|  |  |
| --- | --- |
| U.S. Radiocommunications Sector  Fact Sheet | |
| **Working Party:** ITU-R WP 5B | **Document No:** USWP5B25-04 |
| **Ref:** ITU-R 5B/712-E Annex 5 | **Date:** 7 October 2020 |
| **Document Title:** WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW REPORT/RECOMMENDATION ITU-R M.[UAS CNPC\_CHAR] - **Characteristics of unmanned aircraft system control and non-payload Earth stations for use with space stations operating in the Fixed Satellite Service** | |
| **Author(s)/Contributors(s):**  Name: Don Nellis  Org: Federal Aviation Administration  Name: Michael Neale  Org: ACES Corporation for the FAA | Phone: (202) 267-9779  Email: [Donald.Nellis@faa.gov](mailto:Donald.Nellis@faa.gov)  Phone: (858) 705-8978  Email: michael.neale@aces-inc.com |
| **Purpose/Objective:** The purpose of this contribution is to make updates to the version of the report/recommendation that was carried over without discussion during the July 2020 meeting of WP5B. | |
| **Abstract:** In accordance with Resolution **155 (WRC-19)** this report firstly identifies all of the satellite networks contained in the MIFR that have assignments that have been successfully coordinated under Article **9** of the Radio Regulations (RR) and have been notified and recorded in the MIFR with favorable finding in conformity with respect to RR Nos. **11.31, 11.32** or **11.32A** except those which are recorded under RR No. **11.32** by applying Appendix **5** § 6.d. It then evaluates the maximum, 90%ile average, mode, 10%ile and minimum values of the parameters of various characteristics of these systems. This report, in accordance with the Draft Guidelines for Implementation of Resolution **155 (WRC-15)** (Annex 1 to 5B/712), then compares the CNPC link characteristics of the example systems, provided by administrations, with these satellite network characteristics to determine if those CNPC link characteristics fit within the satellite network envelope of characteristics so proving that the CNPC links can be used with the FSS. | |

|  |  |
| --- | --- |
| **Radiocommunication Study Groups** |  |
|  |  |
|  |  |
| Source: Document 5B/712, Annex 5  Subject: Resolution **155 (Rev.WRC-19)** | **Document 5B/XXX** |
| **November 2020** |
| **English only** |
| **United Sates of America** | |
| WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW REPORT/RECOMMENDATION ITU-R M.[UAS CNPC\_CHAR]  **Characteristics of unmanned aircraft system control and non-payload Earth stations for use with space stations operating in the Fixed Satellite Service**  **Introduction**  Both ITU-R (WP) 5B and ICAO require information on the characteristics of UAS CNPC links when they are operated in spectrum allocated to the Fixed Satellite Service in accordance with Resolution **155 (Rev.WRC-19)** and Agenda Item 1.8 **(WRC-23)**.  WP 5B is assessing the conformity of these proposed CNPC Links with current FSS systems.  ICAO is developing Standards and Recommended Practices (SARPs) for the use of UAS CNPC Links in non-segregated airspace and as part of that work has to assess the performance required of these links to ensure adequate levels of safety are met.  **Proposal**  This contribution from the United States of America proposes to continue the development of the Report that was begun in the last study cycle to assist in determination of these required CNPC Link characteristics and their parameter values. This report is one of the three described in Annex 1 to 5B/712. Specifically, it addresses the steps that are the development of the “envelope of satellite network characteristics” selected from all of the satellite networks that are recorded in the MIFR that are in accordance with criteria identified in Resolution **155 (Rev.WRC-19)**. | |

attachment

WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW REPORT/RECOMMENDATION ITU-R M.[UAS CNPC\_CHAR]

**Characteristics of unmanned aircraft system control and non-payload Earth stations for use with space stations operating in the Fixed Satellite Service**

**1 Introduction and scope**

Resolution **155 (Rev.WRC-19)** resolves, that assignments to stations of geostationary FSS satellite networks operating in the frequency bands 10.95-11.2 GHz (space-to-Earth), 11.45-11.7 GHz (space‑to-Earth), 11.7‑12.2 GHz (space-to-Earth) in Region 2, 12.2-12.5 GHz (space-to-Earth) in Region 3, 12.5‑12.75 GHz (space-to-Earth) in Regions 1 and 3 and 19.7-20.2 GHz (space-to-Earth), and in the frequency bands 14-14.47 GHz (Earth-to-space) and 29.5-30.0 GHz (Earth-to-space), may be used for unmanned aircraft system (UAS) control and non-payload communication (CNPC) Links in non-segregated airspace, provided that the conditions specified in *resolves* are met. *Resolves* 19 states:

*19 that ITU Radiocommunication Sector (ITU‑R) studies on technical, operational and regulatory aspects in relation to the implementation of this resolution shall be completed, together with the adoption of relevant ITU‑R Recommendations defining the technical characteristics of CNPC Links and conditions of sharing with other services.*

In accordance to the above *resolves*, the following content contains information on characteristics of UAS CNPC link/Earth station for future regulatory studies on performance requirements for UAS CNPC links.

In order to determine the required CNPC Link characteristics and their parameter values, this report consists of four sections that contain studies as indicated below:

1 Identify all satellite networks recorded in the MIFR in conformity with criteria identified in Resolution **155 (Rev.WRC-19).**

2 Identify the sensitive/critical satellite network parameters that are required in order to determine the generic envelope of satellite network characteristics from the above satellite networks.

3 Extract values of the selected parameters from the MIFR and provide a tool to assist party members in making an extraction of these characteristics values from the MIFR.

4 Compile UAS CNPC earth stations characteristics and their parameter values from those submitted to WP 5B by its members in order to finalize characteristics for UAS CNPC in application of Resolution **155 (Rev.WRC-19)**.

5 Compare the characteristics and their parameter values in 3) with those in 4) to determine if the proposed characteristics of the UAS CNPC earth stations in 4) fit with the characteristics of the specific and/or typical earth stations for the satellite networks described in 3) to determine that UAS CNPC earth stations intended to communicate with satellite networks mentioned in 2) above are in compliance with Resolution **155 (Rev.WRC-19)**.

**2 Abbreviations**

*[Note: To be discussed]*

**3 Selection of fixed service satellite networks in conformity with criteria identified in Resolution 155 (Rev.WRC-19)**

Resolution **155 (Rev.WRC-19)** identifies a number of criteria that satellite networks need to comply with in order to be used for the support of UAS CNPC links.

At a minimum, these networks must:

a) Have assignments that have been successfully coordinated under Article **9** of the Radio Regulations (RR).

b) Have been notified and recorded in the MIFR with favorable finding in conformity with respect to RR Nos. **11.31**, **11.32** or **11.32A** except those which are recorded under RR No. **11.32** by applying Appendix **5** § 6.d.

The database in International Frequency Information Circular (IFIC) 2861 issued on 09.01.2018 was analyzed using Query’s to filter out information only for satellite networks that complied with a) and b) above. In addition only those networks with all frequency assignments without findings under RR No. **11.41** i.e. meeting b) above are included as some networks had groups of findings under RR No. **11.41** even though other groups for the same satellite network had not.

Since Resolution **155 (Rev.WRC-19)** focusses on specific frequency bands the following analysis was performed over those frequency bands namely, in the frequency bands 10.95-11.2 GHz (space-to-Earth), 11.45-11.7 GHz (space-to-Earth), 11.7-12.2 GHz (space-to-Earth) in Region 2, 12.2‑12.5 GHz (space-to-Earth) in Region 3, 12.5-12.75 GHz (space-to-Earth) in Regions 1 and 3 and 19.7-20.2 GHz (space-to-Earth), and in the frequency bands 14-14.47 GHz (Earth-to-space) and 29.5-30.0 GHz (Earth-to-space). In all of the following analysis the 10.95-11.2 GHz (space-to-Earth), 11.45-11.7 GHz (space-to-Earth), 11.7-12.2 GHz (space-to-Earth) in Region 2, 12.2‑12.5 GHz (space-to-Earth) in Region 3, 12.5-12.75 GHz (space-to-Earth) and 14-14.47 GHz (Earth-to-space) frequency bands will be considered as one group referred to as the 14/11 GHz frequency band and the 19.7-20.2 GHz (space-to-Earth), and 29.5-30.0 GHz (Earth-to-space) bands will also be considered as one group referred to as the 30/20 GHz band.

Additionally, although the coordination of satellite networks described above was the first down selection criteria, for the Characteristics required by ITU-R, only information on the associated specific and typical Earth stations (see *resolves* 5 of Resolution **155 (Rev.WRC-19)**) associated with those networks was subsequently analyzed because it is the Earth station characteristics that must be compared to the proposed CNPC Link (Earth station) characteristics. Furthermore, it is a basic assumption in Resolution **155 (Rev.WRC-19)** (see *resolves* 4, 5, 9 and 10) that no changes can be made to the space station of the satellite network when supporting UAS CNPC links since that would require their re-coordination.

Every record in the IFIC database is identified using the ntc\_id (notice identification) Data Item described in the BR IFIC Preface. The IFIC database is comprised of many data Tables containing various Fields associated with each ntc\_id record. Each Table is related to others through the use of a Primary Key (at least one in each Table) that enables retrieval of the related data from the other Tables described in the desired Query.

Table 1 lists the database Tables and Data Items used in the initial filtering described above.

Table 1

**Data Items used to filter only those satellite networks that comply with Resolution 155 (Rev.WRC-19)**

|  |  |  |
| --- | --- | --- |
| **IFIC table name** | **IFIC data item** | **Preface description** |
| **notice** | ntc\_id | Unique identifier of the notice |
| **grp** | freq\_min | Minimum frequency in MHz of all of the frequencies for this group |
| **grp** | freq\_max | Maximum frequency in MHz of all of the frequencies for this group |
| **provn** | coord\_prov | Compliance with RR No. **9.7** or RR No. **1600** |
| **provn** | coord\_prov | Compliance with RR No. **11.32** |
| **provn** | coord\_prov | Compliance with RR No. **11.32A** |
| **provn** | coord\_prov | Not using RR Nos. **11.41**, **11.31.1** or Appendix **5** § 6.d |

After this initial filtering had been performed 424 Earth stations in the 14/11 GHz frequency bands were identified associated with 166 satellite networks. For the 30/20 GHz band 97 Earth stations in the 30/20 GHz frequency bands were identified associated with approximately 62 satellite networks.

The list of satellite networks is included in the Zip file attached in section 5.1.

**4 Selection of sensitive/critical satellite network parameters**

The list of parameters to consider the generic envelope of satellite network characteristics for those satellite networks that conform to the various resolves in Resolution **155 (Rev.WRC-19)** was prepared during the study and was then reviewed by the Radiocommunication Bureau.

The full list of items in RR Appendix **4** were reviewed and those items that were considered as sensitive/critical parameters in this application are indicated with an X in the 4th column “Sensitive/critical parameters”.

**Key to the symbols used in Tables 2, 3, 4**

|  |  |
| --- | --- |
| X | Mandatory information |
| + | Mandatory under the conditions specified in Column 3 of Table 1 and Column 2 of Table 2 |
| O | Optional information |
| C | Mandatory if used as a basis to effect coordination with another administration |
|  | The data item is not applicable to the corresponding notice |

**Additional Keys:**

|  |  |
| --- | --- |
| B | Data is used for No. **11.32A** examination (where applicable, e.g. assignment is subject to No. **9.7**) |

*[Chairman’s note: The format of the following tables seems inconsistent e.g. starting with A.4, going from B.1 to B.1.b, some lines at the level of X.N being headlines whilst others are not. Is this because the rows need to be consistent with other Recommendations/RR?.*

Table 2

**General characteristics of the satellite network, Earth station or   
radio astronomy station (Rev. WRC-15)**

| **1** | **2** | **3** | **4** |
| --- | --- | --- | --- |
| **Items in Appendix** | ***A \_* General characteristics of the satellite network, Earth station or radio astronomy station** | **Notification or coordination of a geostationary-satellite network** | **Sensitive/　critical parameters** |
| **A.4** | **Orbital information** |  |
| A.4.a | **For a space station onboard a geostationary-satellite:** |  |  |
| A.4.a.1 | the nominal geographical longitude on the geostationary-satellite orbit (GSO) | **X B** |  |
| A.4.a.2 | **Orbital tolerances** |  |  |
| A.4.a.2.a | the planned longitudinal tolerance easterly limit | **X B** |  |
| A.4.a.2.b | the planned longitudinal tolerance westerly limit | **X B** |  |
| A.4.a.2.c | the planned inclination excursion | **X** |  |

