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| 3GPP TR 38.863 V18.0.0 (2023-12) |
| Technical Report |
| 3rd Generation Partnership Project;  Technical Specification Group Radio Access Network;  Solutions for NR to support non-terrestrial networks (NTN):  Non-terrestrial networks (NTN) related RF and co-existence aspects  (Release 18) |
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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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x the first digit:

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document covers the RF and co-existence aspects of the work item “Solutions for NR to support non-terrestrial networks (NTN)” [2]

The objectives for the study are the following:

- Study and specify adjacent channel co-existence scenarios of Non-terrestrial networks (NTN).

- Study and specify needed generic RF core requirements for the network and the UE such that adjacent channel co-existence scenarios are met.

NOTE: Satellite operation is used as complementarily to Terrestrial Network operation, and in separate location when satellite operates in an adjacent channel/band of terrestrial network. For instance, NTN satellite UE is assumed to connect and transmit to the satellite when it is outside a Terrestrial Network operating in an adjacent channel/band. The satellite beam might still overlap the terrestrial network.

# 2 Reference

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP RP-213691: "Revised WID: Solutions for NR to support non-terrestrial networks (NTN)".

[3] ITU-R Radio Regulations, 2020 Edition

[4] ECC Decision 06(09): "Designation of the bands 1980-2010 MHz and 2170-2200 MHz for use by systems in the Mobile-Satellite Service including those supplemented by a Complementary Ground Component (CGC)", Approved 01 December 2006, Amended 05 September 2007,

[5] 3GPP TR 38.811: "Study on New Radio (NR) to support non-terrestrial networks".

[6] 3GPP TR 38.821: "Solutions for NR to support Non-Terrestrial Networks (NTN)".

[7] 3GPP RP-152284: "Revised Work Item: Narrowband IoT ".

[8] 3GPP TR 36.942: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Frequency (RF) system scenarios".

[9] 3GPP TR 45.820: "Cellular system support for ultra-low complexity and low throughput Internet of Things (CIoT)".

[10] 3GPP TR 38.901: "Study on channel model for frequencies from 0.5 to 100 GHz".

[11] Report ITU-R M.2292: "Characteristics of terrestrial IMT-Advanced systems for frequency sharing/interference analyses".

[12] 3GPP RP-200559: "LS on Parameters of terrestrial component of IMT for sharing and compatibility studies in preparation for WRC-23 (below 5 GHz) ".

[13] ITU-R Annex 4.4 to Document 5D/716-E.

[14] 3GPP TR 38.921: "Study on International Mobile Telecommunications (IMT) parameters for 6.425 - 7.025 GHz, 7.025 - 7.125 GHz and 10.0 - 10.5 GHz".

[15] 3GPP TR 36.802: "Evolved Universal Terrestrial Radio Access (E-UTRA); NB-IOT; Technical Report for BS and UE radio transmission and reception".

[16] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception".

[17] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[18] 3GPP R4-2111460: "On the Rx Parameters and Rx Testing Setup for NTN gNB".

[19] 3GPP R4-2108099: "WF on [312] NTN\_Solutions\_Part1".

[20] FCC Online Table of Frequency Allocations, 47 C.F.R § 2.106, February 1, 2021.

[21] FCC Order 03-15, Report and Order and Notice of Proposed Rule Making, January 29, 2003.

[22] FCC Order 20-48, Order and Authorization, April 19, 2020.

[23] FCC Code of Federal Regulations.

[24] SoftBank, Loon LLC, Nokia, Ericsson, “Proposed deployment and system characteristics of HIBS in the working document towards a preliminary draft new Report ITU-R M.[HIBS-CHARACTERISTICS],” ITU WP-5D contribution, Sep. 28, 2020.

[25] 3GPP TS 38.181: "NR; Satellite Node conformance testing".

[26] 3GPP TS 38.108: "NR; Satellite Node radio transmission and reception".

[27] 3GPP R4-213618: "Moderator’s summary of discussion [94e-41-R17-NRNTN-RAN4Spec] ".

[28] ERC Recommendation 74-01: "Unwanted emissions in the spurious domain".

[29] Recommendation ITU-R SM.1541-6: "Unwanted emissions in the out-of-band domain".

[30] Recommendation ITU-R SM.329: "Unwanted emissions in the spurious domain".

[31] 3GPP TR 38.817-02: "General aspects for Base Station (BS) Radio Frequency (RF) for NR".

[32] 3GPP TR 38.817-01: " General aspects for User Equipment (UE) Radio Frequency (RF) for NR".

[33] FCC 16-89, REPORT AND ORDER AND FURTHER NOTICE OF PROPOSED RULEMAKING

[34] FCC 20-159, REPORT AND ORDER

[35] FCC 20-166, SECOND REPORT AND ORDER IN IB DOCKET NO. 17-95 AND REPORT AND ORDER IN IB DOCKET NO. 18-315 AND FURTHER NOTICE OF PROPOSED RULEMAKING

[36] ECC Decision(05)01, The use of the band 27.5-29.5 GHz by the Fixed Service and uncoordinated Earth stations of the Fixed-Satellite Service (Earth-to-space)

[37] ECC Decision(13)01, The harmonised use, free circulation and exemption from individual licensing of Earth Stations On Mobile Platforms (ESOMPs) within the frequency bands 17.3-20.2 GHz and 27.5-30.0 GHz

# 3 Definition of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**Feeder link:** Wireless link between NTN-Gateway and satellite

**Geostationary Earth Orbit:** Circular orbit at 35,786 km above the Earth's equator and following the direction of the Earth's rotation. An object in such an orbit has an orbital period equal to the Earth's rotational period and thus appears motionless, at a fixed position in the sky, to ground observers.

**Geosynchronous Orbit:** Earth-centered orbit at approximately 35786 kilometres above Earth's surface and synchronised with Earth's rotation. A geostationary orbit is a non-inclined geosynchronous orbit, i.e. in the Earth’s equator plane.

**Low Earth Orbit:** Orbit around the Earth with an altitude between 300 km, and 1500 km.

**Minimum Elevation angle**: Minimum angle under which the satellite or HAPS can be seen by a UE.

**Non-Geostationary Satellites:** Satellites (LEO and MEO) orbiting around the Earth with a period that varies approximately between 1.5 hour and 10 hours. It is necessary to have a constellation of several Non-Geostationary satellites associated with handover mechanisms to ensure a service continuity.

**Non-terrestrial networks:** Networks, or segments of networks, using an airborne or space-borne vehicle to embark a transmission equipment relay node or base station.

**NTN-Gateway:** An earth station or gateway is located at the surface of Earth, and providing sufficient RF power and RF sensitivity for accessing to the satellite (resp. HAPS).

**Satellite:** A space-borne vehicle embarking a bent pipe payload or a regenerative payload telecommunication transmitter, placed into Low-Earth Orbit (LEO), Medium-Earth Orbit (MEO), or Geostationary Earth Orbit (GEO).

**Service link:** Radio link between satellite and UE

**Transparent payload:** Payload that changes the frequency carrier of the UL/DL RF signal, filters and amplifies it before transmitting it on the DL/UL, respectively.

**UE transmission bandwidth configuration**: Set of resource blocks located within the UE channel bandwidth which may be used for transmitting or receiving by the UE.

**User Throughput:** data rate provided to a terminal

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

ΔFRaster Band dependent channel raster granularityΔFGlobal Granularity of the global frequency raster

ΔFRaster Band dependent channel raster granularity

BWChannel Channel bandwidth

BWinterferer Bandwidth of the interferer

FDL\_low The lowest frequency of the downlink *operating band*

FDL\_high The highest frequency of the downlink *operating band*

FUL\_low The lowest frequency of the uplink *operating band*

FUL\_high The highest frequency of the uplink *operating band*

FInterferer Frequency of the interferer

FInterferer (offset) Frequency offset of the interferer (between the center frequency of the interferer and the carrier frequency of the carrier measured)

FIoffset Frequency offset of the interferer (between the center frequency of the interferer and the closest edge of the carrier measured)

FOOB The boundary between the NR out of band emission and spurious emission domains

FREF RF reference frequency

FREF-Offs Offset used for calculating FREF

Fuw (offset) The frequency separation of the center frequency of the carrier closest to the interferer and the center frequency of the interferer

NRB Transmission bandwidth configuration, expressed in units of resource blocks NREF NR Absolute Radio Frequency Channel Number (NR-ARFCN)

NREF NR Absolute Radio Frequency Channel Number (NR-ARFCN)

NREF-Offs Offset used for calculating NREF

PInterferer Modulated mean power of the interferer

Puw Power of an unwanted DL signal

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

ACLR Adjacent Channel Leakage Ratio

ACS Adjacent Channel Selectivity

A-MPR Additional Maximum Power Reduction

BS Base Station

BW Bandwidth

BWP Bandwidth Part

CG Carrier Group

CP-OFDM Cyclic Prefix-OFDM

CW Continuous Wave

DFT-s-OFDM Discrete Fourier Transform-spread-OFDM

DM-RS Demodulation Reference Signal

DTX Discontinuous Transmission

EIRP Equivalent Isotropically Radiated Power

EVM Error Vector Magnitude

FR Frequency Range

FRC Fixed Reference Channel

FRF Frequency Reuse Factor

FSS Fixed Satellite Services

FWA Fixed Wireless Access

GEO Geostationary Earth Orbiting

gNB next Generation Node B

GW Gateway

GSCN Global Synchronization Channel Number

HAPS High Altitude Platform Station

HIPS HAPS as IMT Base Stations

IBB In-band Blocking

IDFT Inverse Discrete Fourier Transformation

ISL Inter-Satellite Links

ITU‑R Radiocommunication Sector of the International Telecommunication Union

LEO Low Earth Orbiting

Mbps Mega bit per second

MBW Measurement bandwidth defined for the protected band

MCG Master Cell Group

MEO Medium Earth Orbiting

MOP Maximum Output Power

MPR Allowed maximum power reduction

MS Mobile Services

MSD Maximum Sensitivity Degradation

MSS Mobile Satellite Services

NGEO Non-Geostationary Earth Orbiting

NR New Radio

NR-ARFCN NR Absolute Radio Frequency Channel Number

NS Network Signalling

NTN Non-Terrestrial Network

OCNG OFDMA Channel Noise Generator

OOB Out-of-band

P-MPR Power Management Maximum Power Reduction

PRB Physical Resource Block

PSCCH Physical Sidelink Control CHannel

PSSCH Physical Sidelink Shared CHannel

QAM Quadrature Amplitude Modulation

RAN Radio Access Network

RE Resource Element

REFSENS Reference Sensitivity

RF Radio Frequency

RMS Root Mean Square (value)

RSRP Reference Signal Receiving Power

Rx Receiver

SAN Satellite Access Node

SC Single Carrier

SCG Secondary Cell Group

SCS Subcarrier spacing

SEM Spectrum Emission Mask

SNR Signal-to-Noise Ratio

SRS Sounding Reference Symbol

SS Synchronization Symbol

TAE Time Alignment Error

TAG Timing Advance Group

Tx Transmitter

TxD Tx Diversity

UE User Equipment

ULFPTx Uplink Full Power Transmission

# 4 General aspects

## 4.1 Work item objectives

The Work item objectives are captured in [2].

# 5 Regulatory aspects

## 5.1 ITU-R

The following services are among those defined in the ITU-R Radio Regulations [3]:

- Fixed (1.20): A radiocommunication service between specified fixed points.

- Fixed satellite (1.21) : A radiocommunication service between earth stations at given positions, when one or more satellites are used; the given position may be a specified fixed point or any fixed point within specified areas; in some cases this service includes satellite-to-satellite links, which may also be operated in the inter-satellite service; the fixed-satellite service may also include feeder links for other space radiocommunication services.

- Mobile (1.24): radiocommunication service between mobile and land stations, or between mobile stations (CV).

- Mobile satellite (1.25): A radiocommunication service:

- between mobile earth stations and one or more space stations, or between space stations used by this service; or

- between mobile earth stations by means of one or more space stations.

This service may also include feeder links necessary for its operation.

Based on the ITU-R Radio Regulations [3], the following frequency ranges are allocated to MSS and have been identified as first candidate bands for NTN satellite operations:

- S-band: UL: 1980–2010 MHz / DL: 2170–2200 MHz.

- L-band: UL: 1626.5-1660.5 MHz / DL: 1525-1559 MHz.

For providing mobile services through HAPS, current ITU-R Radio Regulations [3] allow the use of frequency ranges 1885–1980 MHz, 2010-2025 MHz and 2110–2170 MHz by HAPS. Additional spectrum may be allocated for HAPS in 2023 (see clause 5.3).

## 5.2 Regulatory aspects for NTN satellites

### 5.2.1 NTN Satellite band: UL 1980–2010 MHz / DL 2170–2200 MHz

The ITU-R Radio Regulations [3] specify the following service allocation for those frequency ranges, shown in Table 5.2.1-1:

Table 5.2.1-1: Allocation of 1980–2010 MHz and 2170–2200 MHz in the ITU-R Radio Regulations

|  |  |  |
| --- | --- | --- |
| Allocation to services | | |
| Region 1 | Region 2 | Region 3 |
| 2 170-2 200 FIXED  MOBILE  MOBILE-SATELLITE (space-to-Earth) 5.351A  5.388 5.389A 5.389F | | |
|  | | |
| 1 980-2 010 FIXED  MOBILE  MOBILE-SATELLITE (Earth-to-space) 5.351A  5.388 5.389A 5.389B 5.389F | | |
| 5.351A: For the use of the bands 1 518-1 544 MHz, 1 545-1 559 MHz, 1 610-1 645.5 MHz, 1 646.5-1 660.5 MHz,1 668- 1 675 MHz, 1 980-2 010 MHz, 2 170-2 200 MHz, 2 483.5-2 520 MHz and 2 670-2 690 MHz by the mobile satellite service, see Resolutions 212 (Rev.WRC-07)\* and 225 (Rev.WRC-07)\*\*.  \* This Resolution was revised by WRC-15 and WRC-19.  \*\* This Resolution was revised by WRC-12.  5.388: The frequency bands 1 885-2 025 MHz and 2 110-2 200 MHz are intended for use, on a worldwide basis, by administrations wishing to implement International Mobile Telecommunications (IMT). Such use does not preclude the use of these frequency bands by other services to which they are allocated. The frequency bands should be made available for IMT in accordance with Resolution 212 (Rev.WRC-15)\* (see also Resolution 223 (Rev.WRC-15)\*). (WRC-15)  \* This Resolution was revised by WRC-19.  5.389A: The use of the bands 1 980-2 010 MHz and 2 170-2 200 MHz by the mobile-satellite service is subject to coordination under No. 9.11A and to the provisions of Resolution 716 (Rev.WRC-2000)\*\*.  \*\* This Resolution was revised by WRC-12.  5.389B: The use of the frequency band 1 980-1 990 MHz by the mobile-satellite service shall not cause harmful interference to or constrain the development of the fixed and mobile services in Argentina, Brazil, Canada, Chile, Ecuador,the United States, Honduras, Jamaica, Mexico, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay and Venezuela. (WRC-19)  5.389F: In Algeria, Cape Verde, Egypt, Iran (Islamic Republic of), Mali, Syrian Arab Republic and Tunisia, the use of the frequency bands 1 980-2 010 MHz and 2 170-2 200 MHz by the mobile-satellite service shall neither cause harmful interference to the fixed and mobile services, nor hamper the development of those services prior to 1 January 2005, nor shall the former service request protection from the latter services. (WRC-19) | | |

Following Figure 5.2.1-1 gives an overview of the NR TN bands adjacent to the NTN n256 band.

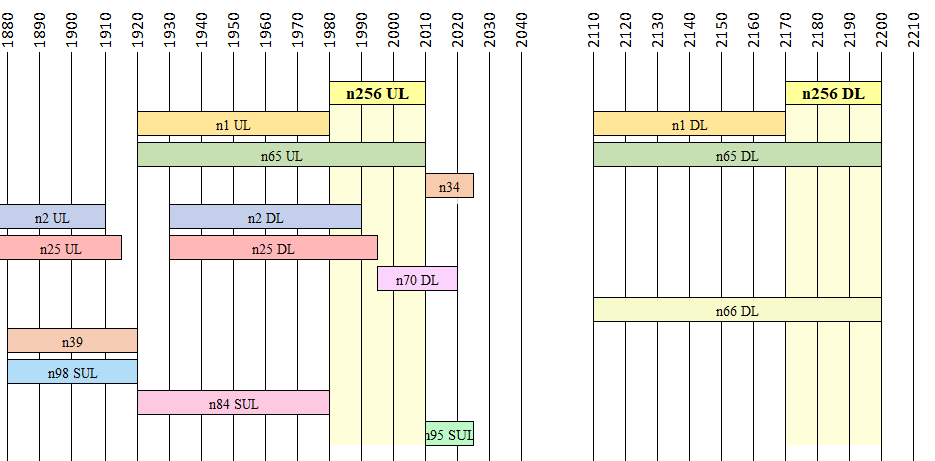


Figure 5.2.1-1: Adjacent TN bands to NTN band n256

As shown in Figure 5.2.1-1, the NTN satellite band is adjacent to NR bands n1 (FDD) and n34 (TDD). The bands need to be protected and co-existence analysis is required to determine the Adjacent Channel Interference Ratio (ACIR) and in-band power levels.

Also, the NTN band n256 will fully be overlapped by TN NR bands n65 and partly overlapped by TN NR bands n2, n25, n70 and n66, limiting band n256 deployment accordingly to countries where n2, n25 and/or n70 are not deployed or regional regulation applies.

Per ECC Decision 06(09) [4], n256 and Complementary Ground Component (CGC) could operate simultaneously in the upper 30 MHz portion of n65 in CEPT countries.

### 5.2.2 NTN Satellite band: UL 1626.5–1660.5 MHz / DL 1525–1559 MHz

The ITU-R Radio Regulations [3] specify the following service allocation for frequency ranges 1525 – 1559 MHz and 1626.5 – 1660.5 MHz as shown in Table 5.2.2-1.

Table 5.2.2-1: Allocation of 1525 –1559 MHz and 1626.5 – 1660.5 MHz in the ITU-R Radio Regulations

|  |  |  |
| --- | --- | --- |
| Allocation to services | | |
| Region 1 | Region 2 | Region 3 |
| 1 525-1 530  SPACE OPERATION  (space-to-Earth)  FIXED  MOBILE-SATELLITE  (space-to-Earth) 5.208B 5.351A  Earth exploration-satellite  Mobile except aeronautical mobile 5.349  5.341 5.342 5.350 5.351  5.352A 5.354 | 1 525-1 530  SPACE OPERATION  (space-to-Earth)  MOBILE-SATELLITE  (space-to-Earth) 5.208B 5.351A  Earth exploration-satellite  Fixed  Mobile 5.343  5.341 5.351 5.354 | 1 525-1 530  SPACE OPERATION  (space-to-Earth)  FIXED  MOBILE-SATELLITE  (space-to-Earth) 5.208B 5.351A Earth exploration-satellite  Mobile 5.349  5.341 5.351 5.352A 5.354 |
| 1 530-1 535  SPACE OPERATION  (space-to-Earth)  MOBILE-SATELLITE  (space-to-Earth) 5.208B 5.351A  5.353A  Earth exploration-satellite  Fixed  Mobile except aeronautical mobile  5.341 5.342 5.351 5.354 | 1 530-1 535  SPACE OPERATION (space-to-Earth)  MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.353A  Earth exploration-satellite  Fixed  Mobile 5.343  5.341 5.351 5.354 | |
| 1 535-1 559 MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A  5.341 5.351 5.353A 5.354 5.355 5.356 5.357 5.357A 5.359 5.362A | | |
| 1 626.5-1 660 MOBILE-SATELLITE (Earth-to-space) 5.351A  5.341 5.351 5.353A 5.354 5.355 5.357A 5.359 5.362A 5.374 5.375 5.376 | | |
| 1 660-1 660.5 MOBILE-SATELLITE (Earth-to-space) 5.351A  RADIO ASTRONOMY  5.149 5.341 5.354 5.362A 5.376A | | |
| The details of the notes 5.208B, 5.341, 5.342, 5.350, 5.351, 5.351A, 5.352A, 5.353A, 5.354, 5.355, 5.356, 5.357, 5.357A, 5.359, 5.362A, 5.374, 5.375 and 5.376A related to MOBILE-SATELLITE service can be found in [3]. | | |

FCC’s specifies the following service allocation for frequency ranges 1525 – 1559 MHz and 1626.5 – 1660.5 MHz in USA[20] as shown in Table 5.2.2-2.

Table 5.2.2-2: Allocation of 1525 –1559 MHz and 1626.5 – 1660.5 MHz in the US

|  |  |  |
| --- | --- | --- |
| Allocation to services | | |
| Federal Table | Non-Federal Table | FCC Rule Part(2) |
| 1525-1535  MOBILE-SATELLITE (space-to-Earth) US315 US380  5.341 5.351 | | Satellite Communications (25)  Maritime (80) |
| 1535-1559  MOBILE-SATELLITE (space-to-Earth) US308 US309 US315 US380    5.341 5.351 5.356 | | Satellite Communications (25)  Maritime (80)  Aviation (87) |
| 1626.5-1660  MOBILE-SATELLITE (Earth-to-space) US308 US309 US315 US380    5.341 5.351 5.375 | | Satellite Communications (25)  Maritime (80)  Aviation (87) |
| 1660-1660.5  MOBILE-SATELLITE (Earth-to-space) US308 US309 US380  RADIO ASTRONOMY    5.341 5.351 US342 | | Satellite Communications (25)  Aviation (87) |
| The details of the notes 5.341, 5.351, 5.356, 5.375, US308, US309, US315 and US342 related to MOBILE-SATELLITE service can be found in [20].  US380 In the bands 1525-1544 MHz, 1545-1559 MHz, 1610-1645.5 MHz, 1646.5-1660.5 MHz, and 2483.5-2500 MHz, a non-Federal licensee in the mobile-satellite service (MSS) may also operate an ancillary terrestrial component in conjunction with its MSS network, subject to the Commission’s rules for ancillary terrestrial components and subject to all applicable conditions and provisions of its MSS authorization. | | |

Chart, bar chart, histogram

Description automatically generated

NOTE: DL operation in band n24 is restricted to 1526-1536MHz and UL operation is restricted to 1627.5-1637.5MHz and 1646.5-1656.5MHz

Figure 5.2.2-1: Adjacent TN bands to NTN band n255

As shown in Figure 5.2.2-1, the NTN satellite band is not adjacent to any TN NR or LTE bands. The edge-to-edge separation for nearest TN band, n74 DL, is 7 MHz.

