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| **U.S. Radiocommunications Sector**  **Fact Sheet** | |
| **Working Party:** ITU-R WP 4C | **Document No:**  US4C-01 |
| **Ref:** Doc. ITU-R M.1787 | **Date:** XX October 2024 |
| **Document Title:** Draft Revision of Recommendation (DRR) on New Non-GSO RNSS system in the 1164-1215 MHz and 1559-1610 MHz Frequency Bands | |
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| **Purpose/Objective:** To provide a DRR for Recommendation ITU-R M.1787 to include a new Annex 15 with the technical description and characteristics of the USASAT-NGSO-12 (Xona PULSAR) RNSS System, a non-geostationary satellite orbit (non-GSO) system filing for the radionavigation-satellite service (RNSS) frequency bands at 1164-1215 MHz and 1559-1610 MHz from the United States. | |
| **Abstract:** This DRR is intended to be included as U.S. contribution to revise Recommendation ITU-R M. 1787 with the inclusion of a new Annex 15. Annex 15 provides the technical description and characteristics of the new non-GSO U.S. RNSS system, USASAT-NGSO-12 (Xona PULSAR). | |
| **Fact Sheet prepared by:** Christina Youn | |

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| **Radiocommunication Study Groups** |  |
| Subject: Recommendation ITU-R M.1787, Doc. 4C/445, Annex 1 (from 2019-2023 ITU-R study cycle) | **4C/USA-** |
| |  | | --- | | **\_\_ October 2024** | |
| **English only** |
| |  | | --- | | **United States of America** | | Updates to Draft Revision of Recommendation ON New non-GSO RNSS system in the 1164-1215 MHz and 1559-1610 MHz Frequency bands |   **Introduction**  This contribution modifies the preliminary draft revision of Recommendation ITU-R M.1787-5 that was initiated at the April 2024 meeting of WP 4C to include a new Annex 15 with the technical description and characteristics of the USASAT-NGSO-12 (Xona PULSAR) RNSS System, a non-geostationary satellite orbit (non-GSO) system filing for the radionavigation-satellite service (RNSS) frequency bands at 1164-1215 MHz and 1559-1610 MHz from the United States. The USASAT-NGSO-12 system is planned for 258 satellites in 18 orbital planes providing RNSS service in the above-identified frequency bands.  The United States intends to continue the process of revising Recommendation ITU-R M.1787 with the revisions to Annex 1 of Doc. 4C/445 (from the 2019-2023 ITU-R study cycle) presented in the attachment to this document. New revisions to Annex 1from the preliminary draft revision of Recommendation ITU-R M.1787-5 are shown in yellow highlighting.  **Attachment**: 1 | |

**ATTACHMENT**

**Revisions to Annex 1 to Working Party 4С Chairman’s Report**

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| Draft revision of Recommendation ITU-R M.1787-[5] |
| Description of systems and networks in the radionavigation-satellite service (space-to-Earth and space-to-space) and technical characteristics of transmitting space stations operating in the bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz |

(2009-2012-2014-2018-2022)

Summary of revision

This Recommendation is revised in its Annex 11, in order to reflect updates in the characteristics of the KASS. New Annex 15 (with the description and technical characteristics of the Xona PULSAR system of transmitting space stations planned for operation in the bands 1 164-1 215 MHz and 1 559-1 610 MHz) and new Annex 16 (with the description and technical characteristics of the KPS in the radionavigation-satellite service to provide positioning, navigation, and timing information in the bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz), are also added.

Scope

The information on orbital parameters, navigation signals and technical characteristics of systems and networks in the radionavigation-satellite service (RNSS) (space-to-Earth, space-to-space) operating in the bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz are presented in this Recommendation. This information is intended for use in the assessment of the interference impact between systems and networks in the RNSS and with other services and systems.