TABLE 3

**Characteristics to be provided for each satellite antenna beam or   
each Earth station or radio astronomy antenna (Rev. WRC‑15)**

| **1** | **2** | **3** | **4** |
| --- | --- | --- | --- |
| **Items in Appendix** | **B \_ Characteristics to be provided for each satellite antenna beam or**  **each Earth station or radio astronomy antenna** | **Notification or coordination of a geostationary-satellite network** | **Sensitive/　critical parameters** |
| **B.1** | **Identification and direction of the satellite antenna beam** |  |
| B.1.b | an indicator showing whether the antenna beam, under B.1.a, is fixed or whether it is steerable and / or reconfigurable | **X** | **X** |
| **B.2** | **Transmission / reception indicator for the beam of the space station or the associated space station** | **X B** | **X** |
| **B.3** | **Space station antenna characteristics** |  |  |
| B.3.a | **For each space station antenna:** |  |  |
| B.3.a.1 | the maximum co-polar isotropic gain, in dBi  Where a steerable beam (see No. **1.191**) is used, if the effective boresight area (see No. **1.175**) is identical with the global service area, the maximum antenna gain, in dBi, is applicable to all points on the Earth’s visible surface | **X B** | **X** |
| B.3.b | **Antenna gain contours:** |  |  |
| B.3.b.1 | the co-polar antenna gain contours plotted on a map of the Earth’s surface, preferably in a radial projection from the satellite onto a plane perpendicular to the axis from the centre of the Earth to the satellite  The space station antenna gain contours shall be drawn as isolines of the isotropic gain, at least for −2, −4, −6, −10 and −20 dB and at 10 dB intervals thereafter, as necessary, relative to the maximum antenna gain, when any of these contours is located either totally or partially anywhere within the limit of visibility of the Earth from the given geostationary satellite  Whenever possible, the gain contours of the space station antenna should also be provided in a numerical format (e.g. equation or table)  Where a steerable beam (see No. **1.191**) is used, if the effective boresight area (see No. **1.175**) is less than the global service area, the contours are the result of moving the boresight of the steerable beam around the limit defined by the effective boresight area and are to be provided as described above but shall also include the 0 dB relative gain isoline. In addition, for a steerable beam, except for the case of Appendix **30B**, see also No. **21.16** (and its associated Rules of Procedure)  The antenna gain contours shall include the effects of the planned inclination excursion, longitudinal tolerance and the planned pointing accuracy of the antenna  *Note* – Taking due account of applicable technical restrictions and allowing some reasonable degree of flexibility for satellite operations, administrations should, to the extent practicable, align the areas the satellite steerable beams could cover with the service area of their networks with due regard to their service objectives.  In the case of Appendix **30**, **30A** or **30B**, required only for non-elliptical beams | **X B** |  |
| B.3.c | **Antenna radiation patterns:** |  |  |
| B.3.c.1 | the co-polar antenna radiation pattern | **+** |  |
| In the case of geostationary space stations required only where the antenna radiation beam is directed towards another satellite  In the case of Appendix **30**, **30A** or **30B**, required only for elliptical antenna beams |  |
| B.3.d | the pointing accuracy of the antenna  In the case of Appendix **30**, **30A** or **30B**, required only for elliptical beams | **X** | **X** |
| B.3.e | if the space station is operating in a frequency band allocated in the Earth-to-space direction and in the space-to-Earth direction, the gain of the antenna in the direction of those parts of the geostationary-satellite orbit which are not obstructed by the Earth.  In the case of Appendix **30**, required only in the frequency band 12.5‑12.7 GHz | **+ B** |  |

Table 4

**Characteristics to be provided for each group of frequency assignments for a satellite antenna beam   
or an Earth station or radio astronomy antenna (Rev.WRC‑15)**

| **1** | **2** | **3** | **4** |
| --- | --- | --- | --- |
| **Items in Appendix** | ***C \_* Characteristics to be provided for each group of frequency assignments for a satellite antenna beam or an Earth station or radio astronomy antenna** | **Notification or coordination of a geostationary-satellite network** | **Sensitive/　critical parameters** |
| **C.2** | **Assigned frequency (frequencies)** |  |
| C.2.a.1 | the assigned frequency (frequencies), as defined in No. **1.148**  – in kHz up to 28 000 kHz inclusive  – in MHz above 28 000 kHz to 10 500 MHz inclusive  – in GHz above 10 500 MHz  If the basic characteristics are identical, with the exception of the assigned frequency, a list of frequency assignments may be provided  In the case of advance publication, required only for active sensors  In the case of geostationary and non geo-stationary satellite networks, required for all space applications except passive sensors  In the case of Appendix **30B**, required only for notification under Article 8 | **+ B** |  |
| C.2.c | if the frequency assignment is to be filed under No. **4.4**, an indication to that effect | **+** |  |
| **C.3** | **Assigned frequency band** |  |
| C.3.a | the bandwidth of the assigned frequency band, in kHz (see No. **1.147**)  In the case of advance publication, required only for active sensors  In the case of geostationary and non geo-stationary satellite networks, required for all space applications except passive sensors  In the case of Appendix **30B**, required only for notification under Article 8 | **+ B** | **X** |
| **C.4** | **Class of station and nature of service** |  |
| C.4.a | the class of station, using the symbols from the Preface | **X B** |  |
| C.4.b | the nature of service performed, using the symbols from the Preface | **X** |  |
| **C.5** | **Receiving system noise temperature** |  |
| C.5.a | the lowest total receiving system noise temperature, in kelvins, referred to the output of the receiving antenna of the space station  In the case of satellite networks, required for all space applications except for active or passive sensors | **+ B** | **X** |
| **C.6** | **Polarization** |  |
| C.6.a | the type of polarization (see the Preface)  In the case of circular polarization, this includes the sense of polarization (see Nos. **1.154** and **1.155**)  In the case of a space station submitted in accordance with Appendix **30** or **30A**, see § 3.2 of Annex 5 to Appendix **30** | **X** | **X** |
| C.6.b | if linear polarization is used, the angle, in degrees, measured counter-clockwise in a plane normal to the beam axis from the equatorial plane to the electric vector of the waves as seen from the satellite  In the case of a space station submitted in accordance with Appendix **30** or **30A**, see § 3.2 of Annex 5 to Appendix **30** | **+** |  |
| **C.7** | **Necessary bandwidth and class of emission**  *(in accordance with Article****2*** *and Appendix****1****)*  For advance publication of a non-geostationary-satellite network not subject to coordination under Section II of Article **9**, changes to this information within the limits specified under C.1 shall not affect consideration of notification under Article **11**  Not required for active or passive sensors |  |
| C.7.a | the necessary bandwidth and the class of emission: for each carrier  In the case of Appendix **30B**, required only for notification under Article 8 | **X B** | **X** |
| C.7.b | the carrier frequency or frequencies of the emission(s) | **C** |  |
| **C.8** | **Power characteristics of the transmission**  *Not required for passive sensors* |  |
| C.8.a | **For the case where individual carriers can be identified:** |  |  |
| C.8.a.1 | the maximum value of the peak envelope power, in dBW, supplied to the input of the antenna for each carrier type  Required if neither C.8.b.1 nor C.8.b.3.a is provided | **+ B** | **X** |
| C.8.a.2 | the maximum power density, in dB(W/Hz), supplied to the input of the antenna for each carrier type2  In the case of Appendix**30B**, required only for notification under Article 8  Required if neither C.8.b.2 nor C.8.b.3.b is provided | **+ B** | **X** |
| C.8.b | **For the case where it is not appropriate to identify individual carriers:** |  |  |
| C.8.b.1 | the total peak envelope power, in dBW, supplied to the input of the antenna  For coordination or notification of an Appendix **30A** earth station the values shall include the maximum range of power control  Required if neither C.8.a.1 nor C.8.b.3.a is provided | **+ B** | **X** |
| C.8.b.2 | the maximum power density, in dB(W/Hz), supplied to the input of the antenna2  For coordination or notification of an Appendix **30A** earth station the values shall include the maximum range of power control  In the case of Appendix **30B**, required only for submission under Article 6  Required if neither C.8.a.2 nor C.8.b.3.b is provided | **+ B** | **X** |
| C.8.c | **For all space applications, except active or passive sensors:** |  |  |
| C.8.c.1 | the minimum value of the peak envelope power, in dBW, supplied to the input of the antenna for each carrier type  If not provided, the reason for absence under C.8.c.2 | **+** |  |
| C.8.c.2 | if C.8.c.1 is not provided, the reason for absence of the minimum value of the peak envelope power | **+** |  |
| C.8.c.3 | the minimum power density, in dB(W/Hz), supplied to the input of the antenna for each carrier type2  If not provided, the reason for absence under C.8.c.4 | **+** | **X** |
| C.8.c.4 | if C.8.c.3 is not provided, the reason for absence of the minimum power density | **+** |  |
| C.8.d.1 | the maximum total peak envelope power, in dBW, supplied to the input of the antenna for each contiguous satellite bandwidth  For a satellite transponder, this corresponds to the maximum saturated peak envelope power  Required only for a space-to-Earth or space-to-space link | **+ B** | **X** |
| C.8.d.2 | each contiguous satellite bandwidth  For the maximum saturated peak envelope power of the satellite transponder, this corresponds to the bandwidth of each transponder  Required only for a space-to-Earth or space-to-space link, if different from item C.3.a | **+** |  |
| C.8.e.1 | for space-to-Earth, Earth-to-space or space-to-space links. for each carrier type, the greater of either the carrier-to-noise ratio, in dB, required to meet the performance of the link under clear-sky conditions or the carrier-to-noise ratio, in dB, required to meet the short-time objectives of the link inclusive of necessary margins  If not provided, the reason for absence under C.8.e.2 | **+ B** | **X** |
| C.8.e.2 | if C.8.e.1 is not provided, the reason for absence of the carrier-to-noise ratio | **+** |  |
| C.8.g.1 | the maximum aggregate power, in dBW, of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station  Not required for coordination of a specific earth station under Nos. **9.15**, **9.17** or **9.17A** | **C B** | **X** |
| C.8.g.2 | the aggregate bandwidth of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station  Not required for coordination of a specific earth station under Nos. **9.15**, **9.17** or **9.17A** | **C** | **X** |
| C.8.g.3 | an indicator showing whether the bandwidth of the transponder corresponds to the aggregate bandwidth of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station  Not required for coordination of a specific earth station under Nos. **9.15**, **9.17** or **9.17A** | **C** |  |
| **C.9** | **Information on modulation characteristics**  *For all space applications except active or passive sensors* |  |
| C.9.a | **For each carrier, according to the nature of the signal modulating the carrier:** |  |  |
| C.9.a.1 | the type of modulation  In the case of a non-geostationary space station required only for Nos. **9.11A**, **9.12** or **9.12A** | **C** |  |
| C.9.a.2 | **For a carrier frequency modulated by a frequency-division multichannel telephony baseband (FDM/FM) or by a signal that can be represented by a multichannel telephony baseband:** |  |  |
| C.9.a.2.a | the lowest frequency of the baseband | **C** |  |
| C.9.a.2.b | the highest frequency of the baseband | **C** |  |
| C.9.a.2.c | the r.m.s. frequency deviation of the pre-emphasized signal for a test tone as a function of baseband frequency | **C** |  |
| C.9.a.3 | **For a carrier frequency modulated by a television signal:** |  |  |
| C.9.a.3.a | the peak-to-peak frequency deviation of the pre-emphasized signal | **C** |  |
| C.9.a.3.b | the pre-emphasis characteristic | **C** |  |
| C.9.a.3.c | if applicable, the characteristics of the multiplexing of the video signal with the sound signal(s) or other signals | **C** |  |
| C.9.a.4 | **For a carrier phase-shift modulated by a digital signal:** |  |  |
| C.9.a.4.a | the bit rate | **C** |  |
| C.9.a.4.b | the number of phases | **C** |  |
| C.9.a.5 | **For an amplitude modulated carrier (including single sideband):** |  |  |
| C.9.a.5.a | the nature of the modulating signal, as precisely as possible | **C** |  |
| C.9.a.5.b | the kind of amplitude modulation used | **C** |  |
| C.9.a.6 | **For a frequency modulated carrier:** |  |  |
| C.9.a.6.a | the peak-to-peak frequency deviation, in MHz, of the energy dispersal waveform | **C** |  |
| C.9.a.6.b | the sweep frequency, in kHz, of the energy dispersal waveform | **C** |  |
| C.9.a.6.c | the energy dispersal waveform | **C** |  |
| C.9.a.7 | if other forms of modulation than frequency modulation, are being used, the type of energy dispersal | **C** |  |
| C.9.a.8 | for all other types of modulation, such particulars as may be useful for an interference study | **C** |  |
| C.9.a.9 | the TV standard | **C** |  |
| **C.10** | **Type and identity of the associated station(s)**  *(the associated station may be another space station, a typical earth station of the network or a specific earth station)*  *For all space applications except active or passive sensors* |  |
| C.10.b | **For an associated earth station:** |  |  |
| C.10.b.1 | the name of the station | **X** |  |
| C.10.b.2 | the type of station (specific or typical) | **X B** | **X** |
| C.10.c | **For a specific associated earth station:** |  |  |
| C.10.c.1 | the geographical coordinates of the antenna site | **X B** |  |
| C.10.c.2 | the country or geographical area in which the earth station is located, using the symbols from the Preface | **X** |  |
| C.10.d | **For an associated earth station (whether specific or typical):** |  |  |
| C.10.d.1 | the class of station, using the symbols from the Preface | **X** |  |
| C.10.d.2 | the nature of service performed, using the symbols from the Preface | **X** |  |
| C.10.d.3 | the isotropic gain, in dBi, of the antenna in the direction of maximum radiation (see No. **1.160**) | **X B** | **X** |
| C.10.d.4 | the beamwidth, in degrees, between the half-power points (described in detail if not symmetrical) | **X B** | **X** |
| C.10.d.5.a | either the measured co-polar radiation pattern of the antenna or the co-polar reference radiation pattern | **X B** | **X** |
| C.10.d.6 | if the associated station is a receiving earth station, the lowest total receiving system noise temperature, in kelvins, referred to the output of the receiving antenna of the earth station under clear-sky conditions | **+ B** | **X** |
| C.10.d.7 | the antenna diameter, in metres  In cases other than Appendix **30A**, required for fixed-satellite service networks operating in the frequency bands 13.75-14 GHz, 14.5-14.75 GHz (in countries listed in Resolution **163 (WRC‑15)** not for feeder links for the broadcasting-satellite service), 14.5-14.8 GHz (in countries listed in Resolution **164 (WRC‑15)** not for feeder links for the broadcasting-satellite service), 24.65‑25.25 GHz (Region 1) and 24.65-24.75 GHz (Region 3) and for maritime mobile-satellite service networks operating in the frequency band 14‑14.5 GHz | **+ B** | **X** |
| C.10.d.9 | antenna dimension aligned with the geostationary arc (*DGSO*), in metres (see the most recent version of Recommendation ITU‑R S.1855)  except in the case of Appendix **30** or **30A** | **O B** |  |
| **C.11** | **Service area(s)**  *For all space applications except active or passive sensors* |  |
| C.11.a | the service area or areas of the satellite beam on the Earth, when the associated transmitting or receiving stations are earth stations  For a space station submitted in accordance with Appendix **30**, **30A** or **30B**, the service area identified by a set of a maximum of 100 test points and by a service area contour on the surface of the Earth or defined by a minimum elevation angle  *Note* – When an assignment converted from an allotment is reinstated in the Appendix **30B** Plan, the notifying administration may choose a maximum of 20 test points within its national territory for the reinstated allotment | **X B** |  |

**5 Extraction of the envelope characteristics of each sensitive/critical satellite network parameters**

**5.1 Extracted values**

The following two tables contain statistical analysis of the values for the parameters addressed in Section 4 for the satellite networks addressed in section 3 for both the 14/11 GHz and 30/20 GHz frequency bands.