Also, the NTN band n255 fully overlaps with TN NR bands n24 and SUL NR band n99. Per note US380 in Table 5.2.2-2 simultaneous operation of n24/n99 and n255 is allowed in USA. Commission’s authorization and technical rules for TN can be found in FCC Orders 03-15 [21] and 20-48 [22] respectively. Commission’s technical rules for its MSS authorization can be found in FCC 47 C.F.R Part 25.

Technical rules for NTN SAN and UEs operating in 1 to 3 GHz from FCC’s 47 C.F.R. § 25.202 [23] are summarized below:

47 C.F.R. § 25.202:

(d) Frequency tolerance, Earth stations. The carrier frequency of each earth station transmitter authorized in these services shall be maintained within 0.001 percent of the reference frequency.

(e) Frequency tolerance, space stations. The carrier frequency of each space station transmitter authorized in these services shall be maintained within 0.002 percent of the reference frequency.

47 C.F.R. § 25.202 (f):

Emission limitations. Except for SDARS terrestrial repeaters and as provided for in paragraph (i), the mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in [paragraphs (f)(1)](https://www.ecfr.gov/current/title-47/section-25.202#p-25.202(f)(1)) through [(f)(4)](https://www.ecfr.gov/current/title-47/section-25.202#p-25.202(f)(4)) of this section. The out-of-band emissions of SDARS terrestrial repeaters shall be attenuated in accordance with the schedule set forth in [paragraph (h)](https://www.ecfr.gov/current/title-47/section-25.202#p-25.202(h)) of this section.

(1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;

(2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;

(3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;

(4) In any event, when an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in [paragraphs (f) (1)](https://www.ecfr.gov/current/title-47/section-25.202#p-25.202(f)(1)), [(2)](https://www.ecfr.gov/current/title-47/section-25.202#p-25.202(f)(2)) and [(3)](https://www.ecfr.gov/current/title-47/section-25.202#p-25.202(f)(3)) of this section.

47 C.F.R. § 25.216:

(a) The e.i.r.p. density of emissions from mobile earth stations placed in service on or before July 21, 2002 with assigned uplink frequencies between 1610 MHz and 1660.5 MHz shall not exceed −70 dBW/MHz, averaged over any 2 millisecond active transmission interval, in the band 1559-1587.42 MHz. The e.i.r.p. of discrete emissions of less than 700 Hz bandwidth generated by such stations shall not exceed −80 dBW, averaged over any 2 millisecond active transmission interval, in that band.

(b) The e.i.r.p. density of emissions from mobile earth stations placed in service on or before July 21, 2002 with assigned uplink frequencies between 1610 MHz and 1626.5 MHz shall not exceed −64 dBW/MHz, averaged over any 2 millisecond active transmission interval, in the band 1587.42-1605 MHz. The e.i.r.p. of discrete emissions of less than 700 Hz bandwidth generated by such stations shall not exceed −74 dBW, averaged over any 2 millisecond active transmission interval, in the 1587.42-1605 MHz band.

(c) The e.i.r.p. density of emissions from mobile earth stations placed in service after July 21, 2002 with assigned uplink frequencies between 1610 MHz and 1660.5 MHz shall not exceed −70 dBW/MHz, averaged over any 2 millisecond active transmission interval, in the band 1559-1605 MHz. The e.i.r.p. of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed −80 dBW, averaged over any 2 millisecond active transmission interval, in the 1559-1605 MHz band.

(d) As of January 1, 2005, the e.i.r.p. density of emissions from mobile earth stations placed in service on or before July 21, 2002 with assigned uplink frequencies between 1610 MHz and 1660.5 MHz (except Standard A and B Inmarsat terminals used as Global Maritime Distress and Safety System ship earth stations) shall not exceed −70dBW/MHz, averaged over any 2 millisecond active transmission interval, in the 1559-1605 MHz band. The e.i.r.p. of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed −80 dBW, averaged over any 2 millisecond active transmission interval, in the 1559-1605 MHz band. Standard A Inmarsat terminals used as Global Maritime Distress and Safety System ship earth stations that do not meet the e.i.r.p. density limits specified in this paragraph may continue operation until December 31, 2007. Inmarsat-B terminals manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 must meet these limits. Inmarsat B terminals manufactured before then are temporarily grandfathered under the condition that no interference is caused by these terminals to aeronautical satellite radio-navigation systems. The full-compliance deadline for grandfathered Inmarsat-B terminals is December 31, 2012.

(e) The e.i.r.p density of emissions from mobile earth stations with assigned uplink frequencies between 1990 MHz and 2025 MHz shall not exceed −70 dBW/MHz, averaged over any 2 millisecond active transmission interval, in frequencies between 1559 MHz and 1610 MHz. The e.i.r.p. of discrete emissions of less than 700 Hz bandwidth from such stations between 1559 MHz and 1605 MHz shall not exceed −80 dBW, averaged over any 2 millisecond active transmission interval. The e.i.r.p. of discrete emissions of less than 700 Hz bandwidth from such stations between 1605 MHz and 1610 MHz manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 shall not exceed −80 dBW, averaged over any 2 millisecond active transmission interval.

(f) Mobile earth stations placed in service after July 21, 2002 with assigned uplink frequencies in the 1610-1660.5 MHz band shall suppress the power density of emissions in the 1605-1610 MHz band to an extent determined by linear interpolation from −70 dBW/MHz at 1605 MHz to −10 dBW/MHz at 1610 MHz.

(g) Mobile earth stations manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 with assigned uplink frequencies in the 1610-1626.5 MHz band shall suppress the power density of emissions in the 1605-1610 MHz band-segment to an extent determined by linear interpolation from −70 dBW/MHz at 1605 MHz to −10 dBW/MHz at 1610 MHz averaged over any 2 millisecond active transmission interval. The e.i.r.p of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed a level determined by linear interpolation from −80 dBW at 1605 MHz to −20 dBW at 1610 MHz, averaged over any 2 millisecond active transmission interval.

(h) Mobile earth stations manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 with assigned uplink frequencies in the 1626.5-1660.5 MHz band shall suppress the power density of emissions in the 1605-1610 MHz band-segment to an extent determined by linear interpolation from −70 dBW/MHz at 1605 MHz to −46 dBW/MHz at 1610 MHz, averaged over any 2 millisecond active transmission interval. The e.i.r.p of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed a level determined by linear interpolation from −80 dBW at 1605 MHz to −56 dBW at 1610 MHz, averaged over any 2 millisecond active transmission interval.

(i) The e.i.r.p density of carrier-off state emissions from mobile earth stations manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 with assigned uplink frequencies between 1 and 3 GHz shall not exceed −80 dBW/MHz in the 1559-1610 MHz band averaged over any two millisecond interval.

(j) A Root-Mean-Square detector shall be used for all power density measurements.

For L-band NTN satellite operation in the US, additional spectrum emission requirements in 47 C.F.R § 25.216 (h) need to be specified for L-band NTN satellite UE. This can be captured as part of additional spurious emission requirements which allows inclusion of frequency ranges that are less than FOOB (MHz) from the edge of the channel bandwidth.

### 5.2.3 NTN Satellite band: UL 27.5-30.0 GHz / DL 17.3-20.2 GHz

#### 5.2.3.1 ITU-R

The ITU-R Radio Regulations [3] specify the following service allocation for those frequency ranges, shown in Table 5.2.3.1-1:

Table 5.2.3.1-1: Allocation of 17.3-20.2 GHz and 27.5-30.0 GHz in the ITU-R Radio Regulations

|  |  |  |
| --- | --- | --- |
| Allocation to services | | |
| Region 1 | Region 2 | Region 3 |
| 17.3-17.7  FIXED-SATELLITE (Earth-to-space) 5.516 (space-to-Earth) 5.516A 5.516B  Radiolocation  5.514 | 17.3-17.7  FIXED-SATELLITE (Earth-to-space) 5.516  BROADCASTING-SATELLITE  Radiolocation  5.514 5.515 | 17.3-17.7  FIXED-SATELLITE (Earth-to-space) 5.516  Radiolocation  5.514 |
| 17.7-18.1  FIXED  FIXED-SATELLITE (space-to-Earth) 5.484A 5.517A (Earth-to-space) 5.516  MOBILE | 17.7-17.8  FIXED  FIXED-SATELLITE (space-to-Earth) 5.517 5.517A (Earth-to-space) 5.516  BROADCASTING-SATELLITE  Mobile  5.515 | 17.7-18.1  FIXED  FIXED-SATELLITE (space-to-Earth) 5.484A 5.517A (Earth-to-space) 5.516  MOBILE |
| 17.8-18.1  FIXED  FIXED-SATELLITE (space-to-Earth) 5.484A 5.517A (Earth-to-space) 5.516  MOBILE  5.519 |
| 18.1-18.4 FIXED  FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B 5.517A  (Earth-to-space) 5.520  MOBILE  5.519 5.521 | | |
| 18.4-18.6 FIXED  FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B  5.517A  MOBILE | | |
| 18.6-18.8  EARTH EXPLORATION-SATELLITE (passive)  FIXED  FIXED-SATELLITE (space-to-Earth) 5.517A 5.522B  MOBILE except aeronautical mobile  Space research (passive)  5.522A 5.522C | 18.6-18.8  EARTH EXPLORATION- SATELLITE (passive)  FIXED  FIXED-SATELLITE (space-to-Earth) 5.516B 5.517A 5.522B  MOBILE except aeronautical mobile  SPACE RESEARCH (passive)  5.522A | 18.6-18.8  EARTH EXPLORATION-SATELLITE (passive)  FIXED  FIXED-SATELLITE (space-to-Earth) 5.517A 5.522B  MOBILE except aeronautical mobile  Space research (passive)  5.522A |
| 18.8-19.3 FIXED  FIXED-SATELLITE (space-to-Earth) 5.516B 5.517A 5.523A  MOBILE | | |
| 19.3-19.7 FIXED  FIXED-SATELLITE (space-to-Earth) (Earth-to-space) 5.517A 5.523B 5.523C 5.523D 5.523E  MOBILE | | |
| 19.7-20.1  FIXED-SATELLITE (space-to-Earth) 5.484A 5.484B 5.516B 5.527A  Mobile-satellite (space-to-Earth) | 19.7-20.1  FIXED-SATELLITE (space-to-Earth) 5.484A 5.484B 5.516B 5.527A  MOBILE-SATELLITE (space-to-Earth) | 19.7-20.1  FIXED-SATELLITE (space-to-Earth) 5.484A 5.484B 5.516B 5.527A  Mobile-satellite (space-to-Earth) |
| 5.524 | 5.524 5.525 5.526 5.527 5.528 5.529 | 5.524 |
| 20.1-20.2 FIXED-SATELLITE (space-to-Earth) 5.484A 5.484B 5.516B 5.527A  MOBILE-SATELLITE (space-to-Earth)  5.524 5.525 5.526 5.527 5.528 | | |
|  | | |
| 27.5-28.5 FIXED 5.537A  FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.517A 5.539  MOBILE  5.538 5.540 | | |
| 28.5-29.1 FIXED  FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.517A 5.523A 5.539  MOBILE  Earth exploration-satellite (Earth-to-space) 5.541  5.540 | | |
| 29.1-29.5 FIXED  FIXED-SATELLITE (Earth-to-space) 5.516B 5.517A 5.523C 5.523E 5.535A 5.539 5.541A  MOBILE  Earth exploration-satellite (Earth-to-space) 5.541  5.540 | | |
| 29.5-29.9  FIXED-SATELLITE (Earth-to-space) 5.484A 5.484B 5.516B 5.527A 5.539  Earth exploration-satellite (Earth-to-space) 5.541  Mobile-satellite (Earth-to-space)  5.540 5.542 | 29.5-29.9  FIXED-SATELLITE (Earth-to-space) 5.484A 5.484B 5.516B 5.527A 5.539  MOBILE-SATELLITE (Earth-to-space)  Earth exploration-satellite (Earth-to-space) 5.541  5.525 5.526 5.527 5.529 5.540 | 29.5-29.9  FIXED-SATELLITE (Earth-to-space) 5.484A 5.484B 5.516B 5.527A 5.539  Earth exploration-satellite (Earth-to-space) 5.541  Mobile-satellite (Earth-to-space)  5.540 5.542 |
| 29.9-30.0 FIXED-SATELLITE (Earth-to-space) 5.484A 5.484B 5.516B 5.527A 5.539  MOBILE-SATELLITE (Earth-to-space)  Earth exploration-satellite (Earth-to-space) 5.541 5.543  5.526 5.527 5.538 5.540 5.542 | | |

In addition:

- WRC-15 authorized ESIM operations in 19.7-20.2 GHz (space-to-Earth) and 29.5-30.0 GHz (Earth-to-space) under certain conditions, and for GSO systems only.

- WRC-19 authorized ESIM operations in 17.7‑19.7 GHz (space-to-Earth) and 27.5-29.5 GHz (Earth-to-space) under certain conditions, and for GSO systems only (Resolution 173).*Editor’s note: This TR would be updated with WRC-23 outcomes (Agenda Item 1.16 on NGSO ESIM Ka band).*

#### 5.2.3.2 FCC

In 2016, FCC issued Report and Order FCC 16-89 [33] allocating the 27.50-28.35 GHz frequency range for terrestrial licensed mobile operations (IMT 5G). This frequency range corresponds to the 3GPP band n261.

In 2020, FCC issued Report and Order FCC 20-159 [34] which streamlines part 25 rules that govern the licensing of satellite space and earth stations in a satellite system through a unified license. The unified licensing framework specified frequency bands which includes:

- Space-to-Earth:

- For GSO: 18.3-18.8 GHz and 19.7-20.2 GHz

- For NGSO: 17.8-18.6 GHz, 18.8-19.4 GHz and 19.6-20.2 GHz

- Earth-to-space:

- For GSO: 28.35-29.1 GHz and 29.25-30.0 GHz.

- For NGSO: 28.35-29.1 GHz and 29.5-30.0 GHz.

In 2020 as well, FCC issued the Report and Order FCC-20-66 [35] which facilitates the deployment of, and reduce the regulatory burdens on, Earth Stations in Motion (ESIMs). It allows ESIMs to communicate in additional frequency bands with GSO satellites operating in FSS bands and adopts rules for ESIMs to communicate with NGSO satellites in specific FSS bands. Those FSS bands include:

- Space-to-Earth:

- For GSO: 17.8-19.4 GHz, 19.6-20.2 GHz.

- For NGSO: 17.8-18.6 GHz, 18.8-19.4 GHz, 19.6-20.2 GHz

- Earth-to-space:

- For GSO: 28.35-29.1 GHz and 29.25-30.0 GHz.

- For NGSO: 28.4-29.1 GHz and 29.5-30.0 GHz.

#### 5.2.3.3 CEPT

The ECC Decision (05)01 [36] addresses the use of band 27.5-29.5GHz, regulated for Fixed Service and Fixed Satellite Service:

- The bands 27.5-27.8285 GHz, 28.4445-28.8365 GHz and 29.4525-29.5 GHz are designated for the use of uncoordinated FSS earth stations.

- The band 28.8365-28.9485 GHz is designated for the use of uncoordinated FSS earth stations, considering, until 1 January 2020, the legacy FS systems licensed in this band in some countries before 18 March 2005.

- The bands 27.8285-28.4445 GHz and 28.9485-29.4525 GHz are designated for the use of FS systems.

Also, this ECC Decision(05)01 states that the CEPT administrations shall not authorize the deployment of uncoordinated FSS earth stations in the bands designed for the use of FS systems.

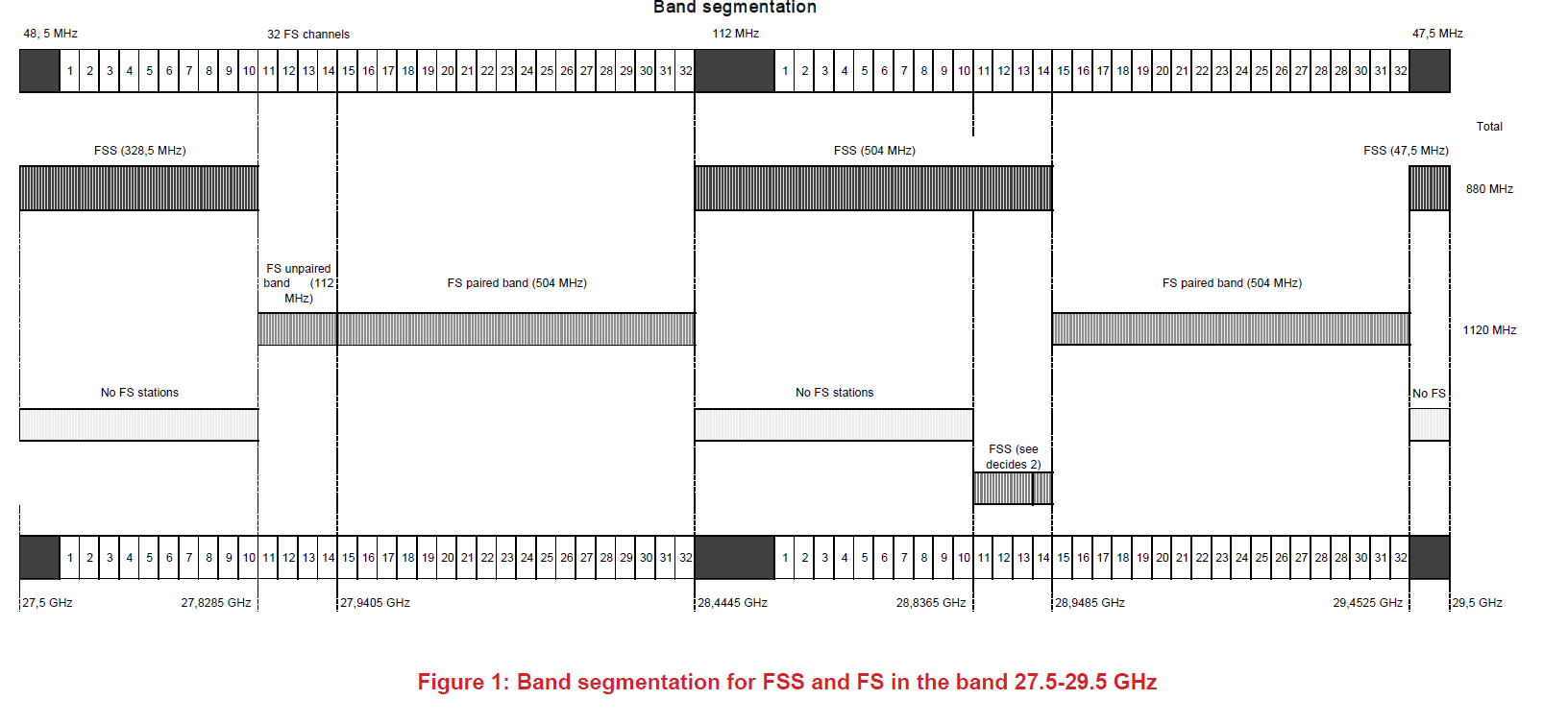


Figure 5.2.3.3-1: ECC Decision(05)01 - 27.5-29.5 band segmentation

The [ECC Decision(13)01](https://docdb.cept.org/document/439) [37] specifies the harmonized use, free circulation, and exemption from individual licensing of Earth stations on mobile platforms (ESOMPs) within the ranges 17.3-20.2 GHz and 27.5-30.0 GHz, in the portion identified for their use within the territory of operation, and under the conditions specified in Annexes 1,2 and 3 of this ECC Decision. ESOMPs are terminals with small directional antennas for the provision of broadband communication services. The terminals may be mounted on aircraft, ships or land vehicles or may be transportable devices used in motion or at temporary halts. This ECC Decision also specifies the conditions for those ESOMP devices to operate.

## 5.3 Regulatory aspects for HAPS

ITU–R began to study HAPS in the 1990s initially for fixed services. The telecommunications ecosystem and technology enablers for HAPS have evolved significantly since then. At WRC-2000, the bands 1885 – 1980 MHz, 2010 – 2025 MHz and 2110 – 2170 MHz were identified for HAPS operating as IMT Base Stations, in accordance with Resolution 221 (Rev.WRC-07) [3]. With increasing interest in HAPS to offer mobile services, the WRC-19 agreed to study certain frequency bands which have been already identified for IMT below 2.7 GHz for HAPS as IMT Base Stations (HIBS). ITU-R Working Party 5D is currently studying co-existence requirements for HIBS in the additional three bands listed in Table 5.4-1 to support spectrum identification decisions in WRC-23 in accordance with Resolution 247 (WRC-19) [3].

NOTE: In the current ITU terminology, the use of HAPS to implement IMT (i.e. offer mobile wireless services) is referred to as “HAPS as IMT Base Stations” or HIBS.

Table 5.4-1: Frequencies for HAPS as IMT Base Stations (HIBS).

|  |  |  |
| --- | --- | --- |
| Region | Spectrum | Remarks |
| Region 1 and 3 | 1885 – 1980 MHz  2010 – 2025 MHz  2110 – 2170 MHz | Identified HIBS designations at WRC-2000 |
| Region 2 | 1885 – 1980 MHz3  2110 – 2160 MHz4 |
| Global | 694 – 960 MHz  1710 – 1885 MHz1  2500 – 2690 MHz2 | Under study, for decision at WRC-23 |
| NOTE 1: 1710-1815 MHz to be used for uplink only in Region 3.  NOTE 2: 2500-2535 MHz to be used for uplink only in Region 3, except 2655-‑2690 MHz in Region 3).  NOTE 3: In most of Region 2 1885-1910 is used for Mobile uplink and 1930-1980 is used for Mobile downlink. In the United States, 1910-1915 and 1915-1920 are also used for Mobile uplink.  NOTE 4: In Region 2 2110-2160 is used for Mobile downlink. | | |

# 6 Co-existence study

## 6.1 Co-existence simulation scenario

Scenarios for coexistence study are listed in Table 6.1-1.