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*[****Editor’s Note****: PDRR ITU-R M.1787[5] from the April 2024 meeting includes revisions to Annex 11 as well as the addition of Annex 15 and Annex 16. This contribution only pertains to the Annex 15 portion of the document for consideration. All of the material for Annex 15 is proposed as a new addition to Recommendation ITU-R M.1787. The sections highlighted in yellow are changes to PDRR ITU-R M.1787[5] submitted at the April 2024 meeting. It is shown here without track changes for ease of review.]*

Annex 15

Technical description and characteristics of the USASAT-NGSO-12 (“Xona PULSAR”) RNSS System

# 1 Introduction

USASAT-NGSO-12 is United States non-GSO RNSS system planned for operation in the 1164-1215 MHz and 1559-1610 MHz RNSS frequency bands. The United States filing was made on behalf of Xona PULSAR, a commercial provider of positioning, navigation, and timing (PNT) services. These services will be provided by 258 Low Earth Orbiting (LEO) satellites across [12 inclined planes of 16 satellites and 6 polar planes of 11 satellites]. The nominal orbit altitude will be 1080km.

*{Editor’s Note:  The bracketed information in the preceding paragraph has been updated based on discussion at the April 2024 meeting and will be reviewed for the October 2024 meeting of WP 4C.}*

## 1.1 Xona PULSAR frequency requirements

Xona PULSAR service will be provided through two navigation signals centered at 1593.3225 MHz (LNK1) and 1190.51625 MHz (LNK2).

# 2 System overview

Xona PULSAR is a space-based LEO constellation that will provide PNT services to users worldwide. The system will operate on the principle of passive trilateration, similar to other Global Navigation Satellite System (GNSS). Once a receiver acquires signals transmitted from the space segment, the receiver computes pseudo-ranges to the satellites, computes their position, and synchronizes its clock to Xona PULSAR System Time. Stationary users with known positions can also use signals from a single satellite to synchronize its clock to Xona PULSAR System Time.

The high data-rate streams on LNK1 and LNK2 provide orbit and clock information of the satellites as well as corrections to UTC from Xona PULSAR System Time, corrections to orbit and clock information of other operational GNSS systems, and integrity information for safety of life services. The service is designed to be usable by all types of receivers of varying complexity and cost.

# 3 System segments

The system is comprised of three main segments: the Space Segment, the Control Segment, and the User Segment. Brief descriptions of the segments are in the subsections below.

## 3.1 Space segment

The space segment consists of a total of 258 satellites in the final deployment. The orbit parameters for these are summarized in Table 1 below:

Table 1: Orbit Parameters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number of 53 deg planes | Number of Sats per 53 deg plane | Number of 97 deg planes | Number of Sats per 97 deg plane | Total Sats |
| 12 | 16 | 6 (Note 1) | 11 | 258 |

The altitude for all satellites in all deployment phases is about 1080 km. The satellites are three-axis stabilized and the boresight of the antennas broadcasting the navigation signal are always nadir pointing.

Note 1: Xona’s first satellite, the In-Orbit Validation (IOV) mission, will be at 500-550km altitude and 98 degrees SSO. At the end of its mission, the IOV will be replaced by a production satellite in accordance with the full system parameters.

{***Editor’s Note****:  Xona notified the ITU Space Publication and Registration Division its constellation for the referenced ITU filing for USASAT-NGSO-12 at 1080km is not SSO pursuant to discussion at the April 2024 meeting. However, Xona’s IOV mission, for which the ITU filing will be amended, will be SSO.*}

## 3.2 Control segment

The control segment is responsible for all aspects of constellation command and control. It is a network of distributed reference and uplink sites worldwide.

## 3.3 User segment

The user segment is comprised of many different users and their support equipment. A typical user device consists of an antenna, front-end, processor, input/output devices, and a power supply. For the purposes of using the navigation signals broadcast from the Xona PULSAR constellation, the user equipment operates in a receive-only mode.

After the signals are acquired and tracked by user receivers, corrections are applied to various atmospheric and local error sources to calculate a precise position and time solution. User equipment takes many forms from lightweight, low-cost receivers to sophisticated, mounted receivers.

# 4 Signal structure

The navigation signals transmitted from the satellites consist of 2 modulated carriers: LNK1 at a center frequency of 1190.51625 MHz and LNK2 at a center frequency of 1593.3225 MHz. All navigation signals consist of three layers: (1) a carrier wave, (2) a repeating pseudo-random noise (PRN) sequence, and (3) a data sequence.

The service operates using Code Division Multiple Access (CDMA), which is employed on the PRN layer of the signals.

# 5 Signal power and spectra

The Xona PULSAR satellites will employ an antenna that is designed to radiate uniform power to receivers near the Earth’s surface. The signals transmitted on the LNK1 and LNK2 carriers are right-hand circularly polarized (RHCP).