All the values of the parameters addressed in Section 4 for all the satellite networks addressed in section 3 are contained in the Zip file attached below.

attachment temporarily removed to reduce file size

Table 5

**14/11 GHz Envelope characteristics**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Items in Appendix** | **B \_ Characteristics to be provided for each satellite antenna beam or each Earth station or radio astronomy antenna** | **Table and Data Item** | E or  R | **Max** | **90%** | **Average** | **10%** | **Min** |
| **B.1** | **Identification and direction of the satellite antenna beam** |  |  |  |  |  |  |  |
| B.1.b | an indicator showing whether the antenna beam, under B.1.a, is fixed or whether it is steerable and / or reconfigurable | **s\_beam**  f\_steer | E | 17.9% are steerable | | | | |
| R | 19.6% are steerable | | | | |
| **B.2** | **Transmission / reception indicator for the beam of the space station or the associated space station** | **s\_beam**  emi\_rcp | E or  R | Used to select E or R for the parameters in this table | | | | |
| **B.3** | **Space station antenna characteristics** |  |  |  |  |  |  |  |
| **B.3.a** | **For each space station** |  |  |  |  |  |  |  |
| B.3.a.1 | the maximum co-polar isotropic gain, in dBi  Where a steerable beam (see No. **1.191**) is used, if the effective boresight area (see No. **1.175**) is identical with the global service area, the maximum antenna gain, in dBi, is applicable to all points on the Earth’s visible surface | **s\_beam**  gain | E | 45.2 | 41.8 | 37.3 | 32.0 | 16.5 |
| R | 47.8 | 41.0 | 35.8 | 30.0 | 23.8 |
| B.3.d | the pointing accuracy of the antenna  In the case of Appendix **30**, **30A** or **30B**, required only for elliptical beams | **s\_beam**  pnt\_acc | E | 0.70 | 0.20 | 0.15 | 0.05 | 0.03 |
| R | 0.70 | 0.30 | 0.13 | 0.05 | 0.05 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Items in Appendix** | **C \_ Characteristics to be provided for each group of frequency assignments for a satellite antenna beam or an Earth station or radio astronomy antenna** | **Data Item and Table** | E or  R | **Max** | | **90%** | | **Average** | | | | **10%** | | **Min** | |
| **C.3** | **Assigned frequency band** |  |  |  | |  | |  | | | |  | |  | |
| C.3.a | the bandwidth of the assigned frequency band, in kHz (see No. **1.147**)  In the case of advance publication, required only for active sensors  In the case of geostationary and non geo-stationary satellite networks, required for all space applications except passive sensors  In the case of Appendix **30B**, required only for notification under Article 8 | **grp**  bdwdth | E | 996000 | | 85000 | | 59957 | | | | 27000 | | 1 | |
| R | 500000 | | 85000 | | 64386 | | | | 30000 | | 1000 | |
| **C.5** | **Receiving system noise temperature** |  |  |  | |  | |  | | | |  | |  | |
| C.5.a | the lowest total receiving system noise temperature, in kelvins, referred to the output of the receiving antenna of the space station  In the case of satellite networks, required for all space applications except for active or passive sensors | **grp**  noise\_t | E | N/A | | N/A | | N/A | | | | N/A | | N/A | |
| R | 4000 | | 1600 | | 970 | | | | 600 | | 450 | |
| **C.6** | **Polarization** |  |  |  | |  | |  | | | |  | |  | |
| C.6.a | the type of polarization (see the Preface)  In the case of circular polarization, this includes the sense of polarization (see Nos. **1.154** and **1.155**)  In the case of a space station submitted in accordance with Appendix **30** or **30A**, see § 3.2 of Annex 5 to Appendix **30** | **grp**  polar\_type | E | H =  20.4% | V =  20.2% | | CR =  0.1% | | CL =  0.0% | | D =  0.2% | | M =  32.6% | | L =  18.5% |
| R | H =  15.9% | V =  15.9% | | CR =  0.0% | | CL =  0.0% | | D =  0.2% | | M =  14.3% | | L =  5.5% |
| **C.7** | **Necessary bandwidth and class of emission** |  |  |  | |  | |  | | | |  | |  | |
| C.7.a | the necessary bandwidth and the class of emission: for each carrier  In the case of Appendix **30B**, required only for notification under Article 8 | **emiss**  design\_emi | E | 996M | | - | | - | | | | - | | 1K00 | |
| R | 241M | | - | | - | | | | - | | 1K00 | |
| **C.8** | **Power characteristics of the transmission** |  |  |  | |  | |  | | | |  | |  | |
| **C.8.a** | **For the case where individual carriers can be identified:** |  |  |  | |  | |  | | | |  | |  | |
| C.8.a.1 | the maximum value of the peak envelope power, in dBW, supplied to the input of the antenna for each carrier type  Required if neither C.8.b.1 nor C.8.b.3.a is provided | **emiss**  pep\_max | E | 35.2 | | 17.8 | | 4.3 | | | | -15.1 | | -37.3 | |
| R | 48.8 | | 34.9 | | 18.3 | | | | -0.7 | | -29.5 | |
| C.8.a.2 | the maximum power density, in dB(W/Hz), supplied to the input of the antenna for each carrier type2  In the case of Appendix**30B**, required only for notification under Article 8  Required if neither C.8.b.2 nor C.8.b.3.b is provided | **emiss**  pwr-ds\_max | E | -33.0 | | -48.7 | | -56.5 | | | | -64.6 | | -82.2 | |
| R | -19.8 | | -36.0 | | -43.5 | | | | -54.7 | | -75.7 | |
| **C.8.b** | **For the case where it is not appropriate to identify individual carriers:** |  |  |  | |  | |  | | | |  | |  | |
| C.8.b.1 | the total peak envelope power, in dBW, supplied to the input of the antenna  For coordination or notification of an Appendix **30A** earth station the values shall include the maximum range of power control  Required if neither C.8.a.1 nor C.8.b.3.a is provided | **emiss**  pep\_max | E | 35.2 | | 17.8 | | 4.3 | | | | -15.1 | | -37.3 | |
| R | 48.8 | | 34.9 | | 18.3 | | | | -0.7 | | -29.5 | |
| C.8.b.2 | the maximum power density, in dB(W/Hz), supplied to the input of the antenna2  For coordination or notification of an Appendix **30A** earth station the values shall include the maximum range of power control  In the case of Appendix **30B**, required only for submission under Article 6  Required if neither C.8.a.2 nor C.8.b.3.b is provided | **emiss**  pwr-ds\_max | E | -33.0 | | -48.7 | | -56.5 | | | | -64.6 | | -82.2 | |
| R | -19.8 | | -36.0 | | -43.5 | | | | -54.7 | | -75.7 | |
| C.8.c | **For all space applications, except active or passive sensors:** |  |  |  | |  | |  | | | |  | |  | |
| C.8.c.3 | the minimum power density, in dB(W/Hz), supplied to the input of the antenna for each carrier type  If not provided, the reason for absence under C.8.c.4 | **emiss**  pwr\_ds\_min | E | -33.5 | | -56.7 | | -66.1 | | | | -75.4 | | -110.7 | |
| R | -30.0 | | -45.5 | | -59.3 | | | | -71.7 | | -94.1 | |
| C.8.d.1 | the maximum total peak envelope power, in dBW, supplied to the input of the antenna for each contiguous satellite bandwidth  For a satellite transponder, this corresponds to the maximum saturated peak envelope power  Required only for a space-to-Earth or space-to-space link | **grp**  pwr\_max | E | 38.3 | | 29.2 | | 18.2 | | | | 10.8 | | -21.0 | |
| R | 42.0 | | 39.6 | | 34.6 | | | | 27.0 | | 0.0 | |
| C.8.e.1 | for space-to-Earth, Earth-to-space or space-to-space links. for each carrier type, the greater of either the carrier-to-noise ratio, in dB, required to meet the performance of the link under clear-sky conditions or the carrier-to-noise ratio, in dB, required to meet the short-time objectives of the link inclusive of necessary margins  If not provided, the reason for absence under C.8.e.2 | **emiss**  c\_to\_n | E | 33.7 | | 16.0 | | 12.5 | | | | 8.5 | | -20.0 | |
| R | 30.0 | | 17.0 | | 12.6 | | | | 7.9 | | 2.8 | |
| C.8.g.1 | the maximum aggregate power, in dBW, of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station  Not required for coordination of a specific earth station under Nos. **9.15**, **9.17** or **9.17A** | **grp**  pwr\_max | E | 38.3 | | 29.2 | | 18.2 | | | | 10.8 | | -21.0 | |
| **e\_as\_stn**  pwr\_max | R | 19.8 | | 19.0 | | 15.6 | | | | 9.1 | | 8.2 | |
| C.8.g.2 | the aggregate bandwidth of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station  Not required for coordination of a specific earth station under Nos. **9.15**, **9.17** or **9.17A** | **grp**  bdwdth\_aggr | E | 700000 | | 250000 | | 95209 | | | | 36000 | | 10 | |
| **e\_as\_stn**  bdwdth\_aggr | R | 250000 | | 250000 | | 250000 | | | | 250000 | | 250000 | |
| **C.10** | **Type and identity of the associated station(s)**  *(the associated station may be another space station, a typical earth station of the network or a specific earth station)*  *For all space applications except active or passive sensors* |  |  |  | |  | |  | | | |  | |  | |
| C.10.b | **For an associated earth station:** |  |  |  | |  | |  | | | |  | |  | |
| C.10.b.2 | the type of station (specific or typical) | **e\_as\_stn**  stn\_type | E | S = 0.24% | | | | | | T = 99.76% | | | | | |
| R | S = 0.15% | | | | | | T = 99.85% | | | | | |
| C.10.d | **For an associated earth station (whether specific or typical):** |  |  |  | |  | |  | | | |  | |  | |
| C.10.d.3 | the isotropic gain, in dBi, of the antenna in the direction of maximum radiation (see No. **1.160**) | **e\_as\_stn**  gain | E | 65.0 | | 63.0 | | 51.8 | | | | 39.5 | | 32.1 | |
| R | 65.5 | | 65.0 | | 54.1 | | | | 43.0 | | 34.5 | |
| C.10.d.4 | the beamwidth, in degrees, between the half-power points (described in detail if not symmetrical) | **e\_as\_stn**  bmwdth | E | 4.50 | | 1.80 | | 0.73 | | | | 0.13 | | 0.03 | |
| R | 3.79 | | 1.41 | | 0.52 | | | | 0.10 | | 0.06 | |
| C.10.d.5a | either the measured co-polar radiation pattern of the antenna or the co-polar reference radiation pattern | **e\_as\_stn**  pattern\_id | E | A-25Log(F), ABCDphi, AP7, AP8, REC 465, 465-5, 580, 580-6 | | | | | | | | | | | |
| R | A-25Log(F), ABCDphi, AP7, AP8, REC 465, 465-5, 465-6-E, 580, 580-6 | | | | | | | | | | | |
| C.10.d.6 | if the associated station is a receiving earth station, the lowest total receiving system noise temperature, in kelvins, referred to the output of the receiving antenna of the earth station under clear-sky conditions | **e\_as\_stn**  noise\_t | E | 500 | | 270 | | 195 | | | | 100 | | 75 | |
| R | N/A | | N/A | | N/A | | | | N/A | | N/A | |
| C.10.d.7 | the antenna diameter, in meters  In cases other than Appendix **30A**, required for fixed-satellite service networks operating in the frequency bands 13.75-14 GHz, 14.5-14.75 GHz (in countries listed in Resolution **163 (WRC‑15)** not for feeder links for the broadcasting-satellite service), 14.5-14.8 GHz (in countries listed in Resolution **164 (WRC‑15)** not for feeder links for the broadcasting-satellite service), 24.65‑25.25 GHz (Region 1) and 24.65-24.75 GHz (Region 3) and for maritime mobile-satellite service networks operating in the frequency band 14‑14.5 GHz | **e\_as\_stn**  ant\_diam | E | 13.0 | | 7.0 | | 4.0 | | | | 0.9 | | 0.4 | |
| R | 12.7 | | 9.0 | | 4.7 | | | | 1.2 | | 0.4 | |

