 | 10 | 6.1 |
| Satellite antenna radiation pattern | Isoflux | Isoflux | Isoflux | Isoflux | Isoflux | Isoflux |
| Satellite antenna gain toward nadir (dBi) | -3 | 1 | 2 | 2 | 2 | −6.5 |
| Satellite antenna maximum gain (dBi) | 4 | 2 | 4.4 | 5 | 3.5 | 3.5 |
| Satellite antenna polarization | RHCP | RHCP | RHCP | RHCP | RHCP | RHCP |
| Earth station antenna gain toward satellite (dBi) | 57.7 - 61 | 60 | 57.8 - 58.7 | 53.6 - 58.7 | 56.3 - 58.6 | 47 - 58.9 |
| Earth station antenna polarization | RHCP/LHCP | RHCP/ LHCP | RHCP/LHCP | RHCP/LHCP | RHCP/LHCP | RHCP/LHCP |
| Earth station antenna radiation diagram | ITU App.8 | ITU App.8 | ITU App.8 | ITU App.8 | ITU App.8 | ITU App.8 |
| Earth station receiver noise temperature (K) | 120-150 | 125 | 107/133 | 120-144.5 | 200-250 | 138-158 |

TABLE C-5

Non-GSO EESS space-to-Earth Parameters for systems in the band 8 025-8 400 MHz

| Function | Stored mission data | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Satellite system | Satellite AH | Satellite AI | Satellite Z | Satellite L | Satellite S | Satellite X |
| Earth station(s) | Station 2 | Stations 30, 31 and 32 | Station 8, 19,  20, 48 and 64 | Stations 19 and 20 | Station 5 | Stations 2 and 7 |
| Carrier frequency (MHz) | 8 225 | 8 190 | 8212 | 8 300 | 8 212.5 | 8 090 |
| Information data rate (Mbits/s) | 105 | 150 | 450 | 128 | 262 | 131 |
| Necessary bandwidth (MHz) | 105 | 150 | 375 |  | 300 | 120 |
| Modulation |  |  |  |  |  |  |
| Coding |  |  |  |  |  |  |
| Encoded data rate |  |  |  |  |  |  |
| Minimum elevation angle (degree) |  | 5 | 5 | 5 | 5 | 5 |
| Satellite antenna input power (dBW) | 4.7 | 16 | 10 | 17 | 9.8 | 16.2 |
| Satellite antenna radiation diagram |  | Isoflux | Directional |  |  | ND |
| Satellite antenna gain toward nadir (dBi) | Steerable antenna | 0 | 25 | −4 | Gimballed | −1 |
| Satellite antenna maximum gain (dBi) | 23.3 | 8.81 | 25 | 6.5 | 9.4 | 6 |
| Earth station antenna gain toward satellite (dBi) | 56.5 | 58 | Min 57.3 | 57.4 | 59.3 | 58.6 |
| Earth station antenna polarization |  |  | RHCP/LHCP | RHCP | RHCP | RHCP |
| Earth station antenna radiation diagram |  | Rec. ITU-R S.465-6 |  |  | AP7- Annex 3 | Rec. ITU-R S.465-6 |
| Earth station receiver noise temperature (K) | 190 | 470 | 100 | 155 | 282 | 120 |

TABLE C-6

Non-GSO EESS space-to-Earth parameters for systems in the band 8 025-8 400 MHz

| Function | Stored Mission Data | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Satellite system | Satellite AB | Satellite I | Satellite I1 | Satellite H | Satellite AG | Satellite J |
| Earth station(s) | Stations 5, 37 and 56 Worldwide | Worldwide | Worldwide | Stations 1, 2 and 3 | | |
| Carrier frequency (MHz) | 8 175 | 8 082.5  8 212.5  8 342.5 | 8 200.5 | 8 160 | 8 160 | 8 212.5 |
| Information data rate (Mbit/s) | 800 |  | 150 | 150 | 150 | 150 |
| Necessary bandwidth (MHz) | 275 |  |  |  |  |  |
| Modulation |  |  |  |  |  |  |
| Coding |  |  |  |  |  |  |
| Encoded data rate |  |  |  |  |  |  |
| Minimum elevation angle (degree) | 5 | 5 | 5 | 5 | 5 | 5 |
| Satellite antenna input power (dBW) | 5.6 | −1.46 | 15.9 | 11.18 | 12.5 | 10.6 |
| Satellite antenna radiation diagram | Horn | Directional | Isoflux | Isoflux | Isoflux | Isoflux |
| Satellite antenna gain toward nadir (dBi) | 17.8 | 26.2 | −3 | −4.1 | −4.1 | −6 |
| Satellite antenna maximum gain (dBi) | 17.8 | 26.2 | 7 | 6.8 | 6.8 | 6 |
| Satellite antenna polarization | RHCP | RHCP | LHCP | RHCP | RHCP | RHCP |
| Earth station antenna gain toward satellite (dBi) | 59.2 | 55 | 55 | 56.1 | 56.1 | 56.1 |
| Earth station antenna polarization | RHCP/ LHCP | RHCP | LHCP | RHCP | RHCP | RHCP |
| Earth station antenna radiation diagram | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 | Rec. ITU‑R S.465-6 |
| Earth station receiver noise temperature (K) | 163 | 185 | 185 | 125 | 125 | 190 |