Table 6.1-1: Scenarios for NTN-NTN/TN co-existence

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| FR1: 2GHz | | NTN1,4,5 | | | | | | |
| Set 1 | | | Set 22 | | | HAPS |
| GEO3 | LEO 600km | LEO 1200km | GEO | LEO 600km | LEO 1200km |  |
| NR / NB-IoT | Rural | X | X | X | X | X | X | X |
| Urban macro | X | X | X | X | X | X | X |
| Dense Urban6 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| HAPS | | N/A | N/A | N/A | N/A | N/A | N/A | X |
| NOTE 1: Earth Fixed beam has been considered for co-existence studies.  NOTE 2: Use Set 1 satellite antenna has been used as the starting point for co-existence studies.  NOTE 3: GEO and LEO only operate at adjacent channel.  NOTE 4: Use GEO and LEO@600km when TN is victim.  NOTE 5: The satellite-to-satellite coexistence scenarios are not in the scope of this study considering this is already addressed by ITU (ITU RR Article 9 etc.) and regional regulations (e.g. FCC rules).  NOTE 6: Dense Urban is not considered as it is expected NTN UE will connect to terrestrial networks rather than satellite networks in such scenario. | | | | | | | | |

The aggressor and victim combinations are listed in Table 6.1-2.

Table 6.1-2: Aggressor and victim

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No. | Combination | Aggressor | Victim | Notes | Study Phase |
| 1 | TN with NTN | TN DL | NTN DL | Applicable for satellite operating in e.g. S-band, for e.g. coexistence with n1 FDD. | Phase 1 |
| 2 | TN with NTN | TN UL | NTN UL | Applicable for satellite operating in e.g. S-band, for e.g. coexistence with n1 FDD. | Phase 1 |
| 3 | TN with NTN | NTN DL | TN DL | Applicable for satellite operating in e.g. S-band, for e.g. coexistence with n1 FDD. | Phase 1 |
| 4 | TN with NTN | NTN UL | TN UL | Applicable for satellite operating in e.g. S-band, for e.g. coexistence with n1 FDD. | Phase 1 |
| 5 | TN with NTN | NTN UL | TN DL | Applicable for satellite operating in S-band, for e.g. coexistence with n34 TDD. | Phase 1 |
| 6 | TN with NTN | TN DL | NTN UL | Applicable for satellite operating in S-band, for e.g. coexistence with n34 TDD. | Phase 1 |
| 7 | NTN with NTN | NTN DL | NTN DL | HAPS-HAPS | Phase 2 |
| NTN UL | NTN UL | HAPS-HAPS | Phase 2 |

For further visualisation, the interference charts with respect to scenarios 1 to 6 are further represented with respect to NTN-TN coexistence scenarios in Figure 6.1-1 (scenarios 1 to 4) and Figure 6.1-2 (scenarios 5 and 6).

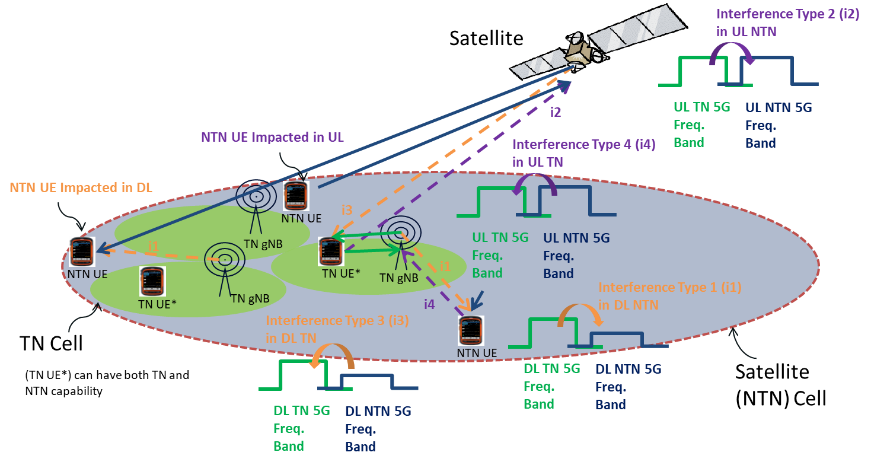


Figure 6.1-1: S-band NTN-TN adjacent band coexistence scenarios with TN in FDD mode

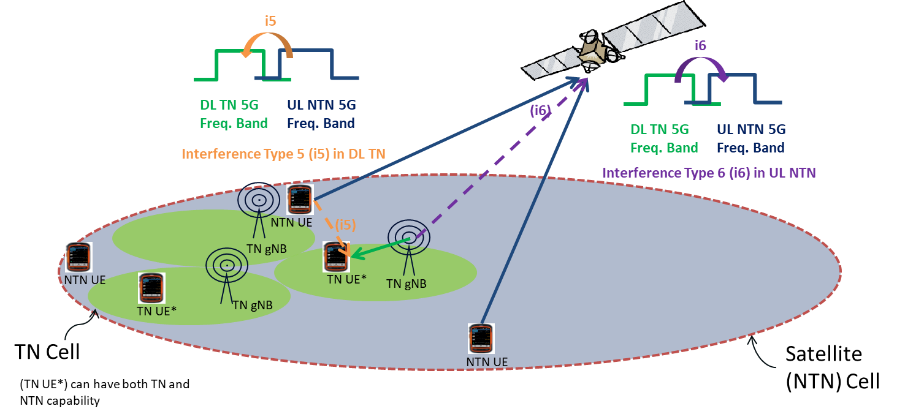


Figure 6.1-2: S-band NTN-TN adjacent band coexistence scenarios with TN in TDD mode (e.g. n34)

The frequency and bandwidth are listed in Table 6.1-3.

Table 6.1-3: Proposed frequency and bandwidth for co-existence study

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Frequency | Bandwidth | Duplex mode | Frequency reuse factor |
| TN Rural | 2 GHz | 20MHz | FDD, TDD | 1 |
| TN Urban macro | 2 GHz | 20MHz | FDD, TDD | 1 |
| GEO | 2 GHz | 5/10/15/20 MHz for FR1 | FDD | 1, 31 |
| LEO | 2 GHz | 5/10/15/20 MHz for FR1 | FDD | 1, 31 |
| HAPS | 2 GHz | TBD | FDD | 1 |
| NOTE: Only FRF=1 has been used in co-existence studies for simplification. | | | | |

## 6.2 Co-existence simulation assumption

### 6.2.1 Network layout model

#### 6.2.1.1 Co-existence between NTN satellite and TN

Cellular cell structure is considered for both NTN satellite and TN network layout.

Referring to TR 38.811[5] Section 6.3 and Annex A, a 3D global coordinate system is considered (Earth-Centred Earth Fixed) for simulating NTN satellite beams direction and location on the earth surface. It means the NTN satellite beam location, TN randomly dropping location are generated with a set of three parameters (x,y,z).

Deployment of NTN satellite and TN cells and UEs for co-existence study is listed in Table 6.2.1.1-1.

NOTE: The NTN UE(s) shall be dropped at the edge of the “central 19 TN cells (cluster)”. For Case 1 (Urban scenario), an Isolation distance of 1500m as 2\*ISD is considered to reflect the NTN-TN selection algorithm at the border, assuming TN connection will always be prioritized over NTN.

As defined in Figure 6.2.1.1-1, isolation distance is the distance between the blue-dotted line which represents TN cell boarder and the red line. No UEs deployed in the isolation region is assumed to reduce the calculation complexity.

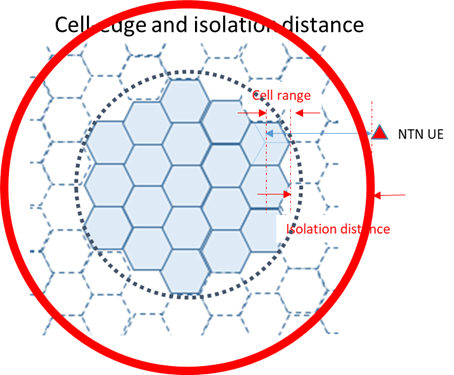


Figure 6.2.1.1-1: Isolation distance for Case 1

Table 6.2.1.1-1: Network and UE deployment

| No. | Combination | Aggressor | Victim | Which NTN cell/UE to observe? | Which TN/UE to observe? | Which TN cells in a TN to observe? |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | TN with NTN satellite | TN DL | NTN DL | NTN cell:  Observe NTN central beam for SINR, 6 adjacent beams for inter-beam interference.  NTN UE:  NTN UEs dropped at the edge of TN clusters | One cluster with 19 TN cells (57 sectors) randomly placed in the central NTN beam | All active TN clusters which has the NTN UE(s) at its edge. |
| 2 | TN with NTN satellite | TN UL | NTN UL | NTN cell:  Observe NTN central beam for SINR, 6 adjacent beams for inter-beam interference.  NTN UE:  NTN UEs dropped at the edge of TN clusters | Consider an active rate of 20% for Rural and Urban of TN. | All active TN cells in central NTN beam |
| 3 | TN with NTN satellite | NTN DL | TN DL | NTN cell:  Nadir point.  NTN UE:  NTN UEs dropped outside or at the edge of TN clusters | TN clusters randomly placed in this NTN beam | All in central NTN beam |
| NTN cell:  NTN cell with satellite at low elevation (45° for GEO and LEO，Interested companies can bring analysis and results for other values)  NTN UE:  NTN UEs dropped outside or at the edge of TN clusters | TN clusters randomly placed in this NTN beam |
| 4 | TN with NTN satellite | NTN UL | TN UL | NTN cell:  Nadir point.  NTN UE:  NTN UEs dropped at the edge of TN clusters | TN randomly placed in this NTN beam | Option 1: All active TN clusters which has the NTN UE(s) at its edge.  Option 2: Only the TN sectors which have NTN UE(s) at their edges.  Option 1 is the baseline and it is not precluded companies can follow Option 2 to bring results |
| 5 | TN with NTN satellite | NTN UL | TN DL | NTN cell:  Nadir point  NTN UE:  NTN UEs dropped at the edge of TN clusters | TN clusters randomly placed in this NTN beam | All active TN clusters which has the NTN UE(s) at its edge |
| NTN cell:  NTN cell with satellite at low elevation (45° for GEO and LEO，Interested companies can bring analysis and results for other values).  NTN UE:  NTN UEs dropped at the edge of TN clusters | TN clusters randomly placed in this NTN beam | All active TN clusters which has the NTN UE(s) at its edge. |
| 6 | TN with NTN satellite | TN DL | NTN UL | NTN cell:  Observe NTN central beam for SINR, 6 adjacent beams for inter-beam interference.  NTN cell with satellite at low elevation to be further investigated.  NTN UE:  NTN UEs dropped outside or at the edge of TN clusters | Consider the active rate of 20% for Rural and Urban of TN.  The Urban TN deployment for GEO in Case 6 is a mixture of urban and rural TN deployment. A representative percentage of urban TN could be considered for further study. | All active TN cells in central NTN beam |

#### 6.2.1.2 Co-existence between HAPS and TN

For simulations of HAPS and TN co-existence, a cluster of TN cells is randomly dropped in the HAPS coverage area as shown in Figure 6.2.1.2-1. The TN cell cluster consists of 19 sites, 57 sectors, with the same assumption described in clause 6.2.2.4. HAPS coverage and cell layout are described in clause 6.2.2.3.

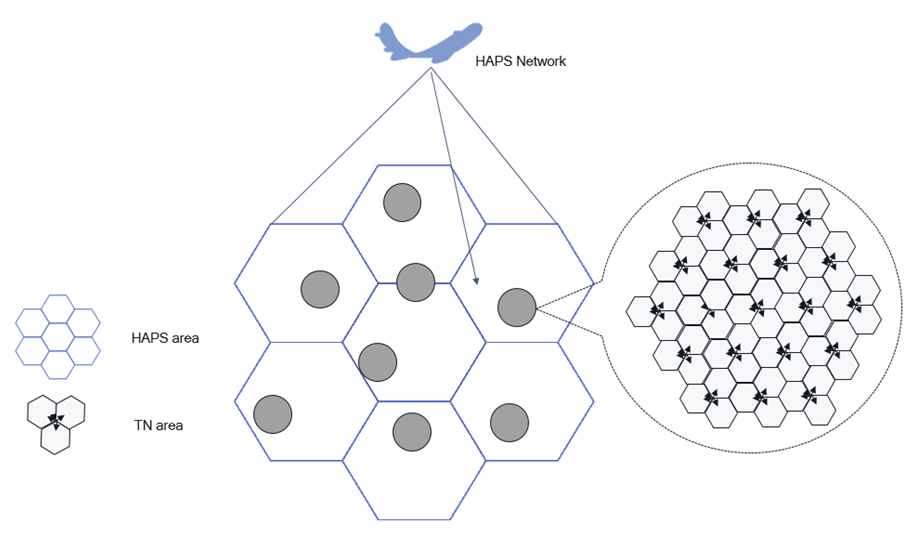


Figure 6.2.1.2-1: Simulation layout between HAPS and TN

#### 6.2.1.3 Co-existence between HAPS and HAPS

HAPS and HAPS co-existence can be characterized by “center-to-center” inter-system distance (i.e., the distance between two coverage centers) as depicted in Figure 6.2.1.3-1. Since HAPS location is at the center of its coverage area, the inter-system distance is the separation of the two HAPS. Different inter-system distances may be simulated to evaluate the interference caused by antenna gain variation in the elevation domain.

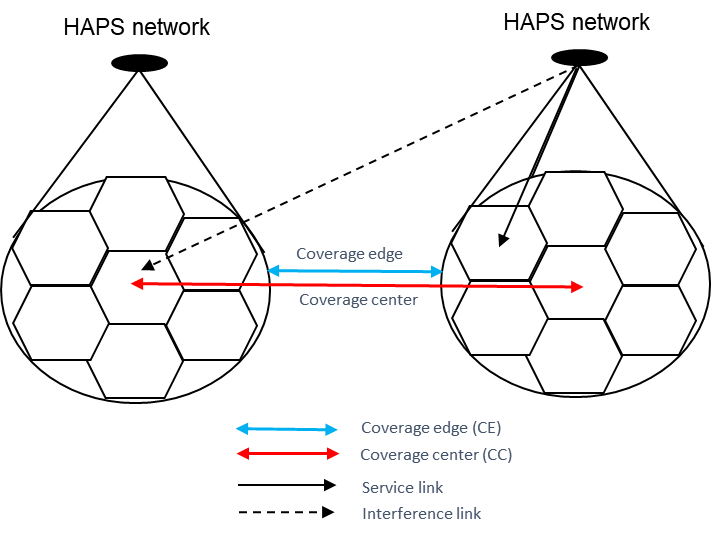


Figure 6.2.1.3-1: Simulation layout between HAPS and HAPS

### 6.2.2 System parameters

#### 6.2.2.1 Satellite parameters

Two sets of satellite parameters are listed in Table 6.2.2.1-2 and Table 6.2.2.1-3 according to TR 38.821[6].

The satellite max Tx power can be calculated by the equation as below:

Table 6.2.2.1-1: NRB configuration per BandWidth size and SCS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Configuration FR1 S-band | NRB (5MHz BW) | NRB (10MHz BW) | NRB (15MHz BW) | NRB (20MHz BW) |
| SCS 15 kHz | 25 | 52 | 79 | 106 |
| SCS 30 kHz | 11 | 24 | 38 | 51 |

Table 6.2.2.1-2: Set-1 satellite parameters for co-existence study

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Satellite orbit | | | GEO | | | | LEO-1200 | | | | LEO-600 | | | |
| Satellite altitude | | | 35786 km | | | | 1200 km | | | | 600 km | | | |
| Payload characteristics for DL transmissions | | | | | | | | | | | | | | |
| Satellite EIRP density | | 2GHz | 59 dBW/MHz | | | | 40 dBW/MHz | | | | 34 dBW/MHz | | | |
| Satellite max TX power in dBm | BW (MHz) | 5 | 10 | 15 | 20 | 5 | 10 | 15 | 20 | 5 | 10 | 15 | 20 |
| SCS 15kHz | 44.53 | 47.71 | 49.53 | 50.81 | 46.53 | 49.71 | 51.53 | 52.81 | 40.53 | 43.71 | 45.53 | 46.81 |
| SCS 30kHz | 43.98 | 47.37 | 49.36 | 50.64 | 45.98 | 49.37 | 51.36 | 52.64 | 39.98 | 43.37 | 45.36 | 46.64 |
| Satellite Tx max Gain | | 51 dBi | | | | 30 dBi | | | | 30 dBi | | | |
| Channel bandwidth | | 5/10/15/20MHz | | | | 5/10/15/20MHz | | | | 5/10/15/20MHz | | | |
| 3dB beamwidth or HPBW (Half-Power BandWidth) of main central beam | | 0.4011 deg | | | | 4.4127 deg | | | | 4.4127 deg | | | |
| ABS (Adjacent Beam Spacing) of adjacent beams from the central beam | | 0.3474 deg | | | | 3.8206 deg | | | | 3.8206 deg | | | |
| Satellite beam diameter | | 250 km | | | | 90 km | | | | 50 km | | | |
| Payload characteristics for UL transmissions | | | | | | | | | | | | | | |
| G/T | | 2 GHz | 19 dB K-1 | | | | 1.1 dB K-1 | | | | 1.1 dB K-1 | | | |
| Satellite Rx max Gain | | 51 dBi | | | | 30 dBi | | | | 30 dBi | | | |

Table 6.2.2.1-3: Set-2 satellite parameters for co-existence study

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Satellite orbit | | GEO | LEO-1200 | LEO-600 |
| Satellite altitude | | 35786 km | 1200 km | 600 km |
| Payload characteristics for DL transmissions | | | | |
| Satellite EIRP density | 2GHz | 53.5 dBW/MHz | 34 dBW/MHz | 28 dBW/MHz |
| Satellite Tx max Gain | 45.5 dBi | 24 dBi | 24 |
| Channel bandwidth | 5/10/15/20MHz | 5/10/15/20MHz | 5/10/15/20MHz |
| 3dB beamwidth | 0.7353 deg | 8.8320 deg | 8.8320 deg |
| Satellite beam diameter | 450 km | 190 km | 90 km |
| Payload characteristics for UL transmissions | | | | |
| G/T | 2 GHz | 14 dB K-1 | -4.9 dB K-1 | -4.9 dB K-1 |
| Satellite Rx max Gain | 45.5 dBi | 24 dBi | 24 dBi |

Table 6.2.2.1-4: Other parameters for NTN satellite

|  |  |  |
| --- | --- | --- |
| Parameters | NTN satellite | Remark |
| Carrier frequency | 2GHz |  |
| The number of active UE (UL) | 9 UEs and 2RBs per UE for GEO and LEO1 | NOTE |
| The number of active UE (DL) | 1 | Same with TN |
| Traffic model | Full buffer |  |
| DL power control | NO |  |
| UL power control | See Session 6.2.6.2 |  |
| NTN satellite Noise Figure in dB | See Table 2.3-3-1 |  |
| Handover margin | 3dB |  |
| NOTE: UEs are equally splitted inside the channel bandwidth into ACIR 3 regions. Scheduled PRB position for UE1 per satellite beam should be also fully aligned to simulate the worst case for co-channel interference and this is also aligned with full buffer case.  http://kr5.samsung.net/mail/rest/v1/files/image/download/202108260042453_CZHWKC3T.png?1=1&filepath=/LOCAL/ML/CACHE/image/y/20210825/110_31_JZ9R2KEKVGKD@namo.co.kr_4_yiran.jin&user=yiran.jin&partno=4&folderId=110&seqid=31&contentType=image%2Fpng | | |

Table 6.2.2.1-5: NTN satellite Noise Figure in dB

|  |  |  |  |
| --- | --- | --- | --- |
| Satellite | GEO | LEO 600 | LEO 1200 |
| G/T (dB K-1) | 19 | 1.1 | 1.1 |
| G\_Rx (dBi) | 51 | 30 | 30 |
| NF (dB) | 7.4 | 4.3 | 4.3 |

#### 6.2.2.2 NTN UE parameters

NTN UE parameters are given in Table 6.2.2.2-1

Table 6.2.2.2-1: NTN UE characteristics for system level simulations

|  |  |
| --- | --- |
| Characteristics | Handheld |
| Frequency band | S band (i.e. 2 GHz) |
| Antenna type and configuration | (1, 1, 2) with omni-directional antenna element |
| Polarisation | Linear: +/-45°X-pol |
| Rx Antenna gain | 0 dBi per element |
| Antenna temperature | 290 K |
| Noise figure | 9 dB |
| Tx transmit power | 200 mW (23 dBm) |
| Tx antenna gain | 0 dBi per element |

#### 6.2.2.3 HAPS parameters

Using the antenna model in Section 6.2.3.3, HAPS deployed at 20 km altitude has a coverage radius of 100 km in a 7-cell layout. Two implementations of the layout are shown in Figure 6.2.2.3-1. The UEs in the HAPS system are assumed to be outdoor and uniformly distributed in the coverage area in the rural environment. The serving cell is selected by the strongest RSRP or least coupling loss. (Note: Calibration data show these two implementations yield similar results). HAPS system parameters for the co-existence study are listed in Table 6.2.2.3-1.