Table 6

**30/20 GHz Envelope characteristics**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Items in Appendix** | **B \_ Characteristics to be provided for each satellite antenna beam or each Earth station or radio astronomy antenna** | **Table and Data Item** | E or  R | **Max** | **90%** | **Average** | **10%** | **Min** |
| **B.1** | **Identification and direction of the satellite antenna beam** |  |  |  |  |  |  |  |
| B.1.b | an indicator showing whether the antenna beam, under B.1.a, is fixed or whether it is steerable and / or reconfigurable | **s\_beam**  f\_steer | E | 72.7% are steerable | | | | |
| R | 48.4% are steerable | | | | |
| **B.2** | **Transmission / reception indicator for the beam of the space station or the associated space station** | **s\_beam**  emi\_rcp | E or  R | Used to select E or R for the parameters in this table | | | | |
| **B.3** | **Space station antenna characteristics** |  |  |  |  |  |  |  |
| **B.3.a** | **For each space station** |  |  |  |  |  |  |  |
| B.3.a.1 | the maximum co-polar isotropic gain, in dBi  Where a steerable beam (see No. **1.191**) is used, if the effective boresight area (see No. **1.175**) is identical with the global service area, the maximum antenna gain, in dBi, is applicable to all points on the Earth’s visible surface | **s\_beam**  gain | E | 53.0 | 50.6 | 41.2 | 32.0 | 22.0 |
| R | 54.0 | 54.0 | 45.6 | 32.0 | 22.0 |
| B.3.d | the pointing accuracy of the antenna  In the case of Appendix **30**, **30A** or **30B**, required only for elliptical beams | **s\_beam**  pnt\_acc | E | 0.3 | 0.3 | 0.15 | 0.05 | 0.01 |
| R | 0.4 | 0.3 | 0.16 | 0.05 | 0.01 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Items in Appendix** | **C \_ Characteristics to be provided for each group of frequency assignments for a satellite antenna beam or an Earth station or radio astronomy antenna** | **Data Item**  **and Table** | E or  R | **Max** | | **90%** | | **Average** | | | | **10%** | | **Min** | |
| **C.3** | **Assigned frequency band** |  |  |  | |  | |  | | | |  | |  | |
| C.3.a | the bandwidth of the assigned frequency band, in kHz (see No. **1.147**)  In the case of advance publication, required only for active sensors  In the case of geostationary and non geo-stationary satellite networks, required for all space applications except passive sensors  In the case of Appendix **30B**, required only for notification under Article 8 | **grp**  bdwdth | E | 3400000 | | 500000 | | 339972 | | | | 50000 | | 100 | |
| R | 500000 | | 500000 | | 216864 | | | | 50000 | | 6632 | |
| **C.5** | **Receiving system noise temperature** |  |  |  | |  | |  | | | |  | |  | |
| C.5.a | the lowest total receiving system noise temperature, in kelvins, referred to the output of the receiving antenna of the space station  In the case of satellite networks, required for all space applications except for active or passive sensors | **grp**  noise\_t | E | N/A | | N/A | | N/A | | | | N/A | | N/A | |
| R | 14395 | | 1318 | | 1111 | | | | 650 | | 560 | |
| **C.6** | **Polarization** |  |  |  | |  | |  | | | |  | |  | |
| C.6.a | the type of polarization (see the Preface)  In the case of circular polarization, this includes the sense of polarization (see Nos. **1.154** and **1.155**)  In the case of a space station submitted in accordance with Appendix **30** or **30A**, see § 3.2 of Annex 5 to Appendix **30** | **grp**  polar\_type | E | H =  2.2% | V =  2.7% | | CR =  19.7% | | CL =  22.6% | | D =  0.0% | | M =  50.75% | | L =  0.0% |
| R | H =  4.0% | V =  3.4% | | CR =  7.1% | | CL =  36.4% | | D =  0.0% | | M =  49.2% | | L =  0.0% |
| **C.7** | **Necessary bandwidth and class of emission** |  |  |  | |  | |  | | | |  | |  | |
| C.7.a | the necessary bandwidth and the class of emission: for each carrier  In the case of Appendix **30B**, required only for notification under Article 8 | **emiss**  design\_emi | E | 3G4 | | - | | - | | | | - | | 400H | |
| R | 3G4 | | - | | - | | | | - | | 10K0 | |
| **C.8** | **Power characteristics of the transmission** |  |  |  | |  | |  | | | |  | |  | |
| **C.8.a** | **For the case where individual carriers can be identified:** |  |  |  | |  | |  | | | |  | |  | |
| C.8.a.1 | the maximum value of the peak envelope power, in dBW, supplied to the input of the antenna for each carrier type  Required if neither C.8.b.1 nor C.8.b.3.a is provided | **emiss**  pep\_max | E | 36.4 | | 20.5 | | 9.9 | | | | -7.0 | | -22.8 | |
| R | 41.3 | | 24.0 | | 14.7 | | | | 0.0 | | -16.0 | |
| C.8.a.2 | the maximum power density, in dB(W/Hz), supplied to the input of the antenna for each carrier type2  In the case of Appendix**30B**, required only for notification under Article 8  Required if neither C.8.b.2 nor C.8.b.3.b is provided | **emiss**  pwr-ds\_max | E | -22.5 | | -44.0 | | -56.4 | | | | -67.0 | | -83.3 | |
| R | -24.0 | | -40.8 | | -51.6 | | | | -60.0 | | -70.8 | |
| **C.8.b** | **For the case where it is not appropriate to identify individual carriers:** |  |  |  | |  | |  | | | |  | |  | |
| C.8.b.1 | the total peak envelope power, in dBW, supplied to the input of the antenna  For coordination or notification of an Appendix **30A** earth station the values shall include the maximum range of power control  Required if neither C.8.a.1 nor C.8.b.3.a is provided | **emiss**  pep\_max | E | 36.4 | | 20.5 | | 9.9 | | | | -7.0 | | -22.8 | |
| R | 41.3 | | 24.0 | | 14.7 | | | | 0.0 | | -16.0 | |
| C.8.b.2 | the maximum power density, in dB(W/Hz), supplied to the input of the antenna2  For coordination or notification of an Appendix **30A** earth station the values shall include the maximum range of power control  In the case of Appendix **30B**, required only for submission under Article 6  Required if neither C.8.a.2 nor C.8.b.3.b is provided | **emiss**  pwr-ds\_max | E | -22.5 | | -44.0 | | -56.4 | | | | -67.0 | | -83.3 | |
| R | -24.0 | | -40.8 | | -51.6 | | | | -60.0 | | -70.8 | |
| C.8.c | **For all space applications, except active or passive sensors:** |  |  |  | |  | |  | | | |  | |  | |
| C.8.c.3 | the minimum power density, in dB(W/Hz), supplied to the input of the antenna for each carrier type  If not provided, the reason for absence under C.8.c.4 | **emiss**  pwr\_ds\_min | E | -28.5 | | -48.8 | | -66.0 | | | | -76.1 | | -98.1 | |
| R | -41.0 | | -53.0 | | -62.6 | | | | -74.0 | | -91.0 | |
| C.8.d.1 | the maximum total peak envelope power, in dBW, supplied to the input of the antenna for each contiguous satellite bandwidth  For a satellite transponder, this corresponds to the maximum saturated peak envelope power  Required only for a space-to-Earth or space-to-space link | **grp**  pwr\_max | E | 36.4 | | 30.2 | | 20.96 | | | | 13.0 | | -13.6 | |
| R | 27.0 | | 27.0 | | 27.0 | | | | 27.0 | | 27.0 | |
| C.8.e.1 | for space-to-Earth, Earth-to-space or space-to-space links. for each carrier type, the greater of either the carrier-to-noise ratio, in dB, required to meet the performance of the link under clear-sky conditions or the carrier-to-noise ratio, in dB, required to meet the short-time objectives of the link inclusive of necessary margins  If not provided, the reason for absence under C.8.e.2 | **emiss**  c\_to\_n | E | 39.6 | | 24.0 | | 12.6 | | | | 6.6 | | -6.0 | |
| R | 31.1 | | 19.5 | | 10.5 | | | | 5.0 | | -25.0 | |
| C.8.g.1 | the maximum aggregate power, in dBW, of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station  Not required for coordination of a specific earth station under Nos. **9.15**, **9.17** or **9.17A** | **grp**  pwr\_max | E | 36.4 | | 31.2 | | 20.9 | | | | 13.0 | | -13.6 | |
| **e\_as\_stn**  pwr\_max | R | 26.0 | | 26.0 | | 21.2 | | | | 14.8 | | 14.8 | |
| C.8.g.2 | the aggregate bandwidth of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station  Not required for coordination of a specific earth station under Nos. **9.15**, **9.17** or **9.17A** | **grp**  bdwdth\_aggr | E | 3400000 | | 500000 | | 356754 | | | | 50000 | | 100 | |
| **e\_as\_stn**  bdwdth\_aggr | R | 50000 | | 50000 | | 33333 | | | | 20000 | | 20000 | |
| **C.10** | **Type and identity of the associated station(s)**  *(the associated station may be another space station, a typical earth station of the network or a specific earth station)*  *For all space applications except active or passive sensors* |  |  |  | |  | |  | | | |  | |  | |
| C.10.b | **For an associated earth station:** |  |  |  | |  | |  | | | |  | |  | |
| C.10.b.2 | the type of station (specific or typical) | **e\_as\_stn**  stn\_type | E | S = 6.02% | | | | | | T = 93.98% | | | | | |
| R | S = 2.93% | | | | | | T = 97.07% | | | | | |
| C.10.d | **For an associated earth station (whether specific or typical):** |  |  |  | |  | |  | | | |  | |  | |
| C.10.d.3 | the isotropic gain, in dBi, of the antenna in the direction of maximum radiation (see No. **1.160**) | **e\_as\_stn**  gain | E | 70.0 | | 65.9 | | 48.4 | | | | 34.1 | | 30.5 | |
| R | 71.4 | | 69.2 | | 54.9 | | | | 41.8 | | 32.6 | |
| C.10.d.4 | the beamwidth, in degrees, between the half-power points (described in detail if not symmetrical) | **e\_as\_stn**  bmwdth | E | 5.40 | | 3.60 | | 1.19 | | | | 0.11 | | 0.06 | |
| R | 3.80 | | 1.40 | | 0.57 | | | | 0.10 | | 0.05 | |
| C.10.d.5a | either the measured co-polar radiation pattern of the antenna or the co-polar reference radiation pattern | **e\_as\_stn**  pattern\_id | E | A-25Log(F), ABCDphi, AP7, AP8, REC 465, 465-5, 580, 580-6 | | | | | | | | | | | |
| R | A-25Log(F), ABCDphi, REC 465, 465-5, 580, 580-6 | | | | | | | | | | | |
| C.10.d.6 | if the associated station is a receiving earth station, the lowest total receiving system noise temperature, in kelvins, referred to the output of the receiving antenna of the earth station under clear-sky conditions | **e\_as\_stn**  noise\_t | E | 1000 | | 462 | | 255 | | | | 150 | | 96 | |
| R | N/A | | N/A | | N/A | | | | N/A | | N/A | |
| C.10.d.7 | the antenna diameter, in meters  In cases other than Appendix **30A**, required for fixed-satellite service networks operating in the frequency bands 13.75-14 GHz, 14.5-14.75 GHz (in countries listed in Resolution **163 (WRC‑15)** not for feeder links for the broadcasting-satellite service), 14.5-14.8 GHz (in countries listed in Resolution **164 (WRC‑15)** not for feeder links for the broadcasting-satellite service), 24.65‑25.25 GHz (Region 1) and 24.65-24.75 GHz (Region 3) and for maritime mobile-satellite service networks operating in the frequency band 14‑14.5 GHz | **e\_as\_stn**  ant\_diam | E | 15.0 | | 4.1 | | 2.1 | | | | 0.3 | | 0.3 | |
| R | 15.0 | | 5.6 | | 2.8 | | | | 0.3 | | 0.3 | |

**5.2 Tools to extract the values**

To provide the values of the selected characteristics, additional queries have been created.

Table 7 provides the number of assignments with their respective characteristics for each category of the abovementioned list of networks.

Table 7

**Number of assignments**

|  |  |  |
| --- | --- | --- |
|  | **Frequency ranges** | |
| **Condition *b)* is met** | *Range A*  space-to-Earth:  10.95-11.2 GHz, 11.45-11.7 GHz, 11.7-12.2 GHz, 12.2-12.5 GHz, 12.5-12.75 GHz  Earth-to-space:  14-14.47 GHz | *Range B*  space-to-Earth:  19.7-20.2 GHz  Earth-to-space:  29.5-30.0 GHz |
| for a group of frequency assignments | 78 401  Query/Table:  ***2ndNote GR\_Ku\_Characteristics*** | 3 610  Query/Table:  ***2ndNote GR\_Ka\_Characteristics*** |
| for a frequency range under consideration | 44 938  Query/Table:  ***2ndNote RNG\_Ku\_Characteristics*** | 2 628  Query/Table:  ***2ndNote RNG\_Ka\_Characteristics*** |

The queries used to extract the values are attached below and the description of queries used to produce the results is provided in Annex 1.



Each table contains the following fields.

Table 8

**Data fields**

| **Data Field** | **Preface Table.Field** | **Description** |
| --- | --- | --- |
| B1b BeamIsSteerable | s\_beam.f\_steer | code indicating if the beam is steerable (see No. 1.191) or reconfigurable |
| B2 TransmissionReception | s\_beam.emi\_rcp | satellite beam emission/reception code  E – transmitting beam (space-to-Earth)  R – receiving beam (Earth-to-space) |
| B3a1 SpaceMaxGain | s\_beam.gain | maximum isotropic gain of the antenna expressed in dB |
| B3d PointingAccuracy | s\_beam.pnt\_acc | the pointing accuracy of the antenna, in degrees |
| C4 AssignedFreqBand\_kHz | grp.bdwdth | assigned frequency band expressed in kHz |
| C5a SpaceNoiseTemperature | grp.noise\_t | receiving system noise temperature (only for receiving beams) |
| C6 Polarization | grp.polar\_type | symbol indicating the type and the direction of polarization, where applicable (in case of circular or elliptical polarization)  See Section IV, Table 5 of Preface |
| C7A Emission | emiss.design\_emi | designation of emission |
| C7A EmissionBandwidth |  | calculated from design\_emi, expressed in kHz |
| C8a1 C8b1 PeakPower | emiss.pep\_max | the maximum value of the peak envelope power, in dBW, supplied to the input of the antenna for each carrier type |
| C8a2 C8b2 MaxPSD | emiss.pwr\_ds\_max | the maximum power density, in dB(W/Hz), supplied to the input of the antenna for each carrier type |
| C8c3 MinPSD | emiss.pwr\_ds\_min | the minimum power density, in dB(W/Hz), supplied to the input of the antenna for each carrier type |
| C8d1 TotalSatPower | grp.pwr\_max | the maximum total peak envelope power, in dBW, supplied to the input of the antenna for each contiguous satellite bandwidth |
| C8e1 C2N | emiss.c\_to\_n | for space-to-Earth, Earth-to-space or space-to-space links. for each carrier type, the greater of either the carrier-to-noise ratio, in dB, required to meet the performance of the link under clear-sky conditions or the carrier-to-noise ratio, in dB, required to meet the short-time objectives of the link inclusive of necessary margins |
| C8g1 ESAggrPower | e\_as\_stn.pwr\_max | the maximum aggregate power, in dBW, of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station |
| C8g2 ESAggrBdwdth | e\_as\_stn.bdwdth\_aggr | the aggregate bandwidth of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station |
| C10b2 ESType | e\_as\_stn.stn\_type | code indicating if the earth station is specific [S] or typical [T] |
| C10d3 ESGain | e\_as\_stn.gain | maximum isotropic gain of the earth station antenna expressed in dB |
| C10d4 ESBeamwidth | e\_as\_stn.bmwdth | angular width of radiation main lobe expressed in degrees |
| C10d6 ESNoise | e\_as\_stn.noise\_t | total receiving system noise temperature, expressed in kelvins referred to the output of the receiving earth station antenna |
| C10d7 ESDiam | e\_as\_stn.ant\_diam | diameter of the earth station antenna (in meters) or the equivalent antenna diameter, (i.e. the diameter, in metres, of a parabolic antenna with the same off-axis performance as the receiving associated earth station antenna) |
| C10d5a ESPattern | e\_as\_stn.pattern\_id  ant\_type.pattern | antenna radiation pattern indicated by a reference to the appropriate ITU-R Recommendation |
| C10d5a ESPattern A | ant\_type.coefa | coefficient A for non-standard antenna\* |
| C10d5a ESPattern B | ant\_type.coefb | coefficient B for non-standard antenna\* |
| C10d5a ESPattern C | ant\_type.coefc | coefficient C for non-standard antenna\* |
| C10d5a ESPattern D | ant\_type.coefd | coefficient D for non-standard antenna\* |
| C10d5a ESPattern Phi1 | ant\_type.phi1 | coefficient PHI1 for non-standard antenna\* |
| Recorded |  | **11.32**, if recorded with favourable finding under No. **11.32**  **11.32A**, if recorded with favourable finding under No. **11.32A** |
| \* If the earth station radiation pattern is not specified as REC-465, REC-580, AP28, AP29 or as A‑25\*LOG(FI), where A is a two-digit number (typically 32, 29 or 27), but can be described by two logarithmic expressions (ESPattern =”ABCDphi1”):   |  |  | | --- | --- | | G = GMAX | PHI < 1 | | G = COEFA - COEFB \* LOG (PHI) | 1< PHI < PHI1 | | G = MAX (MIN (G(PHI1), COEFC - COEFD \* LOG (PHI)), -10) | PHI > PHI1 |   values of COEFA, COEFB, COEFC, COEFD and PHI1 should be provided. | | |