# 6 Transmission parameters

The LNK1 transmission parameters are summarized in Table 2, the antenna gain pattern in Table 3, and the PSD in Table 4. The LNK2 transmission parameters are summarized in Table 5, the antenna gain pattern in Table 6, and the PSD in Table 7.

## 6.1 LNK1 Transmission parameters

Table 2

LNK1 Transmission Parameters

|  |  |
| --- | --- |
| Parameter | Parameter Value |
| Signal Frequency Range (MHz) | 1593.3225 ± 1 |
| PRN Code Chip Rate (Mcps) | 1.023 |
| Polarization | RHCP |
| Received Isotropic Power (dBW) | -138.4 (Note 2) |

Note 2: Received Isotropic Power is defined as the power received from a single satellite at the output of an isotropic (0dBi) receive antenna that is perfectly polarization matched to the transmitter.

{***Editor’s Note****:  The Received Isotropic Power has been updated from -138.6 to -138.4. The formatting has been updated and former Note 1 has been changed to Note 2 to account for the new Note 1 regarding the IOV mission on Table 1.*

TABLE 3

**LNK1 Antenna Gain Pattern**

|  |  |  |  |
| --- | --- | --- | --- |
| **Off-Boresight Angle (deg)** | **Gain (dBic)** | **Off-Boresight Angle (deg)** | **Gain (dBic)** |
| 0 | 0.000 | 31 | 1.618 |
| 1 | 0.002 | 32 | 1.735 |
| 2 | 0.006 | 33 | 1.858 |
| 3 | 0.014 | 34 | 1.986 |
| 4 | 0.025 | 35 | 2.120 |
| 5 | 0.039 | 36 | 2.260 |
| 6 | 0.056 | 37 | 2.407 |
| 7 | 0.076 | 38 | 2.560 |
| 8 | 0.100 | 39 | 2.721 |
| 9 | 0.126 | 40 | 2.890 |
| 10 | 0.156 | 41 | 3.067 |
| 11 | 0.189 | 42 | 3.253 |
| 12 | 0.225 | 43 | 3.448 |
| 13 | 0.265 | 44 | 3.654 |
| 14 | 0.308 | 45 | 3.871 |
| 15 | 0.354 | 46 | 4.100 |
| 16 | 0.404 | 47 | 4.343 |
| 17 | 0.458 | 48 | 4.601 |
| 18 | 0.515 | 49 | 4.876 |
| 19 | 0.575 | 50 | 5.171 |
| 20 | 0.639 | 51 | 5.488 |
| 21 | 0.708 | 52 | 5.832 |
| 22 | 0.779 | 53 | 6.209 |
| 23 | 0.855 | 54 | 6.628 |
| 24 | 0.935 | 55 | 7.100 |
| 25 | 1.019 | 56 | 7.648 |
| 26 | 1.108 | 57 | 8.319 |
| 27 | 1.200 | 58 | 9.241 |
| 28 | 1.298 | 59 | 10.483 |
| 29 | 1.400 | 60 | 10.483 |
| 30 | 1.506 | 61 | 10.476 |

***{Editor’s Note:*** *LNK1 spacecraft transmit antenna gain pattern information added based on discussion at April 2024 meeting.}*