For DL transmission, one UE is scheduled for the full bandwidth. For UL transmission, 9 UEs are scheduled, each using a bandwidth of 6 RBs. The scheduled UEs are evenly distributed in the frequency domain as shown in Figure 6.2.2.3-2. Note that the scheduled resources are aligned among different cells to model co-channel effect. Since the UE uses only part of the channel bandwidth in UL, the ACI impact may differ in the frequency domain of the adjacent channel. The ACIR model described in Section 6.2.4 should be used to model the ACI from aggressor UEs in UL, taking into account the UE’s transmission bandwidth.

|  |  |
| --- | --- |
| Shape  Description automatically generated  (a) | A picture containing diagram  Description automatically generated  (b) |

Figure 6.2.2.3-1: HAPS cell layout

Table 6.2.2.3-1: HAPS system parameters

|  |  |
| --- | --- |
| HAPS altitude | 20 Km |
| Carrier frequency | 2 GHz |
| Frequency reuse factor | 1 |
| Duplex scheme | FDD |
| Channel bandwidth | 20 MHz |
| Subcarrier spacing (SCS) | 15 KHz |
| Number of cells | 7 |
| Coverage area (7 cells combined) | A 100 Km radius circular area centered by the serving HAPS |
| Frequency reuse | 1 |
| Environment1 | Rural |
| UE distribution | Uniformly distributed in the coverage area |
| Indoor UE percentage | 0% |
| Number of DL scheduled UEs per cell | 1 |
| Number of UL scheduled UEs per cell | 9 |
| DL scheduled bandwidth per UE | 20 MHz |
| UL scheduled bandwidth per UE | 6 RBs |
| DL power control | No |
| UL power control | See section 6.2.6.3 |
| HAPS antenna | See section 6.2.3.3 |
| HAPS noise figure | 5 dB |
| HAPS-UE pathloss model | See section 6.2.5.4 |
| HAPS UE assumption | Same as TN UE in Table 6.2.2.4-1 |
| NOTE 1: HAPS is assumed to serve UEs in the rural environment, but the co-existed TN may be in the rural or urban macro environment. | |

Graphical user interface

Description automatically generated

Figure 6.2.2.3-2: UL scheduled UE bandwidth allocation

#### 6.2.2.4 TN parameters

TN parameters for co-existence study are given in Table 6.2.2.4-1, 6.2.2.4-2 and 6.2.2.4-3.

Table 6.2.2.4-1: Simulation assumptions of TN respectively based on NB-IoT and NR

|  |  |  |
| --- | --- | --- |
|  | NB-IoT  standalone | NR |
| Carrier frequency in GHz | 2 | 2 |
| Size of each nominal channel BW in MHz | 0.2 | 20 |
| Transmission bandwidth in MHz | 0.18 | N/A |
| Environment | Urban macro  Rural | Deployment scenario related, see Table 6.2.2.4-2. |
| Network layout | 19-sites [57 sectors] with wrap-around | 19-sites 57 sectors with wrap-around |
| Inter-site distance in meter | 500 for 2GHz band for UMA  TBD For Rural | Deployment scenario related, see Table 6.2.2.4-2 |
| System loading and activity | Full buffer 100% | See Table 6.2.1.1-1 |
| Network location | TBD | See Table 6.2.1.1-1 |
| DL subcarrier spacing | 15kHz | 15kHz |
| UL | See RP-152284[7] | OFDMA |
| DL power control | No | No |
| UL power control | TR 36.942[8] section 5.1.1.6 (set 1) by bandwidth scale, target SNR at BS is 15 dB | TR 36.942[8] |
| Frequency reuse | 1 | 1 |
| Number of scheduled UE per cell (DL) | 1 | 1 |
| Number of scheduled UE per cell (UL) | 3 for multi-tone (60kHz per UE),  12 for 15kHz single-tone,  48 for 3.75kHz single-tone | 3 |
| UE antenna height in meter | 1.5 | 1.5m |
| UE TX power in dBm | -40 to 23 | -40 to 23 |
| UE antenna gain in dBi | 0 | 0 |
| Building penetration loss | TR 45.820[9] Annex D.1 | In pathloss model, TR 38.901[10] |
| Cell selection margin in dB | 3 | 3 |
| BS-MS min distance in meters | 35 | 35 |
| BS noise figure in dB | 5 | 5 |
| UE noise figure in dB | 9 | 9 |
| BS-UE path-loss model | TR 36.942[8] macro urban | TR 38.901[10] |
| Standard deviation of BS-UE log-normal shadow fading in dB | 10 | Deployment scenario related, referring to TR 38.901[10] |
| Shadowing correlation | Inter-cell 0.5  Intra-cell 1 | Inter-cell 0.5  Intra-cell 1 |
| Link-level performance model |  | See Section 6.2.8  Throughtput-SINR mapping |
| UE distribution |  | Uniform |
| Evaluation metrics | SINR vs ACS (as victim) | See Section 6.2.8  Throughtput or SNR loss criteria |

Table 6.2.2.4-2: Deployment-related parameters of TN (2 GHz)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Urban Macro | Rural Macro | Remarks |
| ISD in meters | 750 | 7500 | ITU-R Report M.2292[11] |
| BS Antenna height in meters | 25 | 30 |
| UE Outdoor/indoor | 100% Outdoor | |  |
| UE height in meter | 1.5 | 1.5 | RP-200559 [12] 3GPP LS to ITU-R WP5D  and  ITU-R WP5D  [IMT\_Parameters] [13] |

Table 6.2.2.4-3: ACLR/ACS for TN (2GHz)

|  |  |  |  |
| --- | --- | --- | --- |
|  | | NR | NB-IOT |
| BS | ACLR | 45 dB | 40 dB |
| ACS | 46 dB | 46 dB |
| UE | ACLR | 30dB (ACLR1)  43dB (ACLR2) | 37 |
| ACS | 33 | 28 |

### 6.2.3 Antenna and beamforming pattern modelling

#### 6.2.3.1 Satellite and UE Antenna and beam forming pattern modelling

Satellite and UE Antenna and beam forming pattern modelling of satellite could be referred to section 6.4.1 in TR 38.811[5].

The following normalized antenna gain pattern, corresponding to a typical reflector antenna with a circular aperture, is considered.

1

where:

- J1(x) is the Bessel function of the first kind and first order with argument ‘x’ , where x is ;

- a, is the radius of the antenna's circular aperture;

- k = 2f/c is the wave number;

- f is the frequency of operation;

- c is the speed of light in a vacuum and  is the angle measured from the bore sight of the antenna's main beam.

Note that *ka* equals to the number of wavelengths on the circumference of the aperture and is independent of the operating frequency.

The antenna patterns for LEO 600km, 1200km and GEO are shown in Figure 6.2.3.1-1 and 6.2.3.1-2.



Figure 6.2.3.1-1: Antenna pattern for LEO 600KM and 1200KM (4.4127 deg for 3dB beamwidth)



Figure 6.2.3.1-2: Antenna pattern for antenna aperture of GEO (0.4011 deg for 3dB beamwidth)

The beam layout definition for a single satellite simulation in S-Band is defined in Table 6.2.3.1-1.

Table 6.2.3.1-1: Beam layout definition for single satellite simulation

|  |  |  |  |
| --- | --- | --- | --- |
| Beam layout definition | Baseline: Hexagonal mapping of the beam bore sight directions on UV plane defined in the satellite reference frame.  Only the 3dB beam width parameters should be used. The beam diameter and beam spacing values can be computed directly from the 3 dB beam width assumptions and should be considered as informative. | | |
| Number of beams | Baseline: 7-beam layout (i.e. 6 co-frequency beams surrounding the central beam) | | |
| UV plane illustration (extracted from [19]) |  | | |
| UV plane convention | U axis is defined as the perpendicular line to the satellite-earth line on the orbital plane as illustrated here after:    The straight line being orthogonal to UV plane is pointing towards the Earth centre.  UV coordinates of the nadir of the reference satellite is (0,0) | | |
| Adjacent beam spacing on UV plane | Baseline: Adjacent beam spacing computation based on 3dB beam width of the satellite antenna pattern:  ABS[rad] = sqrt(3) x sin(HPBW[degrees]/2) or ABS[rad] = sqrt(3) x sinr(HPBW[rad]/2)  with ABS [degree]=180/pi x ABS[rad] and  with HPBW the Half-Power BandWidth of the main lobe from the satellite antenna pattern. | | |
| Central beam bore sight direction definition | Baseline:  Case 1: Central beam center is considered at nadir point  Case 2: 45° for GEO and LEO | | |
|  | Option 1: FRF=1 | Option 2: FRF=3 | Option 3: FRF=2 |
| Polarization re-use | Option 1: Disable  Option 2: Enable  Note: Polarization re-use should apply only if circular polarization for terminal antenna is considered | | |
| UEs outdoor/indoor distribution | 100% outdoor distribution for UEs | | |
| UE distribution | The cell area associated to a given beam is defined as the Voronoi cell associated with the corresponding beam centers. | | |
| UE configuration | S-band: Handheld | | |
| UE orientation | Handheld: Random | | |
| UE attachment | RSRP | | |
| NOTE 1: Typical impairment values (additional frequency error, SNR loss) due to the feeder link except for delay can be considered to be negligible. When available, specific values can be considered in the evaluation and should be reported.  NOTE 2: For the calibration purpose, the ionospheric scintillation loss shall be considered equal to zero (i.e., the UEs are located between 20 and 60 degrees of latitude). | | | |

#### 6.2.3.2 TN BS and UE antenna and beam forming pattern modelling

For AAS antenna, it refers to the pattern in TR 38.921 [14].

Table 6.2.3.2-1: AAS antenna parameters for 2GHz

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Rural | Macro urban |
| 1 | Base Station Antenna Characteristics | | |
| 1.1 | Antenna pattern | TR 38.921[14] | |
| 1.2 | Element gain (dBi) (Note 2) | 7.1 | 6.4 |
| 1.3 | Horizontal/vertical 3 dB beam width of single element (degree) | 90º for H  54º for V | 90º for H  65º for V |
| 1.4 | Horizontal/vertical front‑to‑back ratio (dB) | 30 for both H/V | 30 for both H/V |
| 1.5 | Antenna polarization | Linear ±45º | Linear ±45º |
| 1.6 | Antenna array configuration (Row × Column)  (Note 4) | 8 × 8 elements | 8 × 8 elements |
| 1.7 | Horizontal/Vertical radiating element spacing | 0.5 of wavelength for H, 0.9 of wavelength for V | 0.5 of wavelength for H, 0.7 of wavelength for V |
| 1.8 | Array Ohmic loss (dB) (Note 2) | 2 | 2 |
| 1.9 | Conducted power (before Ohmic loss) per antenna element (dBm) (Note 3) | 25 | 25 |
| 1.10 | Base station maximum coverage angle in the horizontal plane (degrees) | 120 | 120 |
| 1.11 | Base station vertical coverage range (degrees) (Note 1) | 90-100 | 90-120 |
| 1.12 | Mechanical downtilt (degrees) | 3 | 10 |

For non-AAS antenna, the parameters in Table 6.2.3.2-1 are used for 2GHz BS antenna pattern in the NTN system simulation.

Table 6.2.3.2-1: FR1 BS Non-AAS antenna pattern for 2GHz

|  |  |  |
| --- | --- | --- |
| Parameter for BS | Values | |
| Antenna vertical radiation pattern (dB) |  | |
| Antenna horizontal radiation pattern (dB) |  | |
| Combining method for 3D antenna pattern (dB) |  | |
| Maximum directional gain of an antenna *GE,max* | 17 dBi | |
| Conducted power | 46 dBm | |
| Mechanical downtilt in degrees | Rural | 3 |
| Urban | 10 |

Only Non-AAS antenna can be used for NB-IoT.

For UE antennas, an omni-directional radiation pattern with antenna gain 0dBi is assumed.

#### 6.2.3.3 HAPS antenna model

HAPS antenna model is based on the proposal for HIBS (HAPS as IMT base stations) study in ITU WP-5D [24]. The antenna array is composed of seven antenna panels (six side panels and one downward facing panel) as shown in Figure 6.2.3.3-1. Antenna elements on each panel are co-phased to form one beam in two crossed linear polarizations to serve one cell. There are a total of seven cells in two layers, one cell in the 1st layer and six cells in the 2nd layer. The antenna parameters are listed in Table 6.2.3.3-1. Note that a fixed beam in the direction of the panel boresight is formed by each panel to serve one cell. Figure 6.2.3.3-1 shows the antenna gain of the 1st layer cell and a 2nd layer cell projected on the ground.

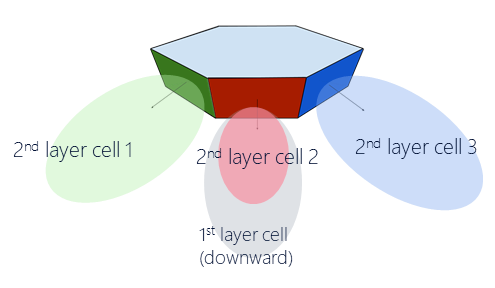


Figure 6.2.3.3-1: HAPS antenna model

Table 6.2.3.3-1: HAPS antenna parameters

|  |  |
| --- | --- |
| Number of cells | 7 |
| Antenna array configuration (row x column) | 2 x 2 for 1st layer cell  4 x 2 for 2nd layer cell |
| Antenna polarization | Linear |
| Element gain 1 | 7.8 dBi |
| Element HPBW horizontal/vertical | 65⁰ for both H/V |
| Element front-to-back ratio horizontal/vertical | 30 dB for both H/V |
| Element spacing horizontal/vertical | 0.7 wavelength for both H/V |
| Antenna panel tilt (from the horizon)2 | 90⁰ for 1st layer cell  23⁰for 2nd layer cell |
| EIPR/cell | 56.8 dBm (1st layer cell),  59.8 dBm (2nd layer cell) |
| EIRP spectral density/cell | 43.8 dBm/MHz (1st layer cell),  46.8 dBm/MHz (2nd layer cell) |
| Tx power per antenna panel | 43 dBm |
| Conducted power (before ohmic loss) per antenna element (dBm) | 34 dBm for 2 x 2 (x 2 polarizations for 1st layer cell)  31 dBm for 4 x 2 (x 2 polarizations for 2nd layer cell) |
| Antenna weight3 | for each of 1st layer cell element  for each of 2nd layer cell element |
| Polarization gain for SINR | 3 dB |
| NOTE 1: The element gain includes the Ohmic loss of 2 dB.  NOTE 2: This is mechanical tilt only.  NOTE 3: These antenna weights create a fixed cell beam in the antenna panel’s boresight direction. | |

|  |  |
| --- | --- |
| **Chart, bubble chart  Description automatically generated**  (a) | **Diagram  Description automatically generated**  (b) |

Figure 6.2.3.3-2: HAPS antenna gain (in dB) in a 100 km radius area on the ground. (a) Antenna gain of the 1st layer cell. (b) Antenna gain of a 2nd layer cell.

### 6.2.4 ACIR model

ACLR modelling for TN and NTN co-existence study referring to clause 5.1.1.4.1 and 5.1.1.4.2 in TR 36.942[8] is used as baseline. The number of RBs refers to Table 6.2.2.1-4 and Table 6.2.2.4-1 respectively.

### 6.2.5 Propagation model

#### 6.2.5.1 Propagation model between NTN SAN and UE

Propagation model between NTN SAN and UE should reference to section 6.6 in TR 38.811[5].

#### 6.2.5.2 Propagation model between TN BS and UE

Propagation model between TN BS and UE should reference to section 7.4 in TR 38.901[10].

#### 6.2.5.3 Propagation model between NTN SAN and TN BS

Propagation model between NTN SAN and TN BS should reference to TS 38.811[5] which is used for DL-UL cross link interference for S band.

#### 6.2.5.4 Propagation model for HAPS

Propagation model between HAPS and UE, regardless of whether the UE is connected to HAPS or TN, should reference to section 6.6 in TR 38.811[5].

### 6.2.6 Transmission power control model

#### 6.2.6.1 TN UL TPC

For uplink scenario, TPC model specified in Section 9.1 TR 36.942[8] is applied for TN with following parameters.



where:

- Pmax = 23dBm,

- Rmin = TBD dB,

- CLx-ile and γ are set as following:

- CLx-ile = 88 + 10\*log10 (200/X) + 11 – Y, where X is UL transmission BW (MHz) and Y is the BS noise figure

- γ = 1For uplink scenario,

#### 6.2.6.2 NTN UL TPC

For the coexistence study, the same TPC model of TN for NTN UL scenarios is adopted to align with UE UL power control parameters used in TR 38.821[6].

#### 6.2.6.3 NTN DL TPC

For downlink scenario, no power control scheme is applied.

#### 6.2.6.4 HAPS UL TPC

HAPS uplink follows the TPC model in Section 6.2.6.1 with X = 1.08 (scheduled bandwidth 6 RBs) and Y = 5 (HAPS noise figure is 5 dB).

#### 6.2.6.5 HAPS DL TPC

For downlink scenario, no power control scheme is applied.

### 6.2.7 Received power model

The received power in downlink and uplink scenarios is defined as below:

*RX\_PWR = TX\_PWR – Path loss + G\_TX + G\_RX*

where:

- RX\_PWR is the received power

- TX\_PWR is the transmitted power

- G\_TX is the transmitter antenna gain (directional array gain)

- G\_RX is the receiver antenna gain (directional array gain).

### 6.2.8 Performance metric

For NR, the average throughput loss and 5%-ile throughput loss should be less than 5%.

For NB-IOT, the SNR loss should refer to TR 36.802 [15].

For NTN, the average throughput loss and 5%-ile throughput loss should be less than 5%.

### 6.2.9 Throughput ~ SNR mapping

Adopt Section 5.2.7 of TR 38.803[20] as the SINR-Throughput performance metrics

## 6.3 Co-existence simulation methodology

### 6.3.1 Simulation procedure

Adopt following simulation steps.

- Step 1: Generate aggressor and victim networks.

- NTN central beam is at satellite nadir, surrounded with 6 co-frequency beams. NTN FRFs higher than 1 need to be considered. Assume one NTN aggressor as default.

- Deployment of TN network (19 cells with wraparound) refers to Table 6.2.1.1-1

- Step2: UE associations

- TN UE are generated randomly inside the TN network, make sure enough TN UEs are associated to each TN sectors based on coupling loss.

- Deployment of NTN UE refers to Table 6.2.1.1-1.

- Step 3: Once association is done, round robin scheduling is used. BF weights are adjusted to point to the LOS direction between BS/SAN-UE. This is done for both victim and aggressor networks.

- Step 4: Throughput is computed in the victim systems without considering ACI as below:

,

where: is the inter-cell interference.

For TN-NTN SINR calculation, the satellite receiver off angle should be considered in the satellite receiver gain calculation when calculating SINR. Note that such angle is not considered in TR 38.821[6] section 6.1.3 equations. Thus those equations should be used for SINR calculation.

- Step 5: Throughput is computed considering ACI as below:

,

where: is the adjacent channel interference.

- Step 6: RF parameters are determined based on the degradation cause by ACI as below:

To simplify the simulation of interference from TN to NTN UL in Case 2 and 6, following method can be used. Consider the active TN cells from central NTN beam for the ACI evaluation from TN to NTN UL. The scaling factor is to be discussed and determined if any in next meeting. There is a view that simplifying such coexistence simulation work for Case 2 may even not be required.

- Step 1: to drop NTN UE per beamprint randomly;

- Step 2: to drop N clusters consisting of 57 sectors per beamprint randomly:

- Step 3: to calculate the total ACI per beam to NTN UL by following scaling factor:



where: active\_TN = **active\_factor**\*round (the area per beam/the area of 57 sectors)

active\_factor = 20% (or lower, particularly for urban scenarios)

- Step 4: to calculate the total ACI from all beams (e.g. M=7 ) for NTN:



### 6.3.2 Methods and principle to process co-existence simulation results

In order to process the co-existence simulation results received for all different scenarios and assumptions, the following steps are adopted:

- Step 1: Discuss and agree on the most stringent scenario(s) for each scenario (Scenario 1, 2, 3…,6);

- Step 2: Discuss and determine the required ACIR from results of the most stringent case(s) for each scenario;

- Step 3: Use equation to derive corresponding ACLR or ACS from the agreed ACIR for each scenario

It is noted that the averaged ACIR for the most stringent case in each scenario would be derived by taking the average among the interpolated ACIR results derived from each company’s results for that case.

Moreover, the following considerations are adopted to deal with major disputes for the selected cases’ results in each scenario:

- If the required ACIR results, from the contributor who did not participate or their results is still not well-aligned in calibration table, has a difference larger than 10 dB with most others, this result can be not considered in the discussion.

- If the required ACIR results, from one contributor, has a difference larger than 10 dB with most others, this result can be not considered in the discussion.

The processed results by adopting above principles and methods for scenarios 1 to 7 identified in Table 6.1-2 are captured in section 6.4. It is noted that due to the space limitation, only part of the simulation results for each case are presented, and the whole results for all studied options, as listed in Table 6.1-1 and section 6.2, can be found in Annex C.

Table 6.3.2-1: Selected option for each scenario

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario | Aggressor system | Victim system | Environment | Contributing |
| 1 | TN DL | NTN GEO DL | Urban | NTN UE ACS |
| 2 | TN UL | NTN GEO UL | Urban | NTN SAN ACS |
| 3 | NTN LEO-600 DL | TN DL | Rural | NTN SAN LEO ACLR |
| NTN GEO DL | TN DL | Rural | NTN SAN GEO ACLR |
| 4 | NTN GEO UL | TN UL | Urban | NTN UE ACLR |
| 5 | NTN GEO UL | TN DL | Rural | NTN UE ACLR |
| 61 | NR-TN DL | NTN LEO-600 UL | Rural 2 | NTN SAN ACS |
| NR-TN DL | NTN GEO UL | Rural 2 | NTN SAN ACS |
| 7 | HAPS DL | TN DL | Rural | HAPS ACLR |
| 8 | TN UL | HAPS UL | Rural | HAPS ACS |
| NOTE 1: Agreed representative case for Scenario 6.  NOTE 2： The initial results suggested that the NR-NTN SAN would suffer more interference in urban deployment scenario. It is agreed that a more relevant environment for case 6 is a mixture of Urban and Rural environment (e.g., urban area with a 50km diameter inside a GEO beam with a 250km diameter). Further studies based on the mixed urban environment could be considered. As compromise, rural only scenario was then selected. | | | | |

## 6.4 Co-existence simulation results

### 6.4.1 Scenario 1: 2GHz TN DL interfering NTN DL

The co-existence results from all concerned options in this scenario were evaluated, and it has been agreed to select the NR DL equipped with both AAS and non-AAS antenna interfering the NR-NTN GEO DL that deployed in urban environment as the most stringent case.