Mechanism of using MS Access may be used to extract the values for the necessary parameters indicated in Table 2, 3, 4.

Inter alia, it allows:

– Using the procedure described in Section 1 of the Annex 1 to link with more recent SRS IFIC databases,

– Modifying queries to extract the required information,

– Filtering information using MS Access interface.

**6 Compilation of unmanned aircraft system command and non-payload control Earth stations characteristics and their parameter values provided by member countries**

Since there are currently no UAS operating using CNPC Links potential characteristics proposed from some member countries are based on:

1 The data rates for CNPC Links in the ICAO contribution that were themselves based, in part, on Report ITU-R [M.2171](https://www.itu.int/rec/R-REC-M.2071-1-201702-I/en).

2 The performance of representative FSS space stations operated within the notified and recorded technical parameters as published by the Radiocommunication Bureau.

3 The operational scenarios as described by ICAO in 14 May 2013 (Doc. [5B/269](https://www.itu.int/md/R12-WP5B-C-0269/en)).

4 The research development of a Ka band on-board variable directive antenna for UAS conducted in one administration (Ka band System 3 in Table 10). For this System, listed CNPC characteristics are extracted from the MIFR information of the satellite that was used in the evaluation test (WINDS satellite), except for those of “Type and identity of the associated station(s)” which are based on the result of the development of a Ka band on-board variable directive antenna (See Annex 2 for further details on the research development/ evaluation test).

Table 9 (Ku Band) and Table 10 (Ka Band) contain the values of the parameters of the characteristics, for links between the unmanned aircraft and the satellite of the sample CNPC Link systems. Values of the parameters of the characteristics of links between the earth station on the ground and the satellite are not included since those links use conventional ground based Earth stations that are identical to any other Earth station used in the FSS that have to comply with ITU-R requirements for them to have been recorded in the MIFR.

Table 9

**14/11 GHz CNPC Link Characteristics for links 2 and 3**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Items in Appendix** | ***B \_ CHARACTERISTICS TO BE PROVIDED FOR EACH SATELLITE ANTENNA BEAM OR EACH EARTH STATION OR RADIO ASTRONOMY ANTENNA*** | **Table and Data Item** | E or  R | **System 1** | **System 2** | **System 3** | **System 4** | **System 5** |
| **B.1** | **IDENTIFICATION AND DIRECTION OF THE SATELLITE ANTENNA BEAM** |  |  |  |  |  |  |  |
| B.1.b | an indicator showing whether the antenna beam, under B.1.a, is fixed or whether it is steerable and / or reconfigurable | **s\_beam**  f\_steer | E | Fixed | Fixed |  |  |  |
| R | Fixed | Fixed |  |  |  |
| **B.2** | **TRANSMISSION / RECEPTION INDICATOR FOR THE BEAM OF THE SPACE STATION OR THE ASSOCIATED SPACE STATION** | **s\_beam**  emi\_rcp | E or  R |  | See Below |  |  |  |
| **B.3** | **SPACE STATION ANTENNA CHARACTERISTICS** |  |  |  |  |  |  |  |
| **B.3.a** | **For each space station** |  |  |  |  |  |  |  |
| B.3.a.1 | the maximum co-polar isotropic gain, in dBi  Where a steerable beam (see No. **1.191**) is used, if the effective boresight area (see No. **1.175**) is identical with the global service area, the maximum antenna gain, in dBi, is applicable to all points on the Earth’s visible surface | **s\_beam**  gain | E | 33.3 | 39.0 |  |  |  |
| R | 33.3 | 39.0 |  |  |  |
| B.3.d | the pointing accuracy of the antenna  In the case of Appendix **30**, **30A** or **30B**, required only for elliptical beams | **s\_beam**  pnt\_acc | E | 0.2° | 0.15 |  |  |  |
| R | 0.2° | 0.15 |  |  |  |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Items in Appendix** | ***C \_ CHARACTERISTICS TO BE PROVIDED FOR EACH GROUP OF FREQUENCY  ASSIGNMENTS FOR A SATELLITE ANTENNA BEAM OR  AN EARTH STATION OR RADIO ASTRONOMY ANTENNA*** | **Data Item**  **and Table** | E or  R | **System 1** | **System 2** | **System 3** | **System 4** | **System 5** |
| **C.3** | **ASSIGNED FREQUENCY BAND** |  |  |  |  |  |  |  |
| C.3.a | the bandwidth of the assigned frequency band, in kHz (see No. **1.147**)  In the case of advance publication, required only for active sensors  In the case of geostationary and non geo-stationary satellite networks, required for all space applications except passive sensors  In the case of Appendix **30B**, required only for notification under Article 8 | **grp**  bdwdth | E | N/A | N/A |  |  |  |
| R | N/A | N/A |  |  |  |
| **C.5** | **RECEIVING SYSTEM NOISE TEMPERATURE** |  |  |  |  |  |  |  |
| C.5.a | the lowest total receiving system noise temperature, in kelvins, referred to the output of the receiving antenna of the space station  In the case of satellite networks, required for all space applications except for active or passive sensors | **grp**  noise\_t | E | N/A | N/A |  |  |  |
|  | R | 560 | 1200 |  |  |  |
| **C.6** | **POLARIZATION** |  |  |  |  |  |  |  |
| C.6.a | the type of polarization (see the Preface)  In the case of circular polarization, this includes the sense of polarization (see Nos. **1.154** and **1.155**)  In the case of a space station submitted in accordance with Appendix **30** or **30A**, see § 3.2 of Annex 5 to Appendix **30** | **grp**  polar\_type | E | V / H | H or V |  |  |  |
| R | V / H | H or V |  |  |  |
| **C.7** | **NECESSARY BANDWIDTH AND CLASS OF EMISSION** |  |  |  |  |  |  |  |
| C.7.a | the necessary bandwidth and the class of emission: for each carrier  In the case of Appendix **30B**, required only for notification under Article 8 | **emiss**  design\_emi | E | 40K0G7W-- | 250KG7W-- |  |  |  |
| R | 1M30G7W-- | 250KG7W-- |  |  |  |
| **C.8** | **POWER CHARACTERISTICS OF THE TRANSMISSION** |  |  |  |  |  |  |  |
| **C.8.a** | **For the case where individual carriers can be identified:** |  |  |  |  |  |  |  |
| C.8.a.1 | the maximum value of the peak envelope power, in dBW, supplied to the input of the antenna for each carrier type  Required if neither C.8.b.1 nor C.8.b.3.a is provided | **emiss**  pep\_max | E | See C.8.b.1 | 2.0 |  |  |  |
| R | 25.5 | 6.6 |  |  |  |
| C.8.a.2 | the maximum power density, in dB(W/Hz), supplied to the input of the antenna for each carrier type2  In the case of Appendix**30B**, required only for notification under Article 8  Required if neither C.8.b.2 nor C.8.b.3.b is provided | **emiss**  pwr-ds\_max | E | -55.0 | -52.0 |  |  |  |
| R | -50.6 | -47.5 |  |  |  |
| **C.8.b** | **For the case where it is not appropriate to identify individual carriers:** |  |  |  |  |  |  |  |
| C.8.b.1 | the total peak envelope power, in dBW, supplied to the input of the antenna  For coordination or notification of an Appendix **30A** earth station the values shall include the maximum range of power control  Required if neither C.8.a.1 nor C.8.b.3.a is provided | **emiss**  pep\_max | E | 21.8 | 2.0 |  |  |  |
| R | 26 | 6.6 |  |  |  |
| C.8.b.2 | the maximum power density, in dB(W/Hz), supplied to the input of the antenna2  For coordination or notification of an Appendix **30A** earth station the values shall include the maximum range of power control  In the case of Appendix **30B**, required only for submission under Article 6  Required if neither C.8.a.2 nor C.8.b.3.b is provided | **emiss**  pwr-ds\_max | E | -55 | -52.0 |  |  |  |
| R | -50.6 | -47.5 |  |  |  |
| C.8.c | **For all space applications, except active or passive sensors:** |  |  |  |  |  |  |  |
| C.8.c.3 | the minimum power density, in dB(W/Hz), supplied to the input of the antenna for each carrier type  If not provided, the reason for absence under C.8.c.4 | **emiss**  pwr\_ds\_min | E | -69.6 | N/A |  |  |  |
| R | -55.9 | N/A |  |  |  |
| C.8.d.1 | the maximum total peak envelope power, in dBW, supplied to the input of the antenna for each contiguous satellite bandwidth  For a satellite transponder, this corresponds to the maximum saturated peak envelope power  Required only for a space-to-Earth or space-to-space link | **grp**  pwr\_max | E | N/A | N/A |  |  |  |
| R | N/A | N/A |  |  |  |
| C.8.e.1 | for space-to-Earth, Earth-to-space or space-to-space links. for each carrier type, the greater of either the carrier-to-noise ratio, in dB, required to meet the performance of the link under clear-sky conditions or the carrier-to-noise ratio, in dB, required to meet the short-time objectives of the link inclusive of necessary margins  If not provided, the reason for absence under C.8.e.2 | **emiss**  c\_to\_n | E | 3.6 | 23.0 |  |  |  |
| R | 2.5 | 20.7 |  |  |  |
| C.8.g.1 | the maximum aggregate power, in dBW, of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station  Not required for coordination of a specific earth station under Nos. **9.15**, **9.17** or **9.17A** | **grp**  pwr\_max | E | N/A | N/A |  |  |  |
| **e\_as\_stn**  pwr\_max | R | N/A | N/A |  |  |  |
| C.8.g.2 | the aggregate bandwidth of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station  Not required for coordination of a specific earth station under Nos. **9.15**, **9.17** or **9.17A** | **grp**  bdwdth\_aggr | E | N/A | N/A |  |  |  |
| **e\_as\_stn**  bdwdth\_aggr | R | N/A | N/A |  |  |  |
| C.10 | **TYPE AND IDENTITY OF THE ASSOCIATED STATION(S)**  *(the associated station may be another space station, a typical earth station of the network or a specific earth station)*  *For all space applications except active or passive sensors* |  | | | | | | |
| C.10.b | **For an associated earth station:** |  |  |  |  |  |  |  |
| C.10.b.2 | the type of station (specific or typical) | **e\_as\_stn**  stn\_type | E | typical | T |  |  |  |
| R | typical | T |  |  |  |
| C.10.d | **For an associated earth station (whether specific or typical):** |  |  |  |  |  |  |  |
| C.10.d.3 | the isotropic gain, in dBi, of the antenna in the direction of maximum radiation (see No. **1.160**) | **e\_as\_stn**  gain | E | 40.4 | 37.4 |  |  |  |
| R | 39.6 | 38.9 |  |  |  |
| C.10.d.4 | the beamwidth, in degrees, between the half-power points (described in detail if not symmetrical) | **e\_as\_stn**  bmwdth | E | 1.21 | 2.2 |  |  |  |
| R | 1.54 | 1.8 |  |  |  |
| C.10.d.5a | either the measured co-polar radiation pattern of the antenna or the co-polar reference radiation pattern | **e\_as\_stn**  pattern\_id | E | App 7 | AP-8 |  |  |  |
| R | App 7 | AP-7 |  |  |  |
| C.10.d.6 | if the associated station is a receiving earth station, the lowest total receiving system noise temperature, in kelvins, referred to the output of the receiving antenna of the earth station under clear-sky conditions | **e\_as\_stn**  noise\_t | E | 190 | 250 |  |  |  |
| R | N/A | N/A |  |  |  |
| C.10.d.7 | the antenna diameter, in meters  In cases other than Appendix **30A**, required for fixed-satellite service networks operating in the frequency bands 13.75-14 GHz, 14.5-14.75 GHz (in countries listed in Resolution **163 (WRC‑15)** not for feeder links for the broadcasting-satellite service), 14.5-14.8 GHz (in countries listed in Resolution **164 (WRC‑15)** not for feeder links for the broadcasting-satellite service), 24.65‑25.25 GHz (Region 1) and 24.65-24.75 GHz (Region 3) and for maritime mobile-satellite service networks operating in the frequency band 14‑14.5 GHz | **e\_as\_stn**  ant\_diam | E | 1.25 | 0.8 |  |  |  |
| R | 1.25 | 0.8 |  |  |  |