Table 4

LNK1 Normalized Power Spectral Density

| Freq (MHz) | PSD (dBc/Hz) | Freq (MHz) | PSD (dBc/Hz) | Freq (MHz) | PSD (dBc/Hz) | Freq (MHz) | PSD (dBc/Hz) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1590.3929 | -117.7003 | 1591.9663 | -91.5382 | 1593.5398 | -59.9374 | 1595.1132 | -103.5319 |
| 1590.4678 | -114.7051 | 1592.0413 | -90.3636 | 1593.6147 | -60.9801 | 1595.1882 | -104.3295 |
| 1590.5427 | -112.7833 | 1592.1162 | -89.2205 | 1593.6896 | -61.7179 | 1595.2631 | -105.7049 |
| 1590.6176 | -112.4104 | 1592.1911 | -87.4417 | 1593.7646 | -62.8127 | 1595.3380 | -106.7811 |
| 1590.6926 | -112.4177 | 1592.2660 | -84.4336 | 1593.8395 | -64.1868 | 1595.4130 | -107.9321 |
| 1590.7675 | -113.5020 | 1592.3410 | -80.6652 | 1593.9144 | -66.0324 | 1595.4879 | -108.9005 |
| 1590.8424 | -113.6658 | 1592.4159 | -77.1027 | 1593.9893 | -68.1620 | 1595.5628 | -110.0811 |
| 1590.9174 | -113.3215 | 1592.4908 | -73.9417 | 1594.0643 | -70.5975 | 1595.6377 | -111.2274 |
| 1590.9923 | -111.9585 | 1592.5657 | -70.9337 | 1594.1392 | -73.1208 | 1595.7127 | -112.7991 |
| 1591.0672 | -110.3443 | 1592.6407 | -68.3185 | 1594.2141 | -76.2707 | 1595.7876 | -114.1890 |
| 1591.1421 | -109.4776 | 1592.7156 | -66.4082 | 1594.2891 | -79.6743 | 1595.8625 | -113.5472 |
| 1591.2171 | -108.2782 | 1592.7905 | -64.9191 | 1594.3640 | -83.6724 | 1595.9374 | -112.6781 |
| 1591.2920 | -107.0851 | 1592.8654 | -63.2745 | 1594.4389 | -87.0262 | 1596.0124 | -112.2916 |
| 1591.3669 | -105.6100 | 1592.9404 | -61.9209 | 1594.5138 | -89.2015 | 1596.0873 | -112.9467 |
| 1591.4418 | -104.4658 | 1593.0153 | -60.8908 | 1594.5888 | -90.2977 | 1596.1622 | -114.0134 |
| 1591.5168 | -103.4315 | 1593.0902 | -60.4295 | 1594.6637 | -91.2073 | 1596.2372 | -116.9285 |
| 1591.5917 | -102.2807 | 1593.1652 | -59.6655 | 1594.7386 | -92.8607 | 1596.3121 | -122.0405 |
| 1591.6666 | -100.7056 | 1593.2401 | -59.5498 | 1594.8135 | -95.0644 | 1595.1132 | -103.5319 |
| 1591.7415 | -98.1376 | 1593.3150 | -59.2211 | 1594.8885 | -97.7131 | 1595.1882 | -104.3295 |
| 1591.8165 | -95.6274 | 1593.3899 | -59.0132 | 1594.9634 | -100.0994 |  |  |
| 1591.8914 | -93.4461 | 1593.4649 | -59.6189 | 1595.0383 | -102.2009 |  |  |

## 6.3 LNK2 Transmission parameters

Table 5

LNK2 Transmission Parameters

|  |  |
| --- | --- |
| Parameter | Parameter Value |
| Signal Frequency Range (MHz) | 1190.51625 ± 10 |
| PRN Code Chip Rate (Mcps) | 10.23 |
| Polarization | RHCP |
| Received Isotropic Power (dBW) | -136.0 (Note 1) |
| Note 1: Received Isotropic Power is defined as the power received from a single satellite at the output of an isotropic (0dBi) receive antenna that is perfectly polarization matched to the transmitter. | |

TABLE 6

**LNK2 Antenna Gain Pattern**

|  |  |  |  |
| --- | --- | --- | --- |
| **Off-Boresight Angle (deg)** | **Gain (dBic)** | **Off-Boresight Angle (deg)** | **Gain (dBic)** |
| 0 | 0.000 | 31 | 1.618 |
| 1 | 0.002 | 32 | 1.735 |
| 2 | 0.006 | 33 | 1.858 |
| 3 | 0.014 | 34 | 1.986 |
| 4 | 0.025 | 35 | 2.120 |
| 5 | 0.039 | 36 | 2.260 |
| 6 | 0.056 | 37 | 2.407 |
| 7 | 0.076 | 38 | 2.560 |
| 8 | 0.100 | 39 | 2.706 |
| 9 | 0.126 | 40 | 2.620 |
| 10 | 0.156 | 41 | 2.505 |
| 11 | 0.189 | 42 | 2.690 |
| 12 | 0.225 | 43 | 2.870 |
| 13 | 0.265 | 44 | 3.036 |
| 14 | 0.308 | 45 | 3.187 |
| 15 | 0.354 | 46 | 3.329 |
| 16 | 0.404 | 47 | 3.459 |
| 17 | 0.458 | 48 | 3.583 |
| 18 | 0.515 | 49 | 3.744 |
| 19 | 0.575 | 50 | 3.907 |
| 20 | 0.639 | 51 | 4.085 |
| 21 | 0.708 | 52 | 4.273 |
| 22 | 0.779 | 53 | 4.468 |
| 23 | 0.855 | 54 | 4.531 |
| 24 | 0.935 | 55 | 4.325 |
| 25 | 1.019 | 56 | 4.075 |
| 26 | 1.108 | 57 | 3.333 |
| 27 | 1.200 | 58 | -6.500 |
| 28 | 1.298 | 59 | -6.500 |
| 29 | 1.400 | 60 | -6.500 |
| 30 | 1.506 | 61 | -6.500 |