Table 6.4.1-1: Simulation results for average throughput loss - TN BS with AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| Qualcomm | 32.76 | 26.13 | 19.50 | 15.41 | 11.32 | 8.26 | 6.21 | 4.16 | 3.22 | 2.27 |
| MTK | 7.28 | 5.71 | 4.60 | 3.77 | 3.05 | 2.35 | 1.90 | 1.30 | 1.02 | 0.80 |
| ZTE | 31.76 | 24.81 | 18.95 | 14.18 | 10.47 | 7.63 | 5.50 | 3.92 | 2.79 | 1.99 |
| Ericsson |  |  | 4.2 | 3.0 | 2.1 | 1.5 | 1.1 |  |  |  |
| CATT | 8.7 | 6.5 | 5.3 | 4.3 |  |  |  |  |  |  |
| Xiaomi | 38.11 | 31.51 | 25.56 | 20.35 | 15.94 | 12.29 | 9.36 | 7.06 | 5.29 | 3.95 |

Figure 6.4.1-1: Simulation results for average throughput loss - TN BS with AAS antenna

Table 6.4.1-2: Simulation results for 5%-tile throughput loss - TN BS with AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
| Qualcomm | 44.68 | 27.01 | 19.33 | 11.66 | 9.31 | 6.96 | 5.20 | 4.03 |  |  |
| MTK | 7.38 | 4.80 | 3.09 | 1.97 | 1.26 | 0.80 | 0.50 | 0.32 | 0.20 | 0.13 |
| ZTE | 33.63 | 24.27 | 17.09 | 12.37 | 9.01 | 6.43 | 4.81 | 3.30 | 2.42 | 1.70 |
| Ericsson | 3.0 | 2.8 | 1.8 |  |  |  |  |  |  |  |
| CATT | 13.4 | 12.7 | 11.8 | 9.33 | 8.76 | 8.18 | 7.65 | 5.83 | 4.91 |  |
| Xiaomi | 65.22 | 54.94 | 44.26 | 33.58 | 24.20 | 16.78 | 11.29 | 7.43 | 4.51 |  |

Figure 6.4.1-2: Simulation results for 5%-tile throughput loss - TN BS with AAS antenna

Table 6.4.1-3: Interpolated ACIR values for Scenario 1 to meet the 5% throughput loss criteria - TN BS with AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| Qualcomm | Average | 19.18 |
| 5%-tile | **26.34** |
| MTK | Average | 9.28 |
| 5%-tile | 15.851 |
| ZTE | Average | 18.63 |
| 5%-tile | **25.77** |
| Ericsson | Average |  |
| 5%-tile | 12.101 |
| CATT | Average | 10.6 |
| 5%-tile | **29.80** |
| Xiaomi | Average | 22.43 |
| 5%-tile | **29.40** |
| NOTE 1: According to the principles, these values are not treated for later process. | | |

Table 6.4.1-4: Average ACIR of 5%-tile values in the above worse case for Scenario 1 - TN BS with AAS antenna

|  |  |
| --- | --- |
|  | Scenario 1 |
| ACIR value [dB] | 27.83 |

Table 6.4.1-5: Simulation results for average throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| MTK | 25,91 | 20,30 | 16,17 | 12,92 | 9,97 | 8,19 | 6,76 | 5,54 | 4,32 | 3,34 |
| ZTE | 35,27 | 27,40 | 20,83 | 15,57 | 11,46 | 8,34 | 6,04 | 4,32 | 3,06 | 2,14 |
| THALES | NA | NA | NA | 13,13 | 9,54 | 6,85 | 4,86 | 3,4 | 2,3 | 1,58 |

Figure 6.4.1-3: Simulation results for average throughput loss - TN BS with non-AAS antenna

Table 6.4.1-6: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
| MTK | 69,59 | 59,31 | 48,18 | 37,24 | 26,31 | 18,42 | 12,49 | 8,27 | 5,39 | 3,47 |
| ZTE | 37,88 | 27,97 | 20,08 | 14,18 | 9,80 | 6,65 | 4,46 | 2,78 | 1,82 | 1,24 |
| THALES | 16,36 | 14,55 | 8,64 | 7,27 | 6,36 | 5,91 | 5,45 | 5,45 | 4,55 | 1,82 |

Figure 6.4.1-4: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

Table 6.4.1-7: Interpolated ACIR values for Scenario 1 to meet the 5% throughput loss criteria - TN BS with non-AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| MTK | Average | 20.89 |
| 5%-tile | **30.41** |
| ZTE | Average | 19.21 |
| 5%-tile | **25.51** |
| Thales | Average | 17.86 |
| 5%-tile | **29.00** |

Table 6.4.1-8: Average ACIR of 5%-tile values in the above worse case for Scenario 1 - TN BS with non-AAS antenna

|  |  |
| --- | --- |
|  | Scenario 1 |
| ACIR value [dB] | 28.31 |

### 6.4.2 Scenario 2: 2GHz TN UL interfering NTN UL

The co-existence results from all concerned options in this scenario were evaluated, and it has been agreed to select the NR UL interfering the NR-NTN GEO UL that deployed in urban environment as the most stringent case.

Table 6.4.2-1: Simulation results for average throughput loss - TN BS with AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 |
| Qualcomm | 36.46 | 24.81 | 18.43 | 12.06 | 7.70 | 5.34 | 2.98 |  |  |  |
| ZTE | 16.46 | 11.77 | 8.26 | 5.51 | 3.55 | 2.25 | 1.48 | 0.98 | 0.63 | 0.39 |
| MTK | 38.61 | 31.96 | 25.57 | 20.13 | 15.27 | 11.22 | 7.96 | 5.48 | 3.68 | 2.42 |
| Ericsson |  | 15.6 | 10.4 | 7.2 | 4.2 | 2.9 | 1.9 |  |  |  |
| CATT | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Xiaomi | 41.11 | 30.58 | 21.75 | 14.92 | 9.96 | 6.53 | 4.22 | 2.70 | 1.72 | 1.09 |

Figure 6.4.2-1: Simulation results for average throughput loss - TN BS with AAS antenna

Table 6.4.2-2: Simulation results for 5%-tile throughput loss - TN BS with AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |
| Qualcomm | NA | NA | NA | NA | NA |  |  |  |  |  |
| ZTE | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MTK | 68.80 | 58.62 | 47.26 | 36.43 | 26.97 | 19.13 | 13.06 | 8.68 | 5.67 | 3.67 |
| Ericsson | NA | NA | NA | NA | NA |  |  |  |  |  |
| CATT | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Xiaomi | NA | NA | NA | NA | NA | NA | NA | NA | NA |  |

Figure 6.4.2-2: Simulation results for 5%-tile throughput loss - TN BS with AAS antenna

Table 6.4.2-3: Interpolated ACIR values for Scenario 2 to meet the 5% throughput loss criteria - TN BS with AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| Qualcomm | Average | **28.29** |
| 5%-tile |  |
| ZTE | Average | **24.52** |
| 5%-tile |  |
| MTK | Average | **32.53** |
| 5%-tile | 38.671 |
| Ericsson | Average | **25.47** |
| 5%-tile |  |
| CATT | Average |  |
| 5%-tile |  |
| Xiaomi | Average | **29.32** |
| 5%-tile |  |
| NOTE 1: According to the principles, this value is not treated for later process. | | |

Table 6.4.2-4: Average ACIR values in the above worse case for Scenario 2 - TN BS with AAS antenna

|  |  |
| --- | --- |
|  | Scenario 2 |
| ACIR value [dB] | 28.03 |

Table 6.4.2-5: Simulation results for average throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 |
| Ericsson | NA | NA | NA | NA | NA | 10,4 | 6,8 | 4,2 | 2,9 | NA |
| THALES | 14,06 | 10,74 | 7,74 | 5,53 | 3,63 | 2,37 | 1,74 | 1,11 | 0,79 | 0,47 |
| MTK | 35,49 | 29,12 | 23,27 | 18,21 | 13,81 | 9,87 | 6,92 | 4,67 | 3,11 | 2,04 |

Figure 6.4.2-3: Simulation results for average throughput loss - TN BS with non-AAS antenna

Table 6.4.2-6: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |
| **Ericsson** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **THALES** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **MTK** | 57,18 | 45,86 | 34,92 | 25,60 | 18,05 | 12,29 | 8,15 | 5,31 | 3,42 | 2,19 |

Figure 6.4.2-4: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

Table 6.4.2-7: Interpolated ACIR values for Scenario 2 to meet the 5% throughput loss criteria - TN BS with non-AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| Ericsson | Average | **31.38** |
| 5%-tile | NA |
| Thales | Average | **24.56** |
| 5%-tile | NA |
| MTK | Average | **31.71** |
| 5%-tile | 36.33 |

Table 6.4.2-8: Average ACIR values in the above worse case for Scenario 2 TN BS with non-AAS antenna

|  |  |
| --- | --- |
|  | Scenario 2 |
| ACIR value [dB] | 29.22 |

### 6.4.3 Scenario 3: 2GHz NTN DL interfering TN DL

#### 6.4.3.1 LEO Class

The co-existence results from all concerned options in this scenario were evaluated, and it has been agreed to select the NR-NTN LEO-600 DL interfering the NR DL equipped with AAS antenna that deployed in rural environment as the most stringent case for LEO class.

Table 6.4.3.1-1: Simulation results for average throughput loss - TN BS with AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 |
| Qualcomm | 21.02 | 16.68 | 12.34 | 8.94 | 6.48 | 4.03 | 2.98 | 1.93 | 1.21 | 0.84 |
| Samsung | 20.06 | 15.28 | 11.24 | 8.00 | 5.52 | 3.72 | 2.45 | 1.60 | 1.03 | 0.66 |
| MTK | 25.22 | 19.06 | 13.86 | 9.70 | 6.66 | 4.41 | 2.92 | 1.90 | 1.22 | 0.77 |
| ZTE | 16.65 | 12.34 | 8.84 | 6.15 | 4.17 | 2.77 | 1.81 | 1.17 | 0.75 | 0.48 |
| Ericsson |  |  |  |  |  | 3.7 | 2.4 | 1.6 | 1.0 |  |
| Huawei |  |  |  |  | 5.94 | 3.97 | 2.52 | 1.64 | 1.24 |  |
| CATT | 17.3 | 12.2 | 10.1 | 8.3 | 6.6 | 4.7 |  |  |  |  |
| Xiaomi | 30.71 | 23.92 | 17.92 | 12.93 | 9.01 | 6.11 | 4.05 | 2.64 | 1.70 | 1.09 |

Figure 6.4.3.1-1: Simulation results for average throughput loss - TN BS with AAS antenna

Table 6.4.3.1-2: Simulation results for 5%-tile throughput loss - TN BS with AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
| Qualcomm | 37.78 | 28.51 | 21.12 | 13.72 | 10.16 | 6.60 | 4.18 | 2.89 |  |  |
| Samsung | 27.10 | 19.19 | 13.13 | 8.76 | 5.73 | 3.71 | 2.37 | 1.51 | 0.97 | 0.62 |
| MTK | 37.56 | 27.47 | 19.31 | 13.11 | 8.69 | 5.67 | 3.65 | 2.33 | 1.49 | 0.94 |
| ZTE | 16.27 | 10.85 | 7.06 | 4.59 | 2.82 | 1.91 | 1.31 | 0.88 | 0.60 | 0.39 |
| Ericsson |  |  |  | 9.8 | 6.2 | 4.5 | 2.8 |  |  |  |
| Huawei |  |  | 8.61 | 5.01 | 3.12 | 1.94 | 1.32 |  |  |  |
| CATT | 42.07 | 32.30 | 22.43 | 15.88 | 10.74 | 7.90 | 4.40 |  |  |  |
| Xiaomi | 38.87 | 28.90 | 20.59 | 14.15 | 9.47 | 6.22 | 4.03 | 2.59 |  |  |

Figure 6.4.3.1-2: Simulation results for average throughput loss - TN BS with AAS antenna

Table 6.4.3.1-3: Interpolated ACIR values for Scenario 3 to meet the 5% throughput loss criteria - TN BS with AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| Qualcomm | Average | 19.21 |
| 5%-tile | **25.32** |
| Samsung | Average | 18.58 |
| 5%-tile | **22.72** |
| MTK | Average | 19.48 |
| 5%-tile | **24.66** |
| ZTE | Average | 17.16 |
| 5%-tile | **19.67** |
| Ericsson | Average |  |
| 5%-tile | **23.41** |
| Huawei | Average | 18.95 |
| 5%-tile | **20.01** |
| CATT | Average | 19.68 |
| 5%-tile | **25.66** |
| Xiaomi | Average | 21.01 |
| 5%-tile | **25.11** |

Table 6.4.3.1-4: Average ACIR of 5%-tle values in the above worse case for Scenario 3 - TN BS with AAS antenna

|  |  |
| --- | --- |
|  | Scenario 3 |
| ACIR value [dB] | 23.32 |

Table 6.4.3.1-5: Simulation results for average throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 |
| Samsung | 10,42 | 7,20 | 4,86 | 3,21 | 2,09 | 1,35 | 0,86 | 0,55 | 0,35 | 0,22 |
| MTK | 27,33 | 20,75 | 15,22 | 10,59 | 7,32 | 4,81 | 3,29 | 2,16 | 1,45 | 0,93 |
| ZTE | 13,12 | 9,28 | 6,37 | 4,27 | 2,81 | 1,82 | 1,17 | 0,75 | 0,48 | 0,30 |
| THALES | NA | 15,84 | 11,43 | 7,99 | 5,43 | 3,61 | 2,35 | 1,52 | 0,97 | 0,62 |
| Ericsson | NA | NA | NA | NA | NA | 3,0 | 2,0 | 1,3 | 0,8 | 0,5 |

Figure 6.4.3.1-3: Simulation results for average throughput loss - TN BS with non-AAS antenna

Table 6.4.3.1-6: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
| Samsung | 18,31 | 12,33 | 8,12 | 5,28 | 3,40 | 2,17 | 1,38 | 0,87 | 0,55 | 0,35 |
| MTK | 39,11 | 28,66 | 20,18 | 13,63 | 9,06 | 5,92 | 3,81 | 2,44 | 1,55 | 0,98 |
| ZTE | 21,75 | 14,80 | 9,68 | 6,52 | 4,36 | 2,83 | 1,82 | 1,20 | 0,71 | 0,39 |
| THALES | 47,09 | 35,73 | 25,48 | 17,17 | 11,08 | 6,65 | 3,6 | 2,22 | 1,39 | 0,83 |
| Ericsson | NA | NA | NA | 7,2 | 4,5 | 2,9 | 1,8 | 1,2 | NA | NA |

Figure 6.4.3.1-4: Simulation results for average throughput loss - TN BS with non-AAS antenna

Table 6.4.3.1-7: Interpolated ACIR values for Scenario 3 LEO Class to meet the 5% throughput loss criteria - TN BS with non-AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| Samsung | Average | 13.88 |
| 5%-tile | **20.30** |
| MTK | Average | 19.85 |
| 5%-tile | **24.87** |
| ZTE | Average | 15.3 |
| 5%-tile | **21.41** |
| THALES | Average | 18.47 |
| 5%-tile | **25.08** |
| Ericsson | Average |  |
| 5%-tile | **21.63** |

Table 6.4.3.1-8: Average ACIR of 5%-tile values in the above worse case for Scenario 3 LEO Class - TN BS with non-AAS antenna

|  |  |
| --- | --- |
|  | Scenario 3 |
| ACIR value [dB] | 22.66 |

6.4.3.2 GEO Class

The co-existence results from all concerned options in this scenario were evaluated, and it has been agreed to select the NR-NTN GEO DL interfering the NR DL equipped with AAS antenna that deployed in rural environment as the most stringent case for GEO class.

Table 6.4.3.2-1: Simulation results for average throughput loss - TN BS with AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
| Qualcomm | 15.65 | 11.48 | 8.25 | 5.96 | 3.67 | 2.70 | 1.74 | 1.09 |  |  |
| Samsung | 15.14 | 11.09 | 7.86 | 5.41 | 3.63 | 2.39 | 1.55 | 1.00 | 0.64 | 0.41 |
| MTK | 20.35 | 15.03 | 10.74 | 7.33 | 4.79 | 3.15 | 2.05 | 1.32 | 0.84 | 0.53 |
| ZTE | 11.39 | 8.09 | 5.58 | 3.76 | 2.48 | 1.62 | 1.04 | 0.67 | 0.42 | 0.27 |
| Ericsson |  |  |  |  | 3.9 | 2.5 | 1.6 | 1.0 |  |  |
| CATT | 9.73% | 7.94% | 6.42% | 5.15% | 4.08% | 3.20% | 2.48% |  |  |  |
| Xiaomi | 22.47 | 16.68 | 11.93 | 8.25 | 5.56 | 3.67 | 2.39 | 1.54 | 0.98 | 0.62 |

Figure 6.4.3.2-1: Simulation results for average throughput loss - TN BS with AAS antenna

Table 6.4.3.2-2: Simulation results for 5%-tile throughput loss - TN BS with AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 |
| Qualcomm | 35.59 | 26.64 | 19.54 | 12.44 | 9.23 | 6.02 | 3.81 |  |  |  |
| Samsung | 26.43 | 18.68 | 12.77 | 8.49 | 5.55 | 3.58 | 2.30 | 1.46 | 0.93 | 0.59 |
| MTK | 42.08 | 31.47 | 22.53 | 15.53 | 10.41 | 6.83 | 4.43 | 2.84 | 1.81 | 1.15 |
| ZTE | 14.19 | 9.38 | 6.19 | 4.19 | 2.58 | 1.62 | 1.00 | 0.57 | 0.38 | 0.25 |
| Ericsson |  |  |  | 8.3 | 5.6 | 3.5 | 2.2 |  |  |  |
| CATT | 20.86 | 19.31 | 14.49 | 13.09 | 7.33 | 5.23 | 4.17 |  |  |  |
| Xiaomi | 36.44 | 26.85 | 18.99 | 12.97 | 8.65 | 5.67 | 3.66 | 2.35 | 1.50 |  |

Figure 6.4.3.2-2: Simulation results for 5%-tile throughput loss - TN BS with AAS antenna

Table 6.4.3.2-3: Interpolated ACIR values for Scenario 3 GEO Class to meet the 5% throughput loss criteria - TN BS with AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| Qualcomm | Average | 8.84 |
| 5%-tile | **14.46** |
| Samsung | Average | 8.46 |
| 5%-tile | **12.56** |
| MTK | Average | 9.83 |
| 5%-tile | **15.53** |
| ZTE | Average | 6.64 |
| 5%-tile | **9.2** |
| Ericsson | Average |  |
| 5%-tile | **12.57** |
| CATT | Average | 8.28 |
| 5%-tile | **14.43** |
| Xiaomi | Average | 10.59 |
| 5%-tile | **14.67** |

Table 6.4.3.2-4: Average ACIR of 5%-tile values in the above worse case for Scenario 3 GEO Class - TN BS with AAS antenna

|  |  |
| --- | --- |
|  | Scenario 3 GEO Class |
| ACIR value [dB] | 13.35 |

Table 6.4.3.2-5: Simulation results for average throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| Samsung | 10.22 | 7.04 | 4.73 | 3.12 | 2.03 | 1.31 | 0.83 | 0.53 | 0.34 | 0.21 |
| MTK | 28.38 | 21.62 | 15.91 | 11.36 | 7.76 | 5.17 | 3.37 | 2.24 | 1.34 | 0.85 |
| ZTE | 11.89 | 8.33 | 5.68 | 3.79 | 2.48 | 1.60 | 1.03 | 0.66 | 0.42 | 0.26 |
| THALES |  |  |  |  |  |  | 2.27 | 1.46 | 0.94 | 0.6 |
| Ericsson |  |  |  |  |  | 3.2 | 2.1 | 1.3 | 0.9 | 0.5 |

Figure 6.4.3.2-3: Simulation results for average throughput loss - TN BS with non-AAS antenna

Table 6.4.3.2-6: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | **6** | **8** | **10** | **12** | **14** | **16** | **18** | **20** | **22** | **24** |
| Samsung | 11,97 | 7,88 | 5,11 | 3,28 | 2,09 | 1,33 | 0,85 | 0,53 | 0,34 | 0,21 |
| MTK | 31,86 | 22,83 | 15,63 | 10,47 | 6,87 | 4,45 | 2,85 | 1,82 | 1,16 | 0,73 |
| ZTE | 13,72 | 9,33 | 6,08 | 3,88 | 2,38 | 1,50 | 1,13 | 0,75 | 0,55 | 0,30 |
| THALES |  |  |  | 9,14 | 5,54 | 3,6 | 2,22 | 1,39 | 0,83 | 0,55 |
| Ericsson |  |  | 9,1 | 5,9 | 4,2 | 2,8 | 1,9 |  |  |  |

Figure 6.4.3.2-4: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

Table 6.4.3.2-7: Interpolated ACIR values for Scenario 3 GEO Class to meet the 5% throughput loss criteria - TN BS with non-AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| Samsung | Average | 3.77 |
| 5%-tile | **10.12** |
| MTK | Average | 10.19 |
| 5%-tile | **15.55** |
| ZTE | Average | 4.72 |
| 5%-tile | **10.98** |
| THALES | Average | NA |
| 5%-tile | **14.56** |
| Ericsson | Average | NA |
| 5%-tile | **13.06** |

Table 6.4.3.2-8: Average ACIR of 5%-tile values in the above worse case for Scenario 3 GEO Class - TN BS with non-AAS antenna

|  |  |
| --- | --- |
|  | Scenario 3 |
| ACIR value [dB] | 12.85 |

### 6.4.4 Scenario 4: 2GHz NTN UL interfering TN UL

The co-existence results from all concerned options in this scenario were evaluated, and it has been agreed to select the NR-NTN GEO UL interfering the NR UL equipped with both AAS and non-AAS antenna that deployed in urban environment as the most stringent case.