Table 10

**30/20 GHz CNPC Link Characteristics for links 2 and 3**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Items in Appendix** | ***B \_ CHARACTERISTICS TO BE PROVIDED FOR EACH SATELLITE ANTENNA BEAM OR EACH EARTH STATION OR RADIO ASTRONOMY ANTENNA*** | **Table and Data Item** | E or  R | **System 1**  **Low gain** | **System 2**  **High gain** | **System 3** | **System 4** | **System 5** |
| **B.1** | **IDENTIFICATION AND DIRECTION OF THE SATELLITE ANTENNA BEAM** |  |  |  |  |  |  |  |
| B.1.b | an indicator showing whether the antenna beam, under B.1.a, is fixed or whether it is steerable and / or reconfigurable | **s\_beam**  f\_steer | E | Steerable | Steerable | Steerable |  |  |
| R | Steerable | Steerable | Steerable |  |  |
| **B.2** | **TRANSMISSION / RECEPTION INDICATOR FOR THE BEAM OF THE SPACE STATION OR THE ASSOCIATED SPACE STATION** | **s\_beam**  emi\_rcp | E or  R |  |  |  |  |  |
| **B.3** | **SPACE STATION ANTENNA CHARACTERISTICS** |  |  |  |  |  |  |  |
| **B.3.a** | **For each space station** |  |  |  |  |  |  |  |
| B.3.a.1 | the maximum co-polar isotropic gain, in dBi  Where a steerable beam (see No. **1.191**) is used, if the effective boresight area (see No. **1.175**) is identical with the global service area, the maximum antenna gain, in dBi, is applicable to all points on the Earth’s visible surface | **s\_beam**  gain | E | 37 | 51 | 41 |  |  |
| R | 37 | 54 | 50 |  |  |
| B.3.d | the pointing accuracy of the antenna  In the case of Appendix **30**, **30A** or **30B**, required only for elliptical beams | **s\_beam**  pnt\_acc | E | 0.2° | 0.1° | 0.1 |  |  |
| R | 0.2° | 0.1° | 0.1 |  |  |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Items in Appendix** | ***C \_ CHARACTERISTICS TO BE PROVIDED FOR EACH GROUP OF FREQUENCY  ASSIGNMENTS FOR A SATELLITE ANTENNA BEAM OR  AN EARTH STATION OR RADIO ASTRONOMY ANTENNA*** | **Data Item**  **and Table** | E or  R | **System 1**  **Low gain** | **System 2**  **High gain** | **System 3** | **System 4** | **System 5** |
| **C.3** | **ASSIGNED FREQUENCY BAND** |  |  |  |  |  |  |  |
| C.3.a | the bandwidth of the assigned frequency band, in kHz (see No. **1.147**)  In the case of advance publication, required only for active sensors  In the case of geostationary and non geo-stationary satellite networks, required for all space applications except passive sensors  In the case of Appendix **30B**, required only for notification under Article 8 | **grp**  bdwdth | E | N/A | N/A | N/A |  |  |
| R | N/A | N/A | N/A |  |  |
| **C.5** | **RECEIVING SYSTEM NOISE TEMPERATURE** |  |  |  |  |  |  |  |
| C.5.a | the lowest total receiving system noise temperature, in kelvins, referred to the output of the receiving antenna of the space station  In the case of satellite networks, required for all space applications except for active or passive sensors | **grp**  noise\_t | E | N/A | N/A | N/A |  |  |
|  |  | R | 920 | 800 | 795 |  |  |
| **C.6** | **POLARIZATION** |  |  |  |  |  |  |  |
| C.6.a | the type of polarization (see the Preface)  In the case of circular polarization, this includes the sense of polarization (see Nos. **1.154** and **1.155**)  In the case of a space station submitted in accordance with Appendix **30** or **30A**, see § 3.2 of Annex 5 to Appendix **30** | **grp**  polar\_type | E | Circular | M | L |  |  |
| R | Circular | M | M |  |  |
| **C.7** | **NECESSARY BANDWIDTH AND CLASS OF EMISSION** |  |  |  |  |  |  |  |
| C.7.a | the necessary bandwidth and the class of emission: for each carrier  In the case of Appendix **30B**, required only for notification under Article 8 | **emiss**  design\_emi | E | 40K0G7W-- | 500KG7W-- | 143MG7W-- |  |  |
| R | 1M30G7W-- | 500KG7W-- | 25M9G7W-- |  |  |
| **C.8** | **POWER CHARACTERISTICS OF THE TRANSMISSION** |  |  |  |  |  |  |  |
| **C.8.a** | **For the case where individual carriers can be identified:** |  |  |  |  |  |  |  |
| C.8.a.1 | the maximum value of the peak envelope power, in dBW, supplied to the input of the antenna for each carrier type  Required if neither C.8.b.1 nor C.8.b.3.a is provided | **emiss**  pep\_max | E | See C.8.b.1 | 4.1 | 20.0 |  |  |
| R | 16.5 | 6.7 | 23.2 |  |  |
| C.8.a.2 | the maximum power density, in dB(W/Hz), supplied to the input of the antenna for each carrier type2  In the case of Appendix 30B, required only for notification under Article 8  Required if neither C.8.b.2 nor C.8.b.3.b is provided | **emiss**  pwr-ds\_max | E | -61 | -52.9 | -60.1 |  |  |
| R | -59.6 | -50.3 | -49.5 |  |  |
| **C.8.b** | **For the case where it is not appropriate to identify individual carriers:** |  |  |  |  |  |  |  |
| C.8.b.1 | the total peak envelope power, in dBW, supplied to the input of the antenna  For coordination or notification of an Appendix **30A** earth station the values shall include the maximum range of power control  Required if neither C.8.a.1 nor C.8.b.3.a is provided | **emiss**  pep\_max | E | 21.1 | See C.8.a.1 | 20.0 |  |  |
| R | 26 | See C.8.a.1 | 23.2 |  |  |
| C.8.b.2 | the maximum power density, in dB(W/Hz), supplied to the input of the antenna2  For coordination or notification of an Appendix **30A** earth station the values shall include the maximum range of power control  In the case of Appendix **30B**, required only for submission under Article 6  Required if neither C.8.a.2 nor C.8.b.3.b is provided | **emiss**  pwr-ds\_max | E | -61 | -52.9 | -60.1 |  |  |
| R | -59.6 | -50.3 | -49.5 |  |  |
| C.8.c | **For all space applications, except active or passive sensors:** |  |  |  |  |  |  |  |
| C.8.c.3 | the minimum power density, in dB(W/Hz), supplied to the input of the antenna for each carrier type  If not provided, the reason for absence under C.8.c.4 | **emiss**  pwr\_ds\_min | E | -72.5 | -98.1 | -68.2 |  |  |
| R | -64.6 | -91.0 | -80.2 |  |  |
| C.8.d.1 | the maximum total peak envelope power, in dBW, supplied to the input of the antenna for each contiguous satellite bandwidth  For a satellite transponder, this corresponds to the maximum saturated peak envelope power  Required only for a space-to-Earth or space-to-space link | **grp**  pwr\_max | E | N/A | N/A | N/A |  |  |
| R | N/A | N/A | N/A |  |  |
| C.8.e.1 | for space-to-Earth, Earth-to-space or space-to-space links. for each carrier type, the greater of either the carrier-to-noise ratio, in dB, required to meet the performance of the link under clear-sky conditions or the carrier-to-noise ratio, in dB, required to meet the short-time objectives of the link inclusive of necessary margins  If not provided, the reason for absence under C.8.e.2 | **emiss**  c\_to\_n | E | 3.6 | 20 | 13.3 |  |  |
| R | 2.5 | 20 | 12.6 |  |  |
| C.8.g.1 | the maximum aggregate power, in dBW, of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station  Not required for coordination of a specific earth station under Nos. **9.15**, **9.17** or **9.17A** | **grp**  pwr\_max | E | N/A | N/A | N/A |  |  |
| **e\_as\_stn**  pwr\_max | R | N/A | N/A | N/A |  |  |
| C.8.g.2 | the aggregate bandwidth of all carriers (per transponder, if applicable) supplied to the input of the transmitting antenna of the earth station or the associated earth station  Not required for coordination of a specific earth station under Nos. **9.15**, **9.17** or **9.17A** | **grp**  bdwdth\_aggr | E | N/A | N/A | N/A |  |  |
| **e\_as\_stn**  bdwdth\_aggr | R | N/A | N/A | N/A |  |  |
| C.10 | **TYPE AND IDENTITY OF THE ASSOCIATED STATION(S)**  *(the associated station may be another space station, a typical earth station of the network or a specific earth station)*  *For all space applications except active or passive sensors* |  | | | | | | |
| C.10.b | **For an associated earth station:** |  |  |  |  |  |  |  |
| C.10.b.2 | the type of station (specific or typical) | **e\_as\_stn**  stn\_type | E | Typical | Typical | T |  |  |
| R | Typical | Typical | T |  |  |
| C.10.d | **For an associated earth station (whether specific or typical):** |  |  |  |  |  |  |  |
| C.10.d.3 | the isotropic gain, in dBi, of the antenna in the direction of maximum radiation (see No. **1.160**) | **e\_as\_stn**  gain | E | 45.7 | 41.1 | 38.3 |  |  |
| R | 48.2 | 45.2 | 38.3 |  |  |
| C.10.d.4 | the beamwidth, in degrees, between the half-power points (described in detail if not symmetrical) | **e\_as\_stn**  bmwdth | E | 0.78 | 1.42 | 1.3 |  |  |
| R | 0.52 | 0.89 | 0.9 |  |  |
| C.10.d.5a | either the measured co-polar radiation pattern of the antenna or the co-polar reference radiation pattern | **e\_as\_stn**  pattern\_id | E | AP 7 | AP 7 | - |  |  |
| R | AP 7 | AP 7 | - |  |  |
| C.10.d.6 | if the associated station is a receiving earth station, the lowest total receiving system noise temperature, in kelvins, referred to the output of the receiving antenna of the earth station under clear-sky conditions | **e\_as\_stn**  noise\_t | E | 370 | 150 | 167.3 |  |  |
| R | N/A | N/A | N/A |  |  |
| C.10.d.7 | the antenna diameter, in meters  In cases other than Appendix **30A**, required for fixed-satellite service networks operating in the frequency bands 13.75-14 GHz, 14.5-14.75 GHz (in countries listed in Resolution **163 (WRC‑15)** not for feeder links for the broadcasting-satellite service), 14.5-14.8 GHz (in countries listed in Resolution **164 (WRC‑15)** not for feeder links for the broadcasting-satellite service), 24.65‑25.25 GHz (Region 1) and 24.65-24.75 GHz (Region 3) and for maritime mobile-satellite service networks operating in the frequency band 14‑14.5 GHz | **e\_as\_stn**  ant\_diam | E | 1.25 | 0.75 | 0.65 |  |  |
| R | 1.25 | 0.75 | 0.65 |  |  |

**7 Comparison study**

*[Editor's note: To be discussed]*

All the extracted parameter values indicated in Chapter 6 fall within the envelope characteristics indicated in Chapter 5.

**8 Conclusion**

*[Editor's note: To be discussed]*

Annex 1

**Description of queries used to extract the list of networks**

**A1.1 Database setup**

Microsoft Access Database ***WP5B\_Queries\_All.mdb*** contains queries used to populate list of networks.

Since this database is linked to BR IFIC SRS, before running the queries, these links needs to be re‑established.

1 Locate BR IFIC 2861 DVD

2 Copy DVD\Databases\SRS\_Data\srs2861.zip to your local drive.

3 Unzip files

srs2861\_part1of2.mdb

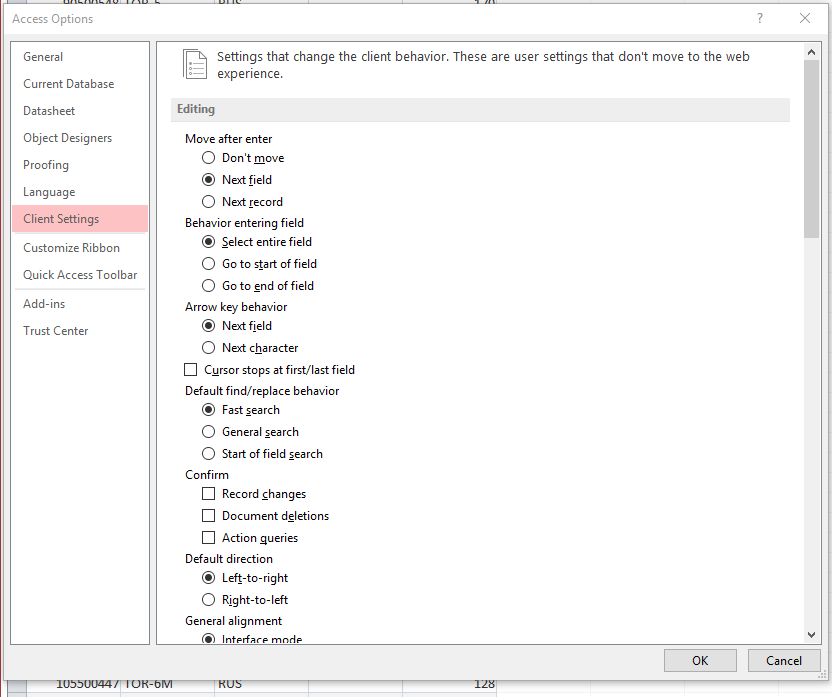
srs2861\_part2of2.mdb

4 It is important to run srs2861\_part1of2.mdb first so it could link to the second srs2861\_part2of2.mdb

5 Unzip WP5B\_Queries\_all.mdb to your local drive, can be the same location as BR IFIC SRS.

6 Run *WP5B\_Queries\_all.mdb*.

7 To facilitate execution of queries, go to Menu ‘File’, click ‘Options’ and under ‘Client Settings’ uncheck Record Changes, Document deletions, Action Queries under Confirm. See below.