TABLE C-7

Non-GSO EESS space-to-Earth Parameters for systems in the band 8 025-8 400 MHz

| Function | Stored Mission Data | | |
| --- | --- | --- | --- |
| Satellite system | Satellite AV, AW and AX | Satellite AH | Satellite AJ |
| Earth station(s) | Stations 5, 6, 18, 34, 47, 51 and 58 | Stations 5 and 58 | Stations 2 and 5 |
| Carrier frequency (MHz) | Two channels; F1: 8095 MHz and F2: 8260 MHz | 8150 | 8 275 |
| Information data rate (Mbit/s) | 262 per channel | 271 |  |
| Necessary bandwidth (MHz) | 140 MHz per channel | 233 | 160 |
| Modulation | 8PSK | Filtered OQPSK |  |
| Coding | R-S (255,239) | R-S (255,223) |  |
| Encoded data rate (Mbit/s) | 280 per channel | 310 |  |
| Minimum elevation angle (degree) | 5 | 5 | 5 |
| Satellite antenna input power (dBW) | 15.3 | 16 | 13 |
| Satellite antenna radiation diagram | Isoflux | Isoflux | Isoflux |
| Satellite antenna gain toward nadir (dBi) | 2 | 2 | -1 |
| Satellite antenna maximum gain (dBi) | 9 | 7 | 5 |
| Satellite antenna polarization | RHCP | RHCP | RHCP/LHCP |
| Earth station antenna gain toward satellite (dBi) | 54.8 | 54.6 | 57.8 |
| Earth station antenna polarization | RHCP/ LHCP | RHCP/ LHCP | RHCP/LHCP |
| Earth station antenna radiation diagram | ITU App. 8 | ITU App. 8 | Rec. ITU‑R S.465-6 |
| Earth station receiver noise temperature | 120 | 120 | 121 |

Annex D  
  
List of abbreviations and acronyms

8PSK Eight-level phase shift keying

A-DCS Advanced data collection system

AGC Automatic gain control

AHRPT Advanced high-resolution picture transmission

APT Automatic (or analogue)picture transmission

APSK Amplitude and phase shift keying, or asymmetric phase shift keying

ARGOS Name for satellite-based location and data collection system (Advanced Research and Global Observation Satellite)

BPSK Binary phase shift keying

CDA Command and data acquisition

CDARS Cooperative data and rescue service

CHRPT Colour high-resolution picture transmission

DCP Data collection platform

DCPC Data collection platform command

DCPIData collection platform interrogate

DCPR Data collection platform report

DCS Data collection system

DPSK Differential phase shift keying

DSSS Direct sequence spread spectrum

EESS Earth exploration-satellite service

e.i.r.p. Effective isotropic radiated power

EMWIN Emergency Managers Weather Information Network

FEC Forward error correction

FY Feng-Yun

GOES Geostationary Operational Environmental Satellite (USA)

GMSK Gaussian minimum shift keying

GSO Geosynchronous orbit

GVAR GOES variable data format

HRDCP High-rate data collection platform

HRIT High-rate information transmission

HRPT High-resolution picture transmission

ICARUS International Cooperation for Animal Research Using Space

LDPC Low-Density Parity-Check code

LEO Low Earth Orbit

LHCP Left Hand Circular Polarization

LRIT Low Rate Information Transmission

LRPTLow-Resolution Picture Transmission

LTAN Local Time Ascending Node

LTDN Local Time Descending Node

MDA Mission Data Acquisition

Metop Meteorological Operational Polar Satellite (EUMETSAT)

MetSat Meteorological Satellite (US)

MTGMeteosat Third Generation (EUMETSAT)

MTSAT Multifunctional Transport Satellite

NOAANational Oceanic and Atmospheric Administration (USA)

NRZ Non-Return to Zero (encoding)

OOBE Out-Of-Band-Emissions

OQPSK Offset Quadrature Phase Shift Keying

PCM Pulse Code Modulation

PFD Power Flux Density

PM Phase Modulation

PSK Phase Shift Keying

QPSK Quadrature Phase Shift Keying

RHCP Right Hand Circular Polarization

RS Reed Solomon (error correction code)

SCCC Serial Concatenated Convolutional Codes

SIDAR Solar Irradiance, Data and Rescue

SOQPSK-TG Shaped-Offset Quadrature Phase Keying

SSMA Spread Spectrum Multiple Access

TIROS Television Infrared Observation Satellite

TIP TIROS Information Processor

VCM Variable Coding Modulation

WMO World Meteorological Organization

1. This Report only addresses EESS transmission links. EESS (passive) and (active) sensors are described in different ITU-R RS-series documents under the purview of WP 7C. [↑](#footnote-ref-1)