Table 6.4.4-1: Simulation results for average throughput loss - TN BS with AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 |
| Qualcomm | 12.60 | 10.78 | 8.96 | 7.42 | 6.18 | 4.93 | 4.11 | 3.29 | 2.63 | 2.12 |
| Samsung | 10.83 | 8.69 | 6.92 | 5.47 | 4.30 | 3.35 | 2.60 | 2.00 | 1.53 | 1.17 |
| MTK | 12.16 | 10.25 | 8.40 | 6.66 | 5.09 | 3.75 | 2.67 | 1.84 | 1.24 | 0.82 |
| ZTE | 9.35 | 7.39 | 5.59 | 4.38 | 3.38 | 2.65 | 2.05 | 1.63 | 1.24 | 0.94 |
| Ericsson1 |  |  |  |  |  |  |  | 1.5 | 1.2 | 1.0 |
| CATT | 2.72 | 2.26 | 1.88 | 1.58 |  |  |  |  |  |  |
| Xiaomi | 10.31 | 8.30 | 6.66 | 5.34 | 4.27 | 3.42 | 2.74 | 2.19 | 1.76 | 1.41 |
| NOTE 1: This result is derived by observing the NR sector having an NR-NTN transmitting UE at its sector edge. | | | | | | | | | | |

Figure 6.4.4-1: Simulation results for average throughput loss - TN BS with AAS antenna

Table 6.4.4-2: Simulation results for 5%-tile throughput loss - TN BS with AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 |
| Qualcomm | 24.62 | 20.07 | 15.53 | 12.02 | 9.55 | 7.08 | 5.83 | 4.58 |  |  |
| Samsung | 16.71 | 12.55 | 9.44 | 7.15 | 5.47 | 4.19 | 3.19 | 2.44 | 1.86 | 1.41 |
| MTK | 20.91 | 14.93 | 10.33 | 6.95 | 4.59 | 2.98 | 1.92 | 1.23 | 0.78 | 0.49 |
| ZTE | 11.43 | 8.86 | 7.23 | 6.23 | 4.71 | 3.34 | 2.66 | 1.47 | 0.87 | 0.75 |
| Ericsson1 |  |  | 7.9 | 7.1 | 4.8 | 4.6 | 0.5 | 0.5 |  |  |
| CATT | 8.83 | 7.49 | 5.57 | 4.10 | 3.44 | 2.95 |  |  |  |  |
| Xiaomi | 16.47 | 11.96 | 8.45 | 5.79 | 3.88 | 2.55 | 1.66 | 1.07 |  |  |
| NOTE 1: This result is derived by observing the NR sector having an NR-NTN transmitting UE at its sector edge. | | | | | | | | | | |

Figure 6.4.4-2: Simulation results for 5%-tile throughput loss - TN BS with AAS antenna

Table 6.4.4-3: Interpolated ACIR values for Scenario 4 to meet the 5% throughput loss criteria - TN BS with AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| Qualcomm | Average | 19.89 |
| 5%-tile | **33.33** |
| Samsung | Average | 16.80 |
| 5%-tile | **28.73** |
| MTK | Average | 18.13 |
| 5%-tile | **27.65** |
| ZTE | Average | 14.98 |
| 5%-tile | **27.62** |
| Ericsson(\*) | Average |  |
| 5%-tile | **27.83** |
| CATT | Average | 3.69 |
| 5%-tile | **24.78** |
| Xiaomi | Average | 16.64 |
| 5%-tile | **26.83** |

Table 6.4.4-4: Average ACIR of 5%-tile values in the above worse case for Scenario 4 - TN BS with AAS antenna

|  |  |
| --- | --- |
|  | Scenario 4 |
| ACIR value [dB] | 28.11 |

Table 6.4.4-5: Simulation results for average throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 |
| Samsung | 10,85 | 8,39 | 6,50 | 5,06 | 3,96 | 3,11 | 2,43 | 1,88 | 1,44 | 1,07 |
| MTK | 11,73 | 9,14 | 7,05 | 5,38 | 4,05 | 2,99 | 2,17 | 1,53 | 1,06 | 0,72 |
| ZTE | 6,12 | 5,01 | 4,16 | 3,32 | 2,85 | 2,27 | 1,83 | 1,17 | 0,80 | 0,50 |
| THALES | NA | 0,04 | 0,03 | 0,01 | 0,01 | 0 | 0 | 0 | 0 | 0 |
| Ericsson1 | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1,2 |
| NOTE 1: This result is derived by observing the NR sector having an NR-NTN transmitting UE at its sector edge. | | | | | | | | | | |

Figure 6.4.4-3: Simulation results for average throughput loss - TN BS with non-AAS antenna

Table 6.4.4-6: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 |
| Samsung | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MTK | 21,98 | 15,18 | 10,19 | 6,70 | 4,34 | 2,79 | 1,78 | 1,13 | 0,72 | 0,45 |
| ZTE | 1,53 | 1,08 | 0,47 | 0,30 | 0,19 | 0,03 | 0,00 | 0,00 | 0,00 | 0,00 |
| THALES | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ericsson | NA | NA | NA | NA | 12,2 | 9,7 | 8,3 | 7,4 | 6,1 | 4,4 |
| NOTE 1: This result is derived by observing the NR sector having an NR-NTN transmitting UE at its sector edge. | | | | | | | | | | |

Figure 6.4.4-4: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

Table 6.4.4-7: Interpolated ACIR values for Scenario 4 to meet the 5% throughput loss criteria - TN BS with non-AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| Samsung | Average | 16.11 |
| 5%-tile | NA |
| MTK | Average | 16.57 |
| 5%-tile | 27.441 |
| ZTE | Average | 12.02 |
| 5%-tile | **15.46** |
| THALES | Average | NA |
| 5%-tile | NA |
| Ericsson | Average | NA |
| 5%-tile | 37.291 |
| NOTE 1: According to the principles, this value is not treated for later process. | | |

Table 6.4.4-8: Average ACIR of 5%-tile values in the above worse case for Scenario 4 - TN BS with non-AAS antenna

|  |  |
| --- | --- |
|  | Scenario 4 |
| ACIR value [dB] | 15.46 |

### 6.4.5 Scenario 5: 2GHz NTN UL interfering TN DL

The co-existence results from all concerned options in this scenario were evaluated, and it has been agreed to select the NR-NTN GEO UL interfering the NR DL equipped with both AAS and non-AAS antenna that deployed in rural environment as the most stringent case.

Table 6.4.5-1: Simulation results for average throughput loss - TN BS with AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 |
| Qualcomm (1) | 7.32 | 5.28 | 3.78 | 2.81 | 1.84 | 1.42 | 0.99 | 0.68 |  |  |
| MTK | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Xiaomi | 10.31 | 7.75 | 5.70 | 4.11 | 2.91 | 2.03 | 1.39 | 0.94 |  |  |
| Samsung (1) | 37.13 | 31.30 | 25.62 | 20.30 | 15.53 | 11.43 | 8.07 | 5.43 | 3.43 | 1.98 |
| Samsung (2) | 0.16 | 0.13 | 0.11 | 0.09 | 0.07 | 0.06 | 0.05 | 0.03 | 0.02 | 0.02 |
| Ericsson | 0.00 |  |  |  |  |  |  |  |  |  |
| NOTE 1: These results were derived by adopting free-space path loss model for the links between NR UE and NR-NTN UE.  NOTE 2: These results were derived by adopting path loss model from TR 38.901[10] for the links between NR UE and NR-NTN UE.  NOTE3: In the meeting, views are expressed on which propagation model is more appropriate for the links between NR UE and NR-NTN UE. Due to the limited time and the fact that this scenario is not the worst case to determine the NR-NTN UE ACLR, this is not discussed nor concluded. | | | | | | | | | | |

Figure 6.4.5-1: Simulation results for average throughput loss - TN BS with AAS antenna

Table 6.4.5-2: Simulation results for 5%-tile throughput loss - TN BS with AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
| Qualcomm (1) | 23.52 | 17.84 | 13.74 | 9.65 | 7.54 | 5.42 | 3.84 |  |  |  |
| MTK | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Xiaomi | 26.06 | 20.19 | 15.30 | 11.29 | 8.09 | 5.64 | 3.81 |  |  |  |
| Samsung (1) | 72.82 | 63.00 | 52.03 | 40.90 | 30.57 | 21.66 | 14.49 | 9.03 | 5.09 | 2.36 |
| Samsung (2) | 0.99 | 0.82 | 0.66 | 0.53 | 0.41 | 0.30 | 0.21 | 0.14 | 0.08 | 0.04 |
| Ericsson | 0.0 |  |  |  |  |  |  |  |  |  |
| NOTE 1: These results were derived by adopting free-space path loss model for the links between NR UE and NR-NTN UE.  NOTE 2: These results were derived by adopting path loss model from TR 38.901[10] for the links between NR UE and NR-NTN UE.  NOTE 3: In the meeting, views are expressed on which propagation model is more appropriate for the links between NR UE and NR-NTN UE. Due to the limited time and the fact that this scenario is not the worst case to determine the NR-NTN UE ACLR, this is not discussed nor concluded. | | | | | | | | | | |

Figure 6.4.5-2: Simulation results for 5%-tile throughput loss - TN BS with AAS antenna

Table 6.4.5-3: Interpolated ACIR values for Scenario 5 to meet the 5% throughput loss criteria - TN BS with AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| Qualcomm (\*) | Average | 14.37 |
| 5%-tile | **24.53** |
| MTK | Average |  |
| 5%-tile |  |
| Xiaomi | Average | 16.88 |
| 5%-tile | **24.70** |
| Samsung (\*) | Average | 26.43 |
| 5%-tile | **30.07** |
| Samsung (\*\*) | Average |  |
| 5%-tile |  |
| Ericsson | Average |  |
| 5%-tile |  |

Table 6.4.5-4: Average ACIR of 5%-tile values in the above worse case for Scenario 5 - TN BS with AAS antenna

|  |  |
| --- | --- |
|  | Scenario 5 |
| ACIR value [dB] | 26.43 |

Table 6.4.5-5: Simulation results for average throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| MTK | 3,01 | 2,43 | 1,88 | 1,39 | 0,99 | 0,69 | 0,46 | 0,30 | 0,20 | 0,13 |
| Samsung | 0,32 | 0,27 | 0,23 | 0,20 | 0,17 | 0,14 | 0,12 | 0,10 | 0,08 | 0,06 |
| THALES | NA | NA | NA | NA | NA | NA | 0,07 | 0,06 | 0,05 | 0,04 |
| NOTE1: In the meeting, views are expressed on which propagation model is more appropriate for the links between NR UE and NR-NTN UE. Due to the limited time and the fact that this scenario is not the worst case to determine the NR-NTN UE ACLR, this is not discussed nor concluded. | | | | | | | | | | |

Figure 6.4.5-3: Simulation results for average throughput loss - TN BS with non-AAS antenna

Table 6.4.5-6: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| MTK | 15,03 | 10,72 | 7,39 | 4,96 | 3,27 | 2,12 | 1,36 | 0,87 | 0,55 | 0,35 |
| Samsung | 1,07 | 0,92 | 0,77 | 0,65 | 0,53 | 0,44 | 0,34 | 0,27 | 0,20 | 0,15 |
| THALES |  |  |  | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NOTE 1: In the meeting, views are expressed on which propagation model is more appropriate for the links between NR UE and NR-NTN UE. Due to the limited time and the fact that this scenario is not the worst case to determine the NR-NTN UE ACLR, this is not discussed nor concluded. | | | | | | | | | | |

Figure 6.4.5-4: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

Table 6.4.5-7: Interpolated ACIR values for Scenario 5 to meet the 5% throughput loss criteria - TN BS with non-AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| MTK | Average | 0 |
| 5%-tile | 11.971 |
| Samsung | Average | 0 |
| 5%-tile | **0** |
| THALES | Average | 0 |
| 5%-tile | **0** |
| NOTE 1: According to the principles, this value is not treated for later process. | | |

Table 6.4.5-8: Average ACIR of 5%-tile values in the above worse case for Scenario 5 - TN BS with non-AAS antenna

|  |  |
| --- | --- |
|  | Scenario 5 |
| ACIR value [dB] | 0 |

### 6.4.6 Scenario 6: 2GHz TN DL interfering NTN UL

The co-existence results from all concerned options in this scenario were evaluated, and the initial results suggested that the NR-NTN SAN would suffer more interference in urban deployment scenario, considering that the central beam of a GEO satellite (with the agreed minimum elevation angle of 45o) will be full of urban TNs. It was further discussed and agreed that simply using 20% active rate and assuming fully deployed NR stations with urban deployment assumptions in the whole NR-NTN beam coverage area would overestimate the density and aggregated interference from NR stations to NR-NTN in this scenario. In the end, the case of NR DL interfering the NR-NTN LEO-600 UL that deployed in a Rural environment has been selected as a representative one that could be used as basis to derive ACIR values. Further study could be considered base on a mixed Urban and Rural environment.

Table 6.4.6-1: Simulation results for average throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |
| THALES | 51.17 | 41.28 | 31.94 | 23.87 | 17.01 | 11.87 | 7.91 | 5.26 | 3.4 | 2.22 |
| MTK | 3.05 | 1.98 | 1.28 | 0.82 | 0.52 | 0.33 | 0.21 | 0.13 | 0.08 | 0.05 |

Figure 6.4.6-1: Simulation results for average throughput loss - TN BS with non-AAS antenna

Table 6.4.6-2: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |
| THALES | 53.49 | 43.02 | 33.72 | 25.58 | 17.44 | 12.79 | 8.14 | 5.81 | 3.49 | 2.33 |
| MTK | 8.85 | 5.78 | 3.73 | 2.39 | 1.52 | 0.97 | 0.61 | 0.39 | 0.24 | 0.15 |

Figure 6.4.6-2: Simulation results for 5%-tile throughput loss - TN BS with non-AAS antenna

Table 6.4.6-3: Interpolated ACIR values for Scenario 5 to meet the 5% throughput loss criteria - TN BS with non-AAS antenna

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| THALES | Average | 36.69 |
| 5%-tile | **36.7** |
| MTK | Average | 19.66 |
| 5%-tile | 24.671 |
| NOTE 1: According to the principles, this value is not treated for later process. | | |

Table 6.4.6-4: Average ACIR of 5%-tile values in the above worse case for Scenario 6 - TN BS with non-AAS antenna

|  |  |
| --- | --- |
|  | Scenario 6 |
| ACIR value [dB] | 36.7 |

### 6.4.7 Scenario 7: 2GHz HAPS DL interfering TN DL

The co-existence results contributed have been collected and compared in the following.

Table 6.4.7-1: Simulation results for average throughput loss

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 |
| Nokia | 28,80 | 16,80 | 8,10 | 3,30 | 1,10 | 0,30 | 0,10 | 0,10 |
| Qualcomm | 38,41 | 23,95 | 12,26 | 5,14 | 1,86 | 0,62 | 0,20 | 0,06 |

Figure 6.4.7-1: Simulation results for average throughput loss

Table 6.4.7-2: Simulation results for 5%-tile throughput loss

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 |
| Nokia | 77,10 | 53,20 | 26,60 | 9,80 | 1,80 | 0,30 | 0,20 | 0,00 |
| Qualcomm | 100,00 | 68,11 | 39,34 | 17,38 | 6,66 | 2,37 | 0,77 | 0,21 |

Figure 6.4.7-2: Simulation results for 5%-tile throughput loss

Table 6.4.7-3: Interpolated ACIR values for Scenario 7 to meet the 5% throughput loss criteria

|  |  |  |
| --- | --- | --- |
| Source | | Interpolated ACIR[dB] |
| Nokia | Average | 18.22 |
| 5%-tile | **23.00** |
| Qualcomm | Average | 20.10 |
| 5%-tile | **26.93** |
|  | | |

Table 6.4.7-4: Average ACIR of 5%-tile values in the above worse case for Scenario 7

|  |  |
| --- | --- |
|  | Scenario 1 |
| ACIR value [dB] | 24.97 |

### 6.4.8 Scenario 8: 2GHz TN UL interfering HAPS UL

The co-existence results contributed have been collected and compared in the following.

Table 6.4.8-1: Simulation results for average throughput loss

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 |
| Nokia | 14.4% | 7.2% | 3.0% | 1.4% | 0.7% | 0.6% | 0.1% | 0.0% |

Figure 6.4.8-1: Simulation results for average throughput loss

Table 6.4.8-2: Simulation results for 5%-tile throughput loss

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ACIR[dB] | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 |
| Nokia | 35.4% | 22.6% | 12.6% | 11.5% | 7.5% | 5.0% | 4.5% | 1.1% |

Figure 6.4.8-2: Simulation results for 5%-tile throughput loss

## 6.5 Summary of co-existence study

### 6.5.1 Coexistence at 2GHz

This sub-clause captures the summary of the co-existence studies. The averaged interpolate ACIR values for each scenario are presented in Table 6.5.1-1 below.

Table 6.5.1-1: Average ACIR values for each scenario

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | | 1 | 2 | 3  LEO | 3  GEO | 4 | 5 | 6 |
| ACIR value [dB] | TN BS with AAS | 27.83 | 28.03 | 23.32 | 13.35 | 28.11 | 26.43 | 36.70 |
| TN BS with non-AAS | 28.31 | 29.22 | 22.66 | 12.85 | 15.46 | 0 |

Then, by considering the following ACLR and ACS of TN BS and UE in Table 6.5.1-2, the suggested ACLR and ACS of NTN SAN, HAPS and UE from each scenario are given in Table 6.5.1-3. It should be noted that the values in Table 6.5.1-3 are directly derived from the selected option of each scenario, and it is limited by the nature of assumptions and methodologies adopted in the co-existence studies.

Table 6.5.1-2: ACLR and ACS of TN

|  |  |  |
| --- | --- | --- |
| TN | | Values |
| BS | ACLR | 45 dB |
| ACS | 46 dB |
| UE | ACLR | 30 dB |
| ACS | 33 dB |

Table 6.5.1-3: Co-existence results suggested ACLR and ACS of NR-NTN

|  |  |  |
| --- | --- | --- |
| Scenario | Contributing | ACLR ACS values |
| 1 | NTN UE ACS | 27.91 dB (AAS) |
| 2 | NTN SAN ACS | 37.06 dB (non-AAS) |
| 3 | NTN SAN ACLR | LEO: 23.81 dB  GEO: 13.39 dB |
| 4 | NTN UE ACLR | 28.18 dB (AAS) |
| 5 | NTN UE ACLR | 27.51 dB (AAS) |
| 6 | NTN SAN ACS | 37.4 dB |
| 7 | HAPS ACLR | 24.97 dB |
| 8 | HAPS ACS | 30 dB |

Considering the above suggested values, the agreed ACLR and ACS of NR-NTN are given in Table 6.5.1-4.

Table 6.5.1-4: ACLR and ACS of NR-NTN

|  |  |  |  |
| --- | --- | --- | --- |
| NR-NTN | | | Values |
| SAN | ACLR | GEO | 14 dB |
| LEO | 24 dB |
| ACS1 | GEO | 38 dB |
| LEO | 38 dB |
| HAPS | ACLR | | 452 |
| ACS | | 46 |
| UE | ACLR | | 30 dB |
| ACS | | 33 dB |
| NOTE 1: The ACS values for SAN apply to both Rural and Urban environment.  NOTE 2: This value could be further relaxed based on co-existence studies if it is found more stringent than necessary. | | | |

# 7 RF requirements

## 7.1 SAN Reference points for RF requirements

### 7.1.1 General

This section describes the SAN reference points for RF requirements with respect to different SAN types.

### 7.1.2 SAN type 1-C

This requirement is not applicable in Release 17.

### 7.1.3 SAN type 1-H

For SAN type 1-H, the requirements are defined for two points of reference, signified by radiated requirements and conducted requirements.



Figure 7.1.3-1: Radiated and conducted reference points for SAN type 1-H

Radiated characteristics are defined over the air (OTA), where the *operating band* specific radiated interface is referred to as the *Radiated Interface Boundary* (RIB). Radiated requirements are also referred to as OTA requirements. The (spatial) characteristics in which the OTA requirements apply are detailed for each requirement.

Conducted characteristics are defined at individual or groups of *TAB connectors* at the *transceiver array boundary*, which is the conducted interface between the transceiver unit array and the composite antenna.

The transceiver unit array is part of the composite transceiver functionality receiving and transmitting modulated signals to ensure radio links with ground base stations and users.

The Non-NTN infrastructure gNB functions implement the modulation and demodulation functionalities of the NTN gNB.

The Satellite NTN Gateway is part of the NTN ground infrastructure and is responsible for up- and down-converting, as well as transmitting and receiving modulated signals between the Non-NTN infrastructure gNB functions and the Satellite payload via the Feeder link.

The satellite payload is composed by a transceiver unit array and a composite antenna array. The transceiver unit array contains an implementation of specific number of transmitter units and an implementation of specific number of receiver units.

The composite antenna contains a radio distribution network (RDN) and an antenna array. The RDN is a linear passive network which distributes the RF power generated by the transceiver unit array to the transmit antenna array.

How a conducted requirement is applied to the *transceiver array boundary* is detailed in the respective requirement clause.

### 7.1.4 SAN type 1-O

For SAN type 1-O the radiated characteristics are defined over the air (OTA), where the *operating band* specific radiated interface is referred to as the *Radiated Interface Boundary* (RIB). Radiated requirements are also referred to as OTA requirements. The (spatial) characteristics in which the OTA requirements apply are detailed for each requirement.



Figure 7.1.4-1: Radiated reference points for SAN type 1-O

The SAN type 1-O payload includes an active antenna with performances characterized in radiated mode (OTA).

## 7.2 Common issues for satellite access node and NTN UE

### 7.2.1 General

This section aims to present the agreed definitions for the newly introduced NTN operating bands. The possible configurations in terms of channel bandwidth, SCS, channel and synchronization raster for NTN operations are introduced as well.

### 7.2.2 Operating bands

The following bands in Table 7.2.2-1 are agreed as exemplary NTN satellite bands in Release 17. Regarding the band numbering for NTN satellite bands, it is agreed to start from the largest band number in FR1 range for NTN satellite bands which fully within FR1 frequency ranges to better differentiate NTN satellite band and TN bands and ensure contiguous band number allocation for NTN satellite bands, the number can be taken in a decreased order with first come, first service.