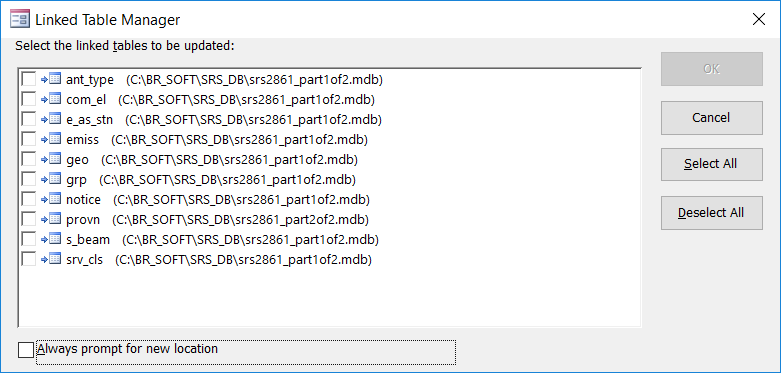


8 Then re-establish the links to tables *com\_el, e\_as\_stn, provn, srv\_cls* which are contained in srs2861.

9 Go to Menu ‘External Data’ and click ‘Linked Table Manager’.

10 In the dialog box below, check *com\_el, grp, srv\_cls, emiss, e\_as\_stn, ant\_type, s\_beam* and click ‘OK’. The program will ask you for a new location of *srs2861\_part1of2.mdb*, point it to a file extracted previously *srs2861\_part1of2.mdb*.

11 Repeat by clicking *provn* table and link it to another file *srs2861\_part2of2.mdb*.



12 Now the database is ready.

**A1.2 Description of queries**

Table below provide information on queries used for each case.

Table A1.1

**Queries attribution**

|  | **Frequency band ranges** | |
| --- | --- | --- |
| **Condition *b)* is met** | **Range A** | **Range B** |
| for a group of frequency assignments | ***Final query (as requested in An.9 to Doc.*** [***5B/538***](https://www.itu.int/md/R15-WP5B-C-0358/en)***):***  2ndNote GR\_Ku\_Characteristics,  ***Final query (as requested in An.9 to Doc. 5B/411):***  GR\_Final\_KU\_Notices  GR\_Final\_KU\_Notices\_With\_Groups  ***Intermediate queries:***  GR\_Notices in Ku Groups  KU\_groups\_all  Uncompleted coord groups | ***Final query (as requested in An. 9 to Doc. 5B/538):***  2ndNote GR\_Ka\_Characteristics  ***Final query (as requested in An.9 to Doc. 5B/411):***  GR\_Final\_KA\_Notices  GR\_Final\_KA\_Notices\_With\_Groups  ***Intermediate queries:***  GR\_Notices in Ka Groups  KA\_groups\_all  Uncompleted coord groups |
| for a range under consideration | ***Final query (as requested in An. 9 to Doc. 5B/538):***  2ndNote RNG\_Ku\_Characteristics  ***Final query (as requested in An.9 to Doc. 5B/411):***  RNG\_Final\_KU\_Notices  RNG\_Final\_KU\_Notices\_With\_Groups  ***Intermediate queries:***  RNG\_KU\_Notices\_Having\_1141\_Flag  RNG\_KU\_Notices\_Having\_NotCompleted  RNG\_Notices in Ku Groups  KU\_groups\_all  Uncompleted coord groups | ***Final query (as requested in An. 9 to Doc. 5B/538):***  2ndNote RNG\_Ka\_Characteristics  ***Final query (as requested in An.9 to Doc. 5B/411):***  RNG\_Final\_KA\_Notices  RNG\_Final\_KA\_Notices\_With\_Groups  ***Intermediate queries:***  RNG\_KA\_Notices\_Having\_1141\_Flag  RNG\_KA\_Notices\_Having\_NotCompleted  RNG\_Notices in Ka Groups  KA\_groups\_all  Uncompleted coord groups |

To get the list of values of Appendix 4 characteristics it is sufficient to run single query for either case:

*2ndNote GR\_Ku\_Characteristics,*

*2ndNote GR\_Ka\_Characteristics,*

*2ndNote RNG\_Ku\_Characteristics,*

*2ndNote RNG\_Ka\_Characteristics*

To get the list of networks it is sufficient to run single query for either case:

*GR\_Final\_KU\_Notices*

*GR\_Final\_KA\_Notices*

*RNG\_Final\_KU\_Notices*

*RNG\_Final\_KA\_Notices.*

For group level analysis, there is also:

*GR\_Final\_KU\_Notices\_With\_Groups*

*GR\_Final\_KA\_Notices\_With\_Groups*

*RNG\_Final\_KU\_Notices\_With\_Groups*

*RNG\_Final\_KA\_Notices\_With\_Groups*

Annex 2

**On-board unmanned aircraft tracking antenna development  
for satellite communication**

**A2.1 Introduction**

**A2.1.1 Background**

Unmanned aircraft systems (UAS) have been attracting attention in recent years in the world for a variety of applications such as supervision and monitoring of wind and flood damages. The realization of the control and non-payload communication (CNPC) links for the operation of UAS between a remote pilot and unmanned aircraft (UA) in the beyond-line-of-sight (BLOS) areas enables the flight in a wide range by using the functions of the global scale of fixed-satellite service (FSS) network. Since the Ku/Ka bands are already crowded, there is a need to consider sharing the bands with those of existing systems such as FSS and also the interference from/to the other satellites. For these reasons, the research and development of interference mitigation techniques has become an urgent issue. Specifically, the antenna beam of on-board tracking antenna must be appropriately controlled to prevent adverse effects on the other satellites.

In one administration, several government-commissioned research projects have been conducted for realizing new wireless communication applications using UAS [1]. This document presents the development of an on-board Ka-band tracking antenna in order to meet the needs of the implementation of the UAS CNPC links between the UA and satellite as an example of the government-commissioned research projects.

**A2.1.2 Unmanned aircraft systems command and non-payload communication link**

FIGURE A2.1 illustrates UAS using satellite links considered in ITU-R, which consists of a geostationary satellite station for FSS, an unmanned aircraft earth station (UAES) and an unmanned aircraft control station (UACS). In this system, we consider that the CNPC links, which are performed between UACS and UAES, are divided into Links 1, 2, 3, and 4 as shown in FIGURE A2.1.

The characteristics of the links 1 and 4 between UACS and FSS space station (FSS-SS) in Fig. 1 is considered to be equated with those of the conventional satellite communication channel. However, the characteristics of the links 2 and 3 between FSS-SS and UAES may be different from those of the links 1 and 4. When developing an on-board antenna for UA, it is important to take into account the characteristics of the propagation of the links 2 and 3 and the motion characteristics of the UA. It is also necessary to refer to relevant standards such as the protection criterions for UAS and for existing systems.

Figure A2.1

**Unmanned aircraft system and command and non-payload communication links**

**2**

**1**

**3**

**4**

**Fix Satellite Station (FSS)**

**Space Station**

**UAS CNPC Links**

**1+2: Forward link (Remote pilot to UA)**

**1: Forward uplink (E-s)**

**2: Forward downlink (s-E)**

**3+4: Return link (UA to remote pilot)**

**3: Return uplink (E-s)**

**4: Return downlink (s-E)**

**UA Earth Station**

**(UAES)**



**Unmanned Aircraft Control Station (UACS)**

**Earth Station**

**Remote Pilot**

**5 GHz band**

**Ku/Ka band**

**5 GHz band**

**A2.2 Performance requirements considering the use of unmanned aircraft systems**

**A2.2.1 Design principles of the Ka-band radiation unit**

As the first step toward development to on-board antenna for UA, the characteristics of the propagation of the links between satellite and UAES and the motion characteristics of the UA are taken into account. It also refers to relevant standards such as protection criteria of existing systems and UAS.

In consideration of the above factors, a Ka-band on-board antenna for the UAS was developed to meet the following conditions:

– Consider the angle ranges of the antenna tracking by considering the longitude and latitude from the system’s service area to track stationary satellites, and control of the antenna beam.

– Whenever possible, to reduce the size, weight, power saving.

– Consider lowering the height of the antenna mounting system.

– Consider the flexible mounting performance in order to respond to diversification of mobile communication using geostationary satellites.

– Wide bandwidth to satisfy the Ka band (29.5 ~ 30.0 GHz/ 19.7 ~ 20.2 GHz band)

– Off-axis e.i.r.p. satisfies Recommendation ITU-R S.524-9.

Most Ku/Ka-band on-board antennas under development or existing have multi-horns or slot array as feeding method to make beam formation. As for the antenna beam control system, mechanical drive system is mostly introduced. Generally, phased array system is advantageous to control the angle of the flexible beam forming. Also, it is possible to reduce the height of the rotation diameter of the antenna.

Meanwhile, there are some drawbacks of the phased array antenna such as a decrease in gain as a decrease in the effective aperture plane, the high power consumption, and high cost. Referring to the development or some existing Ku/Ka-band onboard antennas, the reason why a mechanical drive system to the altitude and azimuth control is introduced is understandable.

In view of the currently available technologies, the mechanical drive system of elevation and azimuth control is thought to be a possible solution for on-board UA antennas at this point.

**A2.2.2 Required specifications and link budget design**

In order to design the antenna specifications for developing the antenna, the communication speed per one UA is supposed to be 5 Mbits/s because of transmitting high quality video images for see-and-avoid in addition to command and control (C2) link, and the communication requirement and conditions for the link budget are summarized in TABLE A2.1 and TABLE A2.2.

As the reference satellite, a broadband communication satellite system ‘WINDS’ developed as an experimental communication satellite to demonstrate technology for broadband satellite communications with internet protocol (IP) [2] is assumed

Table A2.1

**Antenna specifications requirement**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Items** | **Values** | **Comments** |
| ***1*** | Gain to noise temperature | Over 10.0 [dB/K @18.9](mailto:dB/K@18.9) GHz | Information speed: 5 Mbits/s  Margin: 1.5 dB |
| ***2*** | e.i.r.p. | Over 46.7 [dBW @28.6](mailto:dBW@28.6) GHz | Information speed: 5 Mbits/s  Margin: 0.8 dB |
| ***3*** | e.i.r.p. density | 24.5 [dBW/40 kHz @28.6](mailto:dBW/40kHz@28.6) GHz | Information speed: 5 Mbits/s  Symbol rate: 6.02 Msymbols/s |
| ***4*** | Block upgrade converter output | 10 W |  |

Table A2.2

**Assumed conditions for link budget**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Items** | **Values** | **Comments** |
| ***1*** | Satellite | Gain to noise temperature 17.7 dB/K | WINDS satellite[2] |
| ***2*** | Repeater | Vent pipe |  |
| ***3*** | Frequency | Tx: 28.6 GHz  Rx: 18.9 GHz |  |
| ***4*** | Earth station | SDR-VSAT with 2.4 m antenna |  |
| ***5*** | Modem | IDirect Infinity@5000 |  |
| ***6*** | Rain attenuation | None |  |
| ***7*** | Modulation method | QPSK, FEC rage: 0.495, *C/N*: 4.0 dB, Occupied bandwidth: 6.02 MHz | Information speed rate: 5 Mbits/s |

**A2.3 Development of unmanned aircraft tracking antenna system**

**A2.3.1 Design of radiation unit**

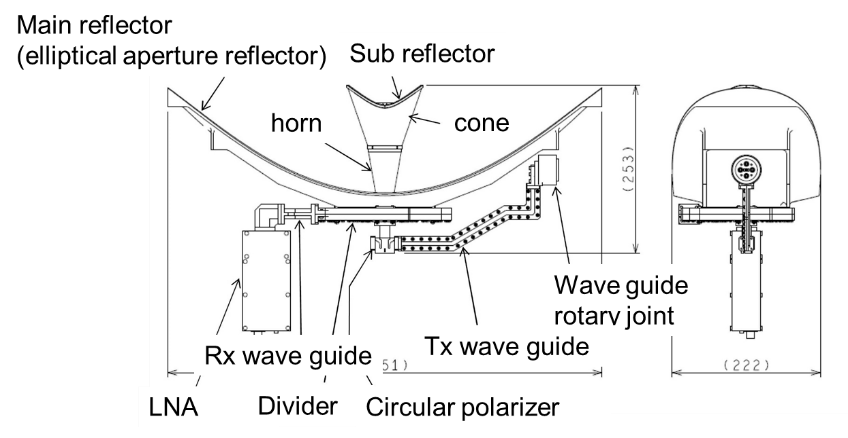
As the results of the above discussion, a Cassegrain type antenna system with elliptical aperture reflector is introduced since it expected to enable reduction of weight and manufacturing costs while reducing the height of the antenna. The Cassegrain system with elliptical aperture reflector also offers a wide frequency band to support the allocated Ka-band.

The hybrid analysis of physical optics approximation and the finite element method (FEM) was utilized to design and analyse the radiation unit. Moreover, the reflector shaping technique [3] that takes into account the suppression of scattered waves such as diffracted waves was utilized to achieve low profile and to satisfy the low side-lobe defined by ITU-R S.524-9.

FIGURE A2.2 shows the result of the appearance of the radiation unit with two reflectors. As shown in FIGURE A2.2, the radiation unit is composed of the main reflector, the sub-reflector, the primary radiator and the cone. The shape of the main reflector is close to elliptical because of the low profile. As the result of the antenna design, the antenna gains of the antenna achieve more than 35.3 dBi and 38.3 dBi at 18.9 GHz and 27.5 GHz, respectively.

Figure A2.2

**Appearance of the radiation unit.**



**A2.3.2 Evaluation of radiation unit of on-board antenna**

Several characteristics of the developed radiation unit were evaluated. The measured receive G/T values are listed in TABLE A2.3 and the off-axis radiation patterns obtained in a compact range anechoic chamber are shown in FIGURE A2.3. As shown in the results, the developed radiation unit of the on-board antenna satisfied the antenna requirements defined in Recommendation ITU-R [S.524-9](https://www.itu.int/rec/R-REC-S.524-9-200604-I/en) and system parameters to realize 5 Mbits/s communication speed. The 2-D radiation patterns using a near field measurement system were also measured. From these results, the symmetries of the antenna patterns were also confirmed.