***{Editor’s Note:*** *LNK2 spacecraft transmit antenna gain pattern information added based on discussion at April 2024 meeting.}*

Table 7

LNK2 Normalized Power Spectral Density

| Freq (MHz) | PSD (dBc/Hz) | Freq (MHz) | PSD (dBc/Hz) | Freq (MHz) | PSD (dBc/Hz) | Freq (MHz) | PSD (dBc/Hz) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1161.2199 | -127.7003 | 1176.9545 | -101.5382 | 1192.6891 | -69.9374 | 1208.4237 | -113.5319 |
| 1161.9692 | -124.7051 | 1177.7038 | -100.3636 | 1193.4384 | -70.9801 | 1209.1730 | -114.3295 |
| 1162.7184 | -122.7833 | 1178.4530 | -99.2205 | 1194.1877 | -71.7179 | 1209.9223 | -115.7049 |
| 1163.4677 | -122.4104 | 1179.2023 | -97.4417 | 1194.9369 | -72.8127 | 1210.6715 | -116.7811 |
| 1164.2170 | -122.4177 | 1179.9516 | -94.4336 | 1195.6862 | -74.1868 | 1211.4208 | -117.9321 |
| 1164.9662 | -123.5020 | 1180.7008 | -90.6652 | 1196.4355 | -76.0324 | 1212.1701 | -118.9005 |
| 1165.7155 | -123.6658 | 1181.4501 | -87.1027 | 1197.1847 | -78.1620 | 1212.9194 | -120.0811 |
| 1166.4648 | -123.3215 | 1182.1994 | -83.9417 | 1197.9340 | -80.5975 | 1213.6686 | -121.2274 |
| 1167.2140 | -121.9585 | 1182.9486 | -80.9337 | 1198.6833 | -83.1208 | 1214.4179 | -122.7991 |
| 1167.9633 | -120.3443 | 1183.6979 | -78.3185 | 1199.4325 | -86.2707 | 1215.1672 | -124.1890 |
| 1168.7126 | -119.4776 | 1184.4472 | -76.4082 | 1200.1818 | -89.6743 | 1215.9164 | -123.5472 |
| 1169.4618 | -118.2782 | 1185.1965 | -74.9191 | 1200.9311 | -93.6724 | 1216.6657 | -122.6781 |
| 1170.2111 | -117.0851 | 1185.9457 | -73.2745 | 1201.6803 | -97.0262 | 1217.4150 | -122.2916 |
| 1170.9604 | -115.6100 | 1186.6950 | -71.9209 | 1202.4296 | -99.2015 | 1218.1642 | -122.9467 |
| 1171.7096 | -114.4658 | 1187.4443 | -70.8908 | 1203.1789 | -100.2977 | 1218.9135 | -124.0134 |
| 1172.4589 | -113.4315 | 1188.1935 | -70.4295 | 1203.9281 | -101.2073 | 1219.6628 | -126.9285 |
| 1173.2082 | -112.2807 | 1188.9428 | -69.6655 | 1204.6774 | -102.8607 | 1220.4120 | -132.0405 |
| 1173.9574 | -110.7056 | 1189.6921 | -69.5498 | 1205.4267 | -105.0644 |  |  |
| 1174.7067 | -108.1376 | 1190.4413 | -69.2211 | 1206.1759 | -107.7131 |  |  |
| 1175.4560 | -105.6274 | 1191.1906 | -69.0132 | 1206.9252 | -110.0994 |  |  |
| 1176.2052 | -103.4461 | 1191.9399 | -69.6189 | 1207.6745 | -112.2009 |  |  |