Table 7.2.2-1: NTN satellite bands in FR1

|  |  |  |  |
| --- | --- | --- | --- |
| **NTN satelliteband #** | Uplink (UL) *operating band* Satellite Access Node receive / UE transmit  **FUL,low – FUL,high** | Downlink (DL) *operating band* Satellite Access Node transmit / UE receive  **FDL,low – FDL,high** | **Duplex mode** |
|  |  |  |  |
| n256 | 1980MHz – 2010 MHz | 2170 MHz – 2200 MHz | FDD |
| n255 | 1626.5 MHz – 1660.5 MHz | 1525 MHz – 1559 MHz | FDD |
| NOTE: NTN bands are numbered in descending order from n256. | | | |

### 7.2.3 Channel bandwidth, SCS and spectral utilization

The common definition for channel bandwidth, transmission bandwidth configuration, minimum guard band, and RB alignment in TS 38.104[16] and TS 38.101-1[17] can be reused for NTN satellite system.

The supported channel bandwidths per operating band should be defined based on NTN operator input. The details are given in Table 7.2.3-1.

Table 7.2.3-1: Channel bandwidths and SCS per NTN satellite operating band in FR1

| NTN satellite band # | SCS  kHz | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| --- | --- | --- | --- | --- | --- |
|  | 15 | Yes | Yes | Yes | Yes |
| n256 | 30 |  | Yes | Yes | Yes |
|  | 60 |  | Yes | Yes | Yes |
|  | 15 | Yes | Yes | Yes | Yes |
| n255 | 30 |  | Yes | Yes | Yes |
|  | 60 |  | Yes | Yes | Yes |

### 7.2.4 Channel raster and sync raster

#### 7.2.4.1 Channel raster

In order to be compatible with current design of sync raster below 3 GHz, the ARFCN parameters below 3000 MHz will be reused and 100 kHz was chosen as the channel raster for NR NTN satellite bands below 3 GHz.

The applicable ARFCNs per operating and for satellite access node are defined in table 7.2.4.1-1.

Table 7.2.4.1-1: ARFCNs per operating band satellite access node

|  |  |  |  |
| --- | --- | --- | --- |
| NTN satellite band # | ΔFRaster  (kHz) | Uplink  range of NREF  (First – <Step size> – Last) | Downlink  range of NREF  (First – <Step size> – Last) |
| n256 | 100 | 396000 – <20> – 402000 | 434000 – <20> – 440000 |
| n255 | 100 | 325300 – <20> – 332100 | 305000 – <20> – 311800 |

#### 7.2.4.2 Sync raster

The applicable SS raster entries per operating band are defined in Table 7.2.4.2-1

Table 7.2.4.2-1: Applicable SS raster entries per operating band

|  |  |  |  |
| --- | --- | --- | --- |
| NTNsatellite band # | SS Block SCS | SS Block pattern | Range of GSCN  (First – <Step size> – Last) |
| n256 | 15 kHz | Case A | 5429 – <1> – 5494 |
| n255 | 15 kHz | Case A | 3818 – <1> – 3892 |
| 30 kHz | Case B | 3824 – <1> – 3886 |

## 7.3 Satellite Access Node requirements

### 7.3.1 General

This section aims to provide some recommendations for the Satellite Access Node RF requirements definition in TS 38.181 [25] and TS 38.108 [26]. The technical justifications which support the requirements definition are also presented in the following sub-clauses.

NTN products are assumed to use AAS BS architecture, with both 1-H and 1-O being included in Release 17 WI. Therefore, both conducted, as well as radiated requirements are required to be considered.

#### 7.3.1.1 SAN class

The requirements in TS 38.108 [26] apply to Satellite Access Node otherwise stated. The associated deployment scenarios are exactly the same for SAN with and without connectors.

For SAN type 1-O and SAN type 1-H, two SAN classes (LEO and GEO) are currently defined in Table 7.3.1.1-1.

Table 7.3.1.1-1: SAN classes

|  |  |
| --- | --- |
| SAN Class | Satellite Constellation |
| GEO class | GEO satellite |
| LEO class | LEO 600 km satellite  LEO 1200 km satellite |

The classification is based on the requirements associated with SAN classes in case-by-case manner including [IoT level/ICS, NF, ACLR/ACS, Emission] requirements. The satellite altitude or orbit type were not identified as part of the class differentiation, and for this reason LEO at 600 km and LEO at 1200 km were grouped together in the same class. At least NF, ACLR and ACS values are the same for LEO 600 km and LEO 1200 km and therefore are not requiring class differentiation. On the other hand, as resulted from the coexistence studies, ACLR requirement values are different between GEO and LEO constellations, requiring a class differentiation. Differences exist as well in terms of emission requirements (e.g. Out-of-band emissions and spurious emissions) between GEO and LEO. At the same time, ACS requirement values from the coexistence studies are the same between GEO and LEO constellations.

### 7.3.2 Transmission characteristics

#### 7.3.2.1 General

Radiated characteristics are defined over the air (OTA), where the radiated interface is referred to as the *Radiated Interface Boundary* (RIB) as shown in Figure 7.3.2.1-1.

Conducted characteristics are defined at individual or groups of *TAB connectors* at the *transceiver array boundary*, which is the conducted interface between the transceiver unit array and the composite antenna. The TAB connector is shown in Figure 7.3.2.1-1.

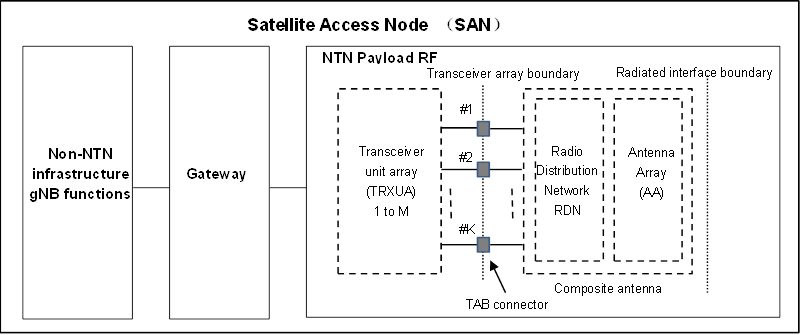


Figure 7.3.2.1-1: Reference point for SAN type 1-H

#### 7.3.2.2 Conducted transmitter requirements

##### 7.3.2.2.1 SAN output power

The SAN conducted output power requirement applies at *TAB connector* for SAN type 1-H.

The *rated carrier output power* of the *SAN type 1-H* shall be as specified in Table 7.3.2.2.1-1.

Table 7.3.2.2.1-1: SAN type 1-H rated output power limits for SAN classes

| SAN class | Prated,c,sys | Prated,c,TABC |
| --- | --- | --- |
| SAN GEO class | (NOTE) | (NOTE) |
| SAN LEO class | (NOTE) | (NOTE) |
| NOTE: Prated,c,sys or Prated,c,TABC of SAN shall be based on manufacture declaration and comply with regulation requirement. | | |

In normal conditions, Pmax,c,TABC shall remain within +2 dB and -2 dB of the *rated carrier output power* Prated,c,TABC for each *TAB connector* as declared by the manufacturer.

In extreme conditions, Pmax,c,TABC shall remain within +2.5 dB and -2.5 dB of *the rated carrier output power* Prated,c,TABC for each *TAB connector* as declared by the manufacturer.

##### 7.3.2.2.2 Output power dynamics

7.3.2.2.2.1 RE power dynamic range

The RE power control dynamic range is the difference between the power of an RE and the average RE power for a SAN at maximum output power for a specified reference condition.

RE power control dynamic range requirement is define in Table 7.3.2.2.2.1-1.

Table 7.3.2.2.2.1-1: RE power control dynamic range

|  |  |  |
| --- | --- | --- |
| Modulation scheme used | RE power control dynamic range (dB) | |
| on the RE | (down) | (up) |
| QPSK (PDCCH) | -6 | +4 |
| QPSK (PDSCH) | -6 | +3 |
| 16QAM (PDSCH) | -3 | +3 |
| NOTE: The output power per carrier shall always be less or equal to the maximum output power of the satellite access node. | | |

7.3.2.2.2.2 Total power dynamic range

Total power dynamic range for SAN will reuse the requirement from TN BS for the same channel bandwidth.

The downlink (DL) total power dynamic range for each carrier shall be larger than or equal to the level in table 7.3.2.2.2.2-1.

Table 7.3.2.2.2.2-1: Total power dynamic range

|  |  |  |  |
| --- | --- | --- | --- |
| SAN channel | Total power dynamic range (dB) | | |
| bandwidth (MHz) | 15 kHz SCS | 30 kHz SCS | 60 kHz SCS |
| 5 | 13.9 | 10.4 | N/A |
| 10 | 17.1 | 13.8 | 10.4 |
| 15 | 18.9 | 15.7 | 12.5 |
| 20 | 20.2 | 17 | 13.8 |

##### 7.3.2.2.3 Transmitted signal quality

7.3.2.2.3.1 Frequency error

For SAN type 1-H, the modulated carrier frequency of each carrier configured by the satellite access node shall be accurate to within 0.05ppm observed over 1 ms.

7.3.2.2.3.2 Modulation quality (EVM)

It is agreed to support QPSK and 16QAM for SAN. 64QAM will be optionally supported based on manufacture declaration.

For SAN type 1-H, the EVM levels of each carrier for different modulation schemes on PDSCH outlined in table 7.3.2.2.3.2-1 shall be met.

Table 7.3.2.2.3.2-1: EVM requirements for *satellite access node type 1-H*

|  |  |
| --- | --- |
| Modulation scheme for PDSCH | Required EVM |
| QPSK | 17.5 % |
| 16QAM | 12.5 % |
| 64QAM1 | 8 % |
| NOTE: Support of 64QAM is based on manufacture declaration | |

##### 7.3.2.2.4 Unwanted emissions

7.3.2.2.4.1 ACLR

Adjacent Channel Leakage power Ratio (ACLR) is the ratio of the filtered mean power centred on the assigned channel frequency to the filtered mean power centred on an adjacent channel frequency.

From *Section 6.5 Summary of co-existence* study (see TR 38.863 related section), it can be observed in *Table 6.5.1-3 Co-existence results suggested ACLR and ACS of NR-NTN* the resulted study value of NTN SAN ACLR:

Table 7.3.2.2.4.1-1: NTN SAN ACLR

|  |  |
| --- | --- |
| NTN LEO class ACLR | 23.81 dB |
| NTN GEO class ACLR | 13.39 dB |

Therefore, the value of 24 dB is the ACLR LEO class limit for the conducted transmitter requirements of SAN as shown in Table 7.3.2.2.4.1-2 and the value 14 dB is the ACLR GEO class limit for the conducted transmitter requirements of SAN as shown in Table 7.3.2.2.4.1-3:

Table 7.3.2.2.4.1-2: Satellite Access Node LEO class ACLR limit

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *SAN channel bandwidth* of *lowest/highest carrier* transmitted BWChannel (MHz) | SAN adjacent channel centre frequency offset below the lowest or above the highest carrier centre frequency transmitted | Assumed adjacent channel carrier (informative) | Filter on the adjacent channel frequency and corresponding filter bandwidth | ACLR limit |
| 5, 10, 15, 20 | BWChannel | NR of same BW2 | Square (BWConfig)1 | 24 dB |
|  | 2 x BWChannel | NR of same BW2 | Square (BWConfig)1 | 24 dB |
| NOTE 1: BWChannel and BWConfig are the *SAN channel bandwidth* and *transmission bandwidth configuration* of the *lowest/highest carrier* transmitted on the assigned channel frequency.  NOTE 2: With SCS that provides largest transmission bandwidth configuration (BWConfig). | | | | |

Table 7.3.2.2.4.1-3: Satellite Access Node GEO class ACLR limit

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *SAN channel bandwidth* of *lowest/highest carrier* transmitted BWChannel (MHz) | SAN adjacent channel centre frequency offset below the lowest or above the highest carrier centre frequency transmitted | Assumed adjacent channel carrier (informative) | Filter on the adjacent channel frequency and corresponding filter bandwidth | ACLR limit |
| 5, 10, 15, 20 | BWChannel | NR of same BW2 | Square (BWConfig) 1 | 14 dB |
|  | 2 x BWChannel | NR of same BW2 | Square (BWConfig) 1 | 14 dB |
| NOTE 1: BWChannel and BWConfig are the *SAN channel bandwidth* and *transmission bandwidth configuration* of the *lowest/highest carrier* transmitted on the assigned channel frequency.  NOTE 2: With SCS that provides largest transmission bandwidth configuration (BWConfig). | | | | |

7.3.2.2.4.2 Out-of-band emissions

The SAN out-of-band emissions requirements for GEO and LEO classes are therefore defined as described in Table 7.3.2.2.4.2-1.

Table 7.3.2.2.4.2-1: SAN out-of-band emissions basic limits

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency offset of measurement filter ‑3dB point, Δf | Frequency offset of measurement filter centre frequency, f\_offset | *Basic limits*  dBm | *Measurement bandwidth* |
| 0 MHz ≤ Δf < 2\* BWChannel | 0.002 MHz ≤ f\_offset < 2× BWChannel + 0.002 MHz |  | 4kHz |
| NOTE 1: PSDchannel = Prated,c,sys – 10log10(BWChannel) – 24, unit dBm/4kHz.  NOTE 2: SE limit is spurious emission limit specified in spurious emission clause.  NOTE 3: PSD attenuation as in Recommendation ITU-R SM.1541-6[29], Annex 5 OoB domain emission limits for space services.  NOTE 4: =0 dB for GEO class and =3 dB for LEO class. | | | |

Recommendation ITU-R SM.1541-6 [29] specifies the OoB mask requirements. The OoB domain emission as attached Annex 5 should be attenuated below the maximum psd by the following and the attenuation can’t be greater than the spurious emission limit.

The OoB domain emissions of a station operating in the bands allocated to the FSS and MSS should be attenuated below the maximum psd, in a reference bandwidth of 4 kHz (for systems operating above 15 GHz a reference bandwidth of 1 MHz may be used in place of 4 kHz) within the necessary bandwidth, by the following:



where F is the frequency offset from the edge of the total assigned band, expressed as a percentage of necessary bandwidth. It is noted that the OoB emission domain starts at the edges of the total assigned band.

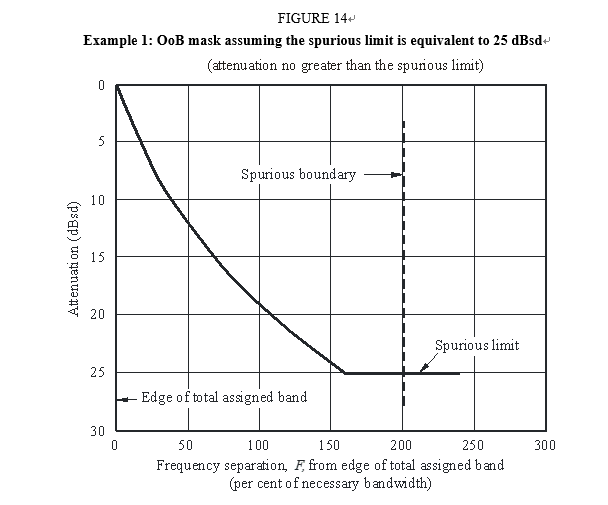


Figure 7.3.2.2.4.2-1: Example of OoB mask assuming the spurious limit is equivalent to 25 dBsd

The “F” = Frequency offset / channel bandwidth × 100 can be get as above. Thus, the OoB mask requirements can be specified as below based on the ITU regulation when we use f\_offset and BWchannel to replace “F”.

##### 7.3.2.2.5 Transmitter spurious emission

Transmitter basic limits for spurious emissions are presented in Table 7.3.2.2.5-1.

Table 7.3.2.2.5-1: SAN transmitter spurious emission limits

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Spurious frequency range | Basic limit GEO class (dBm) | Basic limit LEO class (dBm) | Measurement bandwidth | Notes |
| 30 MHz – 5th harmonic  (NOTE 2, 4, 5) | When Prated,c,sys ≤ 47dBm :  -13  When Prated,c,sys > 47dBm :  Prated,c,sys-60  (NOTE 3) | | 4 kHz  (NOTE 1) | See NOTES 1, 2, 3, 4 ,5 |
| NOTE 1: Measurement bandwidths as in Recommendation ITU-R SM.329 [30], s4.1.  NOTE 2: Lower and Upper frequency as in Recommendation ITU-R SM.329 [30], s2.5, Table 1. Applies only for the fundamental frequency range 600 MHz - 5.2 GHz (e.g. for n255 and n256 frequency bands).  NOTE 3: Values as in Recommendation ITU-R SM.329 [30], Table 10.  NOTE 4: Lower frequency limit is replaced by 0.7 times the waveguide cut-off frequency, according to ITU-R SM.329-12[30], for systems having an integral antenna incorporating a waveguide section, or with an antenna connection in such form, and of unperturbed length equal to at least twice the cut-off  NOTE 5: This spurious frequency range applies only to SAN type 1-H. | | | | |

Recommendation ITU-R SM.329 [30] defines Unwanted emissions in the spurious domain. Measurement bandwidth is listed in section 4.1, lower and upper frequencies are specified in the Table 1 of section 2.5 and the values are taken from the table 10.

#### 7.3.2.3 Radiated transmitter requirements

##### 7.3.2.3.1 Reserved

##### 7.3.2.3.2 Reserved

##### 7.3.2.3.3 Reserved

##### 7.3.2.3.4 Reserved

##### 7.3.2.3.5 Reserved

##### 7.3.2.3.6 Reserved

##### 7.3.2.3.7 Reserved

7.3.2.3.7.1 Reserved

7.3.2.3.7.2 Reserved

7.3.2.3.7.3 OTA Adjacent Channel Leakage Power Ratio (ACLR)

7.3.2.3.7.3.1 General

OTA Adjacent Channel Leakage power Ratio (ACLR) is the ratio of the filtered mean power centred on the assigned channel frequency to the filtered mean power centred on an adjacent channel frequency. The measured power is TRP.

7.3.2.3.7.3.2 Minimum requirement for SAN type 1-O

The OTA ACLR limit requirement for SAN type 1-O is the same as the ACLR limit defined in *Section 7.3.2.2.4.1 ACLR* of TR 38.863. For the OTA SAN ACLR limit refer to Table 7.3.2.2.4.1-2: Satellite Access Node ACLR limit.

The OTA SAN ACLR absolute basic limit from Table 7.3.2.2.4.1-3: SAN ACLR absolute basic limit does not apply to SAN type 1-O.

7.3.2.3.7.3.3 Minimum requirement for SAN type 2-O

This requirement is not applicable in Release 17.

### 7.3.3 Receiver characteristics

#### 7.3.3.1 General

For Rx requirements, the TAB connector is located in the satellite payload, while the throughput measurement is done in the “non-NTN infrastructure gNB”, as shown in the Figure 7.3.3.1-1 for reference sensitivity requirement.[18][19]

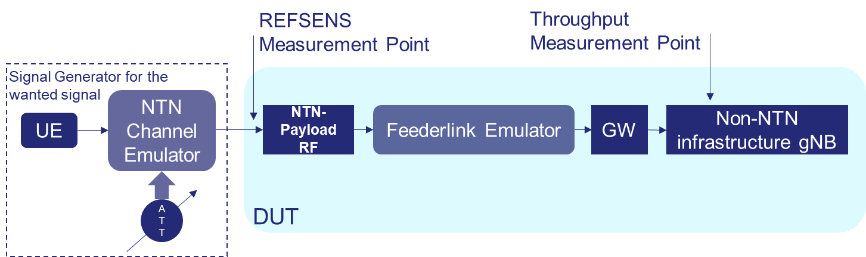


Figure 7.3.3.1-1: Reference points for mmeasurement of Rx requirements

The FRCs specified in TS 38.104[16] shall be re-used to specify the satellite access node Rx requirements. Further revisit is not precluded if the spectrum utilization (SU) would be different.

For derivation of the Rx requirements, the following assumptions were made:

- The FRCs specified in TS 38.104 [16] for NR BS were re-used to specify the NTN SAN Rx requirements.

- The Implementation Margin (IM) value was assumed to be 2 dB for NTN SAN.

- The following Noise Figure (NF) values were used for the derivation of Rx requirements for NTN SAN:

Table 7.3.3.1-1: NF values for NTN SAN requirements derivation

|  |  |  |  |
| --- | --- | --- | --- |
|  | GEO | LEO 600 | LEO 1200 |
| G/T (dB K-1) | 19 | 1.1 | 1.1 |
| G\_Rx (dBi) | 51 | 30 | 30 |
| NF (dB) | 7.4 | 4.3 | 4.3 |

#### 7.3.3.2 Conducted receiver characteristics

##### 7.3.3.2.1 Reference sensitivity level

The following equation was used to derive the reference sensitivity for NTN SAN requirement development, reusing the same methodology for the reference sensitivity derivation as done for the NR BS, as captured in TR 38.817-02 [31]:

PREFSENS = -174 dBm/Hz + 10 \* log10 BW + NF + IM + SNR [dBm]

Where:

- BW is the maximum transmission bandwidth,

- NF is noise figure of NTN SAN receiver in dB,

- IM is implementation margin reserved for NTN SAN manufacturer in dB;

- SNR is the value to satisfy the 95% throughput of the FRC channel.

##### 7.3.3.2.2 Dynamic range

The Rx dynamic range is specified as a measure of the capability of the receiver to receive a wanted signal in the presence of an interfering signal at the TAB connector for SAN type 1-H inside the received SAN channel bandwidth. In this condition, a throughput requirement shall be met for a specified reference measurement channel. As the Rx dynamic range requirement measures the effects of NTN SAN receiver’s impairments, the uncertainty due to the receiver’s own thermal noise floor should be minimized. Therefore, the interference level should be increased by a certain amount of margin to mask the receiver’s own noise floor, represented by Interference over Thermal (IoT).

In order to define the dynamic range requirement, both wanted and interfering signal power levels need to be defined. The mean power levels of interfering and the wanted signals were defined in the following method:

PIntf = -174 dBm/Hz + 10 \* log10(NRB \* SCS \* 12) + NF + IoT

Pwanted = -174 dBm/Hz + 10 \* log10(NRB \* SCS \* 12) + NF + IoT + SNR + IM

Where:

- NRB is the transmission bandwidth configuration of the lowest SCS defined for SAN for each *BS channel bandwidth*;

- SCS is the lowest sub-carrier spacing defined for SAN for each *BS channel bandwidth*;

- NF is noise figure of SAN receiver in dB as defined in table 6.2.2.1-5,

- IoT: during the discussion various values of the IoT were considered for the definition of the dynamic range requirement. In case of LEO600, IoT values in range of 15-18 dB were collected based on the simulation results. In case of LEO1200, IoT values in range of 10-15 dB were collected based on the simulation results, as captured in annex D.