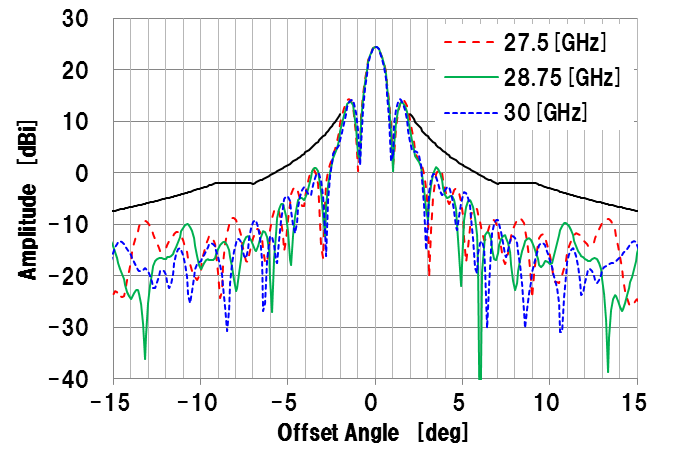
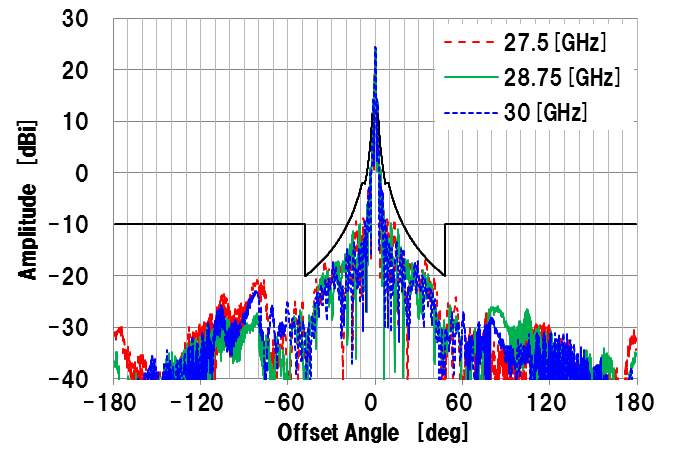
Table A2.3

**Measured receive gain to noise temperature values**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **Unit** |  |  |  |  |  |
| Frequency | | GHz | 17.7 | 18.3 | 18.9 | 19.2 | 20.2 |
| Gain | | dBi | 34.0 | 34.7 | 35.2 | 35.7 | 35.8 |
| System noise temperature | | dB | 22.5 | 22.5 | 23.0 | 22.3 | 22.6 |
|  | | K | 174.8 | 176.7 | 197.5 | 167.3 | 179.0 |
|  | Antenna noise temperature | K | 86.1 | 78.3 | 106.4 | 74.2 | 85.9 |
|  | LNA noise temperature | K | 88.7 | 98.4 | 93.1 | 93.1 | 93.1 |
|  | Gain to noise temperature | dB/K | 11.5 | 12.2 | 12.2 | 13.4 | 13.2 |

Figure A2.33

**Measured off-axis radiation pattern-1 and pattern-2 around 0 degrees**



ITU-R S.524-9

ITU-R S.524-9

**A2.3.3 Design of tracking antenna unit**

In view of the design target values, a variable directional antenna driving control unit was designed to satisfy the requirement of the on-board antenna for UAS. The block diagram of on-board unmanned aircraft tracking antenna including the developed radiation unit and the antenna driving unit is shown in FIGURE A2.4. The on-board unmanned aircraft tracking antenna consists of a radiation unit, low noise block down converter (LNB), a transmit block up converter (BUC), actuator & control unit, and so on.

As for the driving range, the azimuth (AZ) range is designed to cover continuous 360 degrees, and the elevation (EL) range is 0 to 90 degrees.

As the result of the development of the on-board antenna, FIGURE A2.5 shows the appearance view and configuration of the antenna unit.

Figure A2.4

**Block diagram of on-board unmanned aircraft tracking antenna**

FEED

BUC

AZ

R/J

EL

R/J

Control

Component

AZ

S/R

AZ

Motor

EL

Motor

ACU

MODEM

IRU

AC 100V

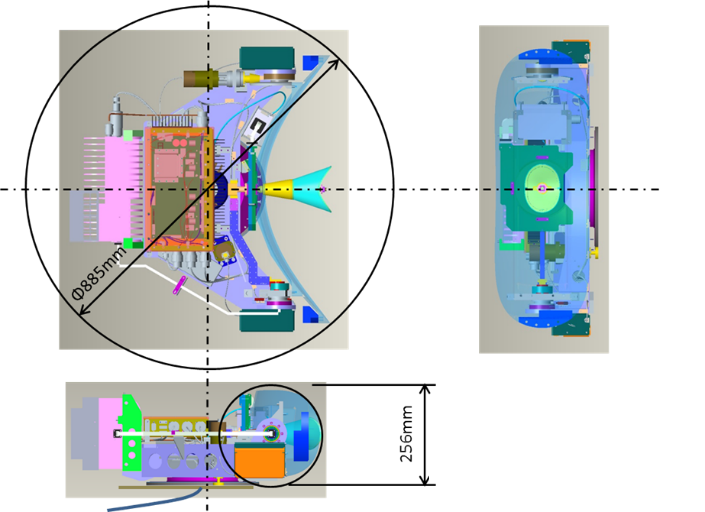
HUB

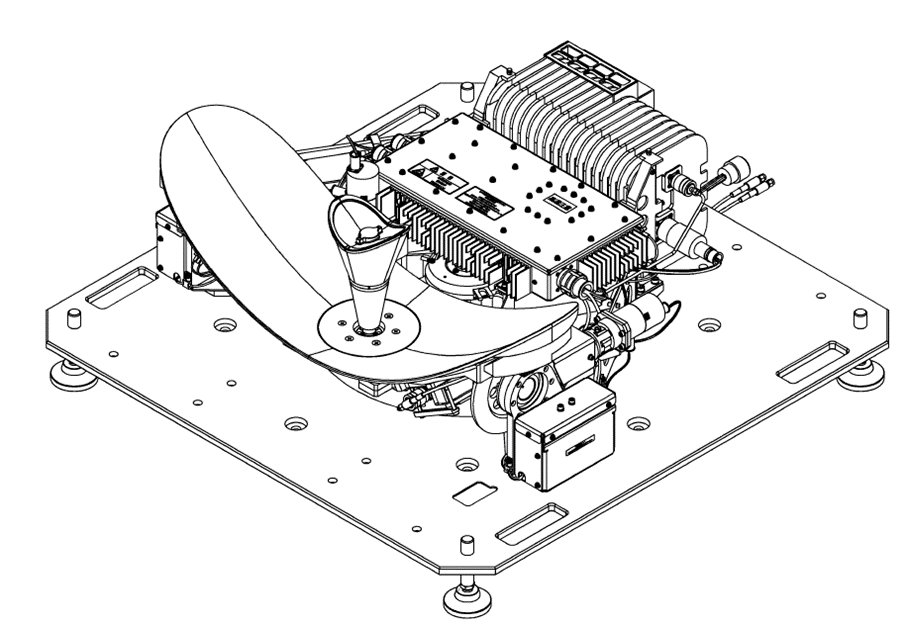
NW

LNB

Figure A2.5

**Appearance view and configuration of on-board unmanned aircraft tracking antenna**





Control Unit

Radiation Unit

BUC

EL motor

AZ motor

**A2.3.4 Evaluation of the antenna tracking unit**

Several performance evaluations of the antenna tracking unit were conducted such as tracking error to confirm several characteristics of the antenna tracking system. As a result of the evaluation, the tracking errors of both AZ and EL axes meet within 0.2 degrees including over-shoots.

**A2.3.5 Characteristics of the unmanned aircraft tracking antenna system**

TABLE A2.4 summarizes the characteristics of the developed Ka-band Unmanned Aircraft Tracking Antenna System particularly in regards to link 2 and 3.

Table A2.4

**Some characteristics of the Ka-band on-board antenna**

| **Items** |  | **Values** | **Comments** |
| --- | --- | --- | --- |
| **Reception Characteristics for Link 2** | | | |
| Frequency | Max | 20.20 GHz |  |
|  | Min | 17.30 GHz |  |
| G/T |  | 12.2 dB/K @ 18.9 GHz | Including, sky, moisture, cloud at 45 degrees elevation |
| Antenna diameter | Gain | 0.65 m | horizontal axis |
| Typical antenna efficiency |  | 50% |  |
|  |  | 35.2 dBi @ 18.9 GHz |  |
| Antenna patterns | Beam width | 1.3 degrees |  |
|  |  | 24.7 dBi at ±2.5 degrees |  |
| Pointing error |  | < 0.184 degree |  |
| Pointing method |  | automatic |  |
| **Transmission Characteristic for Link 3** | | | |
| Frequency | Max | 30.00 GHz |  |
|  | Min | 27.50 GHz |  |
| Maximum on-axis e.i.r.p. density. |  | 26.3 dB(W/40 kHz) |  |
|  | Power\_max | 10.0 dBW |  |
|  | Bandwidth\_aggr | 6 400 kHz |  |
|  | Gain | 38.3 dBi |  |
| Maximum off-axis e.i.r.p density. |  | 16 dB(W/40 kHz) at ±2.5 degrees |  |
| Antenna diameter |  | 0.65 m |  |
| Typical antenna efficiency. |  | 45 % |  |
| Antenna pattern. |  | 0.9 degrees |  |
|  |  | 28 dBi at ±2.5 degrees |  |
| Pointing error |  | < 0.184 degree |  |
| Pointing method. |  | automatic |  |
| Power control. |  | none |  |
| **Other characteristics** | | | |
| Antenna size |  | Height < 26 cm | Without radome |
| Total weight |  | 28.8 kg |  |
| Polarization |  | Tx: right-handed circularly  Rx: left-handed circularly |  |
| AZ, EZ angle range |  | AZ: 360 degrees (continual move)  EL: -10 to 90 degrees |  |
| AZ, EZ angle speed |  | AZ: 80 degrees/s  EL: 140 degrees/s |  |

**A2.4 Evaluation test using an actual aircraft**

The total receiving performance of the developed on-board antenna was evaluated using a small manned airplane by communicating with experimental geostationary satellite named Wideband Inter-Networking engineering test and Demonstration Satellite (WINDS). The WINDS uses the Ka-band (28 GHz uplink / 18 GHz downlink) for communication. The details of WINDS information can be obtained as identification number ‘108501175’ as ‘WINDS-A’ satellite network name in ITU-R MIFR. For evaluation test , beam “UJR” was used for satellite uplink (link 1) and beam “DIR” was used for satellite downlink (link 2).

FIGURE A2.6 shows the aircraft and mounted antenna used for the evaluation campaign. As shown in FIGURE A2.6, the communications to the back of the aircraft cannot be performed due to the mounting condition of the aircraft and there is a gain attenuation by the head of the pilot in the specified angle range.

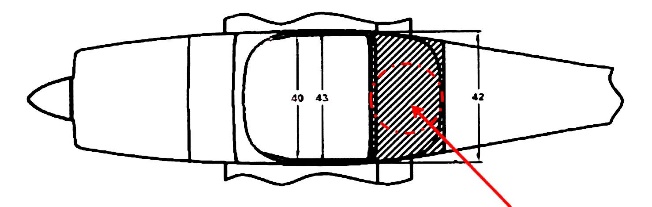
FIGURE A2.7 shows the received *C/N*, the altitude and the azimuth of the aircraft, and the antenna transmission control signal (inter-lock signal) output which indicates the cases of the decrease in the reception level and excessive tolerance of the tracking error (±0.2 degrees or more) obtained by the test that reached a stable altitude (2 000 m) from the takeoff of the aircraft and lowered altitude while turning. The horizontal axis indicates time (second).

From this result, almost the theoretical *C/N* values can be received when the directivity of the antenna is within the receivable range, and the communication control can be performed properly when the reception level is lowered or the tracking error exceeds the allowable range.

Figure A2.6

**Appearance of airplane and on-board antenna**





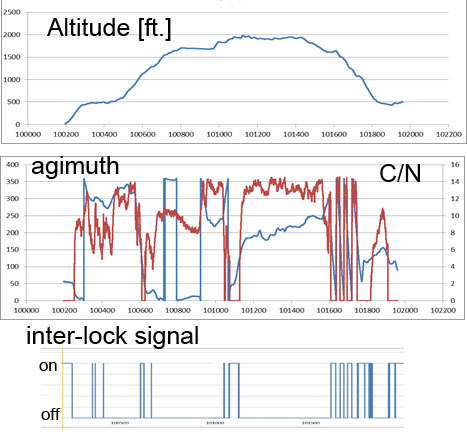
On-board antenna

Communication coverage

Pilot head

Figure A2.7

**An example of measurement result of the evaluation test**

s

**A2.5 Conclusion**

This document provides the background of a new communication system which utilized the frequency band of the fixed-satellite service for the command and non-payload communication links for the operation of unmanned aircraft systems and mentioned the results of the developing of the on-board Ka band tracking antenna for unmanned aircraft system.

References

[1] Miura, R., Inoue, M., Owada Y., Takizawa, K., Ono, F., Suzuki, M., Tsuji, H., and Hamaguchi, K., “Disaster-resilient wireless mesh network,” Proc. WPMC2013, Atlantic City, USA, June 27, 2013.

[2] Kadowaki, N., Yoshimura, N., Ogawa, Y., Hashimoto, Y., “High performance on‑board switch for the next generation multi-beam satellite,” Proceedings of IAC 2004, Vancouver, Canada, Oct. 4-8, 2004.

[3] Inasawa, Y., “Design method for a low-profile dual-shaped reflector antenna with an elliptical aperture by the suppression of undesired scattering,” IEICE Trans., 91‑C, April 2008, pp. 615-624.