- SNR is the value to satisfy the 95% throughput of measurement channel. As the derivation methodology and the FRC’s from the NR BS was reused, more details on the SNR simulation results can be found in TR 38.817-02 [31];

- IM is implementation margin reserved for SAN manufacturer in dB. The IM values was reused from the NR BS as 2 dB;

For SAN it was agreed to define a single dynamic range requirement for LEO SAN (both 600 and 1200) based on the IoT value of 15 dB. Based on the collected simulation results for NTN scenarios, it was decided not to define dynamic rage requirement for SAN GEO class.

The interfering signal for the dynamic range requirement was defined as AWGN signal, same as for NR BS requirements.

##### 7.3.3.2.3 In-band selectivity and blocking

7.3.3.2.3.1 Adjacent Channel Selectivity (ACS)

7.3.3.2.3.1.1 General

Adjacent channel selectivity (ACS) is a measure of the receiver’s ability to receive a wanted signal at its assigned channel frequency at the *antenna connector* for *NTN Satellite Access Node (SAN)* in the presence of an adjacent channel signal with a specified centre frequency offset of the interfering signal to the band edge of a victim system.

The ACS value is coming from coexistence analysis. A worst case value of 38 dB ACS is found in GEO case and the interfering signal mean power (dBm) is computed given a NF 7.4 dB for a 5 MHz band.

It is worth noting that OFDM is considered as interfering waveform (rather than DFT-s-OFDM) corresponding to a coexistence scenario 6 for the MSS S-band where TN BS DL is interfering with SAN UL.

7.3.3.2.3.1.2 Minimum requirements for Satellite Access Node

The throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel.

For SAN, the wanted and the interfering signal coupled to the *antenna connector* are specified in table 7.3.3.2.3.1.2-1 and table 7.3.3.2.3.1.2-2 and the frequency offset between the wanted and interfering signal in table 7.3.3.2.3.1.2-3 for ACS.

The ACS requirement is applicable outside the *SAN RF Bandwidth* or *Radio Bandwidth*. The interfering signal offset is defined relative to the *SAN RF Bandwidth* edges or *Radio Bandwidth* edges.

Minimum conducted requirement is defined at the *antenna connector.*

Table 7.3.3.2.3.1.2-1: SAN GEO class ACS requirement

|  |  |  |
| --- | --- | --- |
| *SAN channel bandwidth* of the lowest/*highest carrier* received (MHz) | Wanted signal mean power (dBm) | Interfering signal mean power (dBm) |
| 5, 10, 15, 20 (NOTE 1) | PREFSENS + 6 dB | -57 |
| NOTE 1: The SCS for the lowest/highest carrier received is the lowest SCS supported by the SAN for that bandwidth.  NOTE 2: For SAN, PREFSENS depends on the *SAN channel bandwidth*. | | |

Table 7.3.3.2.3.1.2-2: SAN LEO class ACS requirement

|  |  |  |
| --- | --- | --- |
| *SAN channel bandwidth* of the lowest/*highest carrier* received (MHz) | Wanted signal mean power (dBm) | Interfering signal mean power (dBm) |
| 5, 10, 15, 20 (NOTE 1) | PREFSENS + 6 dB | -60 |
| NOTE 1: The SCS for the lowest/highest carrier received is the lowest SCS supported by the SAN for that bandwidth.  NOTE 2: For SAN, PREFSENS depends on the *SAN channel bandwidth*. | | |

The wanted signal and interfering signal power level are calculated in the following way in FR1:

Wanted signal power level = REFSENS + 6 dB

Interfering signal power level = SAN noise floor + ACS + 4.7dB = ‑174 dBm/Hz+10\*log10(BW) + NF + ACS + 4.7 dB

Where:

- BW is wanted signal bandwidth in Hz, e.g. 25 PRB for 5 MHz SCS 15 kHz;

- NF is noise figure which is agreed as 7.4 dB for GEO, 4.3 dB for LEO@600, 4.3 dB for LEO@1200;

- SAN ACS is agreed as 38 dBc (more precisely according to coexistence Scenario 6, it has been noticed from the coexistence simulations that the required SAN ACS is in the order of 38 dBc ACS);

- 4.7 dB is calculated from 10log10(10^(6/10)-1).

If the equation considers the worst case of 38 dB ACS, with NF of 7.4 dB for GEO class and NF of 4.3 dB for LEO class, for 5 MHz signal bandwidth (as for TS 38.104[16]), the interfering signal mean power level is:

-174+10\*log10(**5\***10^6)+7.4+38+4.7=**-57dBm** for GEO class, according to the interfering signal mean power value from Table 7.4.1.2-1**.**

-174+10\*log10(**5\***10^6)+4.3+38+4.7=**-60dBm** for LEO class,according to the interfering signal mean power value from Table 7.4.1.2-2**.**

Table 7.3.3.2.3.1.2-3: SAN ACS interferer frequency offset values

|  |  |  |
| --- | --- | --- |
| *SAN channel bandwidth* of the *lowest/highest carrier* received (MHz) | Interfering signal centre frequency offset from the lower/upper *SAN RF Bandwidth edge* or *sub-block* edge inside a *sub-block gap* (MHz) | Type of interfering signal |
| 5 | ±2.5025 |  |
| 10 | ±2.5075 | 5 MHz OFDM NR signal |
| 15 | ±2.5125 | 15 kHz SCS, 25 RBs |
| 20 | ±2.5025 |  |

7.3.3.2.3.2 In-band blocking

No In-band blocker is considered for SAN.

##### 7.3.3.2.4 Out-of-band blocking

7.3.3.2.4.1 General

The out-of-band blocking characteristics is a measure of the receiver ability to receive a wanted signal at its assigned channel at the *TAB connector* for *SAN type 1-H* in the presence of an unwanted interferer out of the *operating band*, which is a CW signal for out-of-band blocking.

Uplink Satellite IMT

3G/Mobile

MSS Reg2

MSS North-Am

MSS North-Am

MSS Reg2

Downlink Satellite IMT

Terrestrial IMT

downlink

Space Ops (TC)

Space Ops (TM)

Terrestrial IMT

uplink

1920

1980

2000

2010

2020

2025

2110

2160

2170

2180

2200

Figure 7.3.3.2.4.1-1: Band of concern to determine OOB blocking

The identified worst case is for the band n256 with the SpaceOps TC (TeleCommand) band between 2025 and 2110 MHz. This band is used to send commands to the satellite platform, taking into account the fact that a very robust radio link is established. To do so, the maximum EIRP of SpaceOps (Space Operations) TC (TeleCommand) stations is 80 dBW.

For a LEO satellite at 600 km (LEO@600km), in a worst case scenario (i.e. SpaceOps TC station at satellite Nadir), the free space losses are 154 dB.

Therefore, the signal level at satellite level is -44 dBm.

7.3.3.2.4.2 Minimum requirements for Satellite Access Node

The throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel, with a wanted and an interfering signal coupled to *SAN type 1-H* *TAB connector* using the parameters in table 7.3.3.2.4.2-1.

The out-of-band blocking requirement apply from 1 MHz to FUL,low – ΔfOOB and from FUL,high + ΔfOOB up to 12750 MHz, including the downlink frequency range of the FDD *operating band*.

Minimum conducted requirement is defined at the *antenna connector* at the *TAB connector* for *SAN type 1-H.*

Table 7.3.3.2.4.2-1: Out-of-band blocking performance requirement for NR

|  |  |  |
| --- | --- | --- |
| Wanted Signal mean power (dBm) | Interfering Signal mean power (dBm) | Type of Interfering Signal |
| PREFSENS +6 dB (NOTE) | -44 | CW carrier |
| NOTE: PREFSENS depends on the RAT. For NR, PREFSENS depends also on the *SAN channel bandwidth*. | | |

##### 7.3.3.2.5 Receiver spurious emissions

The requirement is not applicable in this version of the specification.

##### 7.3.3.2.6 Receiver intermodulation

The requirement is not applicable in this version of the specification.

##### 7.3.3.2.7 In-channel selectivity

The requirement framework from terrestrial network (TN) NR specification is agreed to be reused.

#### 7.3.3.3 Radiated receiver characteristics

##### 7.3.3.3.1 OTA sensitivity

On the same principle as for the NR TN BS Specification TS 38.104[16], the SAN OTA sensitivity testing procedure should be based on SAN manufacturer declarations of sensitivity direction and EIS level.

##### 7.3.3.3.2 OTA reference sensitivity level

OTA reference sensitivity level is a directional requirement specified as an EIS level. On the same principle as for the NR TN BS specification TS38.104[16], the SAN OTA reference sensitivity EISREFSENS requirements should be derived from:

- the conducted reference sensitivity PREFSENS which can be calculated based on the formula presented in Section 7.3.3.2.1;

- a hypothetical antenna gain of a passive satellite antenna;

- some implementation margin reserved for the NTN SAN manufacturer.

The last two contributions are both taken into account under ΔOTAREFSENS parameter.

As OTA reference sensitivity is used as a reference for many of the interference requirements where it is important that the interferer is polarization matched to the receiver antenna it is also important that the wanted signal is polarization matched. Hence OTA reference sensitivity is specifically declared per polarization and the EIS values are under the assumption of *polarization match*.

For SAN type 1-O, OTA reference sensitivity is intended to provide equivalent protection and performance as the conducted reference sensitivity level. The OTA reference sensitivity level is calculated based on the conducted reference sensitivity level for SAN type 1-H and antenna gain of a passive antenna which would be used with a non-AAS SAN in the same deployment scenario.

##### 7.3.3.3.3 OTA dynamic range

The requirement assumes that the wanted signal and interfering signal come from the same direction. And since both wanted signal and AWGN will be transmitted from the test equipment in the same direction, the same combining gain will be achieved for both wanted signal and the AWGN. Hence, the OTA dynamic range for FR1 can be defined based on conductive requirements plus an offset, i.e., ΔOTAREFSENS.

##### 7.3.3.3.4 OTA in-band selectivity and blocking

7.3.3.3.4.1 OTA adjacent channel selectivity

OTA Adjacent channel selectivity (ACS) is a measure of the receiver’s ability to receive an OTA wanted signal at its assigned channel frequency in the presence of an OTA adjacent channel signal with a specified centre frequency offset of the interfering signal to the band edge of a victim system. For SAN type 1-O, interfering signal mean power should be offset by the value ΔminSENS, other parameters could be reused from SAN type 1-H and respective ACS clause.

##### 7.3.3.3.5 OTA out-of-band blocking

7.3.3.3.5.1 General

The OTA out-of-band blocking characteristics are a measure of the receiver unit ability to receive a wanted signal at the *RIB* at its assigned channel in the presence of an unwanted interferer.

7.3.3.3.5.2 Minimum requirement for SAN type 1-O

7.3.3.3.5.2.1 General minimum requirement

The requirement shall apply at the RIBwhen the AoA of the incident wave of the received signal and the interfering signal are from the same direction and are within the *minSENS RoAoA*.

The wanted signal applies to each supported polarization, under the assumption of *polarization match.* The interferer shall be *polarization matched* in-band and the polarization maintained for out-of-band frequencies.

The values for the minimum requirements have been obtained with the hypothesis from section 7.3.3.2.4 Out-of-band blocking, considering the maximum EIRP of SpaceOps (Space Operations) TC (TeleCommand) stations of 80 dBW, and the interfering signal mean power of -44 dBm, for a LEO satellite at 600 km of altitude (LEO@600km).

For OTA wanted and OTA interfering signals provided at the RIB using the parameters in table 7.3.5.6.2.1-1, the following requirements shall be met:

- The throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel.

For *SAN type 1-O* the OTA out-of-band blocking requirement apply from 30 MHz to FUL,low – ΔfOOB and from FUL,high + ΔfOOB up to 12750 MHz, including the downlink frequency range of the FDD operating band.

Table 7.3.3.3.5.2.1-1: OTA out-of-band blocking performance requirement

|  |  |  |
| --- | --- | --- |
| Wanted signal mean power (dBm) | Interfering signal RMS field-strength (V/m) | Type of interfering Signal |
| EISminSENS + 6 dB  (NOTE 1) | 0.091 | CW carrier |
| NOTE 1: EISminSENS depends on the *channel bandwidth*.  NOTE 2: The RMS field-strength level in V/m is related to the interferer EIRP level at a distance described as , where EIRP is in W and r is in m. | | |

7.3.3.3.5.2.2 Co-location minimum requirement

This requirement is not applicable in Release 17.

##### 7.3.3.3.6 OTA receiver spurious emissions

The requirement is not applicable in this version of the specification.

##### 7.3.3.3.7 OTA receiver intermodulation

This requirement is not applicable in Release 17.

##### 7.3.3.3.8 OTA in-channel selectivity

For SAN type 1-O, power level of wanted signal and interfering signal should be offset by the value ΔminSENS. Other parameters could be reused from SAN type 1-H and respective in-channel selectivity (ICS) clause.

### 7.3.4 Others

[To be updated]

## 7.4 NTN UE requirements

### 7.4.1 General

In general, NTN UE products are assumed to meet TN UE requirements as specified in TS 38.101-1[17]. The structure and content of the NTN UE specification TS 38.101-5 should be based on TS 38.101-1[17]. The development of TS 38.101-5 should follow the set of conditions that were agreed at the RAN#94e meeting in RP-213618[27].

### 7.4.2 UE Transmission characteristics for satellite access

#### 7.4.2.1 General

Unless otherwise stated, the transmitter characteristics are specified at the antenna connector of the UE with a single or multiple transmit antenna(s). For UE with integral antenna only, a reference antenna with a gain of 0dBi is assumed. Handheld PC3 UE is assumed in Release 17 for satellite access.

#### 7.4.2.2 Conducted transmitter characteristics

##### 7.4.2.2.1 Maximum output power

The following UE Power Classes define the maximum output power for any transmission bandwidth within the channel bandwidth of NR carrier unless otherwise stated. The period of measurement shall be at least one sub frame (1ms).

Table 7.4.2.2.1-1: UE Power Class

|  |  |  |
| --- | --- | --- |
| NTN satellite band # | Class 3 (dBm) | Tolerance (dB) |
| n256 | 23 | ±2 |
| n255 | 23 | +2 |
| NOTE 1: PPowerClass is the maximum UE power specified without taking into account the tolerance  NOTE 2: Power class 3 is default power class unless otherwise stated | | |

##### 7.4.2.2.2 MPR/AMPR

7.4.2.2.2.1 MPR

UE is allowed to reduce the maximum output power (MPR) due to higher order modulations and transmit bandwidth configurations to meet the general transmission requirements which includes in-band emission, ACLR, out-of-band emission and general spurious emission. As it was agreed those general transmission requirements can be reused from TN, the same requirements specified in Table 6.2.2-1 in TS 38.101-1 [17] can be reused for NTN satellite access UEs.

7.4.2.2.2.2 A-MPR

A-MPR is band specific requirement which is used to meet the additional requirements indicated by network signalling (NS) value.

For n256, based on the regulation conclusion in section 5.2, the A-MPR requirements for n65 could be as starting point. From TS 38.101-1, since the maximum carrier centre frequency of NS\_05 and NS\_05U is lower than 1960 MHz and the maximum carrier centre frequency of NS\_51 is lower than 1980 MHz, it is proposed NS\_05, NS\_05U and NS\_51 don’t need to be considered for n256. The requirements of NS\_01, NS\_24 and NS\_100 specified in Table 6.2.3.1-1 in TS 38.101-1 [17] for band n65 can be reused for n256

For n255, based on regulatory requirements, a new NS is required. The following observations were made from the measurement results using an LTE modem and transceiver supporting 1626.5 – 1656.5 MHz:

- For 5 MHz channel, PA emissions for DFT-s-OFDM are below the spurious emission limits between 1559 and 1606 MHz.

- For 10 MHz channel, PA emissions for DFT-s-OFDM are exceeding the spurious emission limits for 1 MHz MBW by 5 dB between 1604 and 1606 MHz.

- For 15 MHz channel, PA emissions for DFT-s-OFDM are exceeding the spurious emission limits for 1 MHz MBW by 9 dB between 1599 and 1606 MHz.

- For 20 MHz channel, PA emissions for DFT-s-OFDM are exceeding the spurious emission limits by 9 dB between 1584 and 1606 MHz.

- For 700 Hz MBW, PA emissions for all channel bandwidths are below the spurious emission limits between 1559 and 1606 MHz.

A n255 duplexer with rejection of more than 10 dB will be a sufficient to satisfy the spurious emission limits specified in Table 7.4.2.2.8-1.

Based on this measurement observations, the expected filter attenuation of more than 10 dB below 1610 MHz is going to be adequate to meet the additional emissions requirements between 1559 – 1610 MHz, and therefore, no A-MPR needs to be specified for n255.

In view of the above, the additional requirements with their associated network signalling values and the allowed A-MPR and applicable operating band(s) for each NS value shall be specified in Table 7.4.2.2.2.2-1 and the mapping of NR satellite band numbers and values of the *additionalSpectrumEmission* to network signalling labels is specified in Table 7.4.2.2.2.2-1A.

Table 7.4.2.2.2.2-1: Additional maximum power reduction (A-MPR)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Network signalling label | Requirements (clause) | NR satellite Band | Channel bandwidth (MHz) | Resources blocks (*N*RB) | A-MPR (dB) |
| NS\_01 |  | Table 5.2.1-1 | 5, 10, 15, 20 | Table 5.3.2-1 in TS 38.101-1 | N/A |
| NS\_24 | 6.5.3.3.13 in TS 38.101-1 | n256 | 5, 10, 15, 20 | Table 6.2.3.15-1 in TS 38.101-1 | Clause 6.2.3.7 in TS 38.101-12 |
| NS\_57N | 6.5.3.3.1 | n255 | 5, 10, 15, 20 |  | N/A |
| NS\_100 | 6.5.2.4.2 in TS 38.101-1 | n2561 |  |  | Table  6.2.3.1-2 in TS 38.101-1 |
| NOTE 1: This NS can be signalled for NTN satellite bands that have UTRA services deployed.  NOTE 2: A-MPR for the upper 5 MHz is not specified, and therefore shall be used as a guard band. | | | | | |

Table 7.4.2.2.2.2-1A: Mapping of network signalling label

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| NTN satellite band | Value of additionalSpectrumEmission | | | | | | | |
|  | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| n256 | NS\_01 | NS\_24 | NS\_100 |  |  |  |  |  |
| n255 | NS\_01 | NS\_57N |  |  |  |  |  |  |
| NOTE: *additionalSpectrumEmission* corresponds to an information element of the same name defined in clause 6.3.2 of TS 38.331. | | | | | | | | |

For n256, FFS for how to protect n2, n25, n70 and whether A-MPR required.

##### 7.4.2.2.3 Output power dynamics

For Transmit OFF power and Power control, the framework and requirements for existing TN UE can be reused for satellite UE. The transmit OFF power is -50 dBm for 20MHz.

Since handheld UE always transmits the maximum output power for satellite access scenario based on the NR NTN calibration summary in R4-2115628, FFS whether relaxed value needed or not based on existing TN UE requirements

##### 7.4.2.2.4 Frequency error

The UE basic measurement interval of modulated carrier frequency is 1 UL slot. The mean value of basic measurements of UE modulated carrier frequency shall be accurate to within ± 0.1 PPM observed over a period of 1 ms of cumulated measurement intervals compared to the carrier frequency received from the Satellite Access Node.

NOTE: The requirements is applicable only when PVT ephemeris updated at least once [10] seconds.

##### 7.4.2.2.5 Transmit modulation quality

For the EVM (Error Vector Magnitude), the same requirements specified in TS 38.101-1 [17] sub-clause 6.4.2.1 for QPSK, 16QAM, and 64QAM can be reused for NTN satellite access UEs. NTN satellite access UEs support UL/DL 64QAM for NTN operation as optional with per band.

For the carrier leakage, the same requirements specified in TS 3.101-1 [17] sub-clause 6.4.2.2 can be reused for NTN satellite access UEs.

For the in-band emission, the same requirements specified in TS 3.101-1 [17] sub-clause 6.4.2.3 can be reused for NTN satellite access UEs.

##### 7.4.2.2.6 Spectrum emission mask

For SEM of NTN satellite access UEs, the same requirements of TN UE specified in TS 38.101-1 [17] sub-clause 6.5.2.2 can be reused.

##### 7.4.2.2.7 ACLR

For ACLR, the same ACLR for TN NR UE which is specified in TS 3.101-1 [17] sub-clause 6.5.2.4.1 can be applied for NTN satellite access UEs.

The requirement of ALCR is specified in Table 7.4.2.2.7-1.

Table 7.4.2.2.7-1: NTN satellite access UE ACLR requirement

|  |  |
| --- | --- |
|  | Power class 3 |
| NTN UE ALCR | 30dB |

##### 7.4.2.2.8 Spurious emissions

The spurious emissions limits specified in TS 38.101-1[17] sub-clause 6.5.3 would also be applicable to NTN satellite access UEs referring to the ERC Recommendation 74-01[28] Annex 3 item 3.1.4 for Mobile Earth Stations (MES) (see Note 1bis) transmitting in the Mobile Satellite Service between 1 GHz and 3 GHz.

Considering FCC rule 47 C.F.R § 25.216 (h) [23], TN UE’s general spurious emission requirements will be inadequate for L-band NTN satellite UE operation in the US. A new NS value and a subclause with Table 7.4.2.2.8-1 needs to be specified for n255 for NTN satellite operations in the US.

Table 7.4.2.2.8-1: Additional requirements for NS\_57N

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency band  (MHz) | Channel bandwidth / Spectrum emission limit1 (dBW) | Measurement bandwidth | NOTE |
| 5 MHz, 10 MHz, 15 MHz, 20 MHz |
| 1559≤ f ≤ 1605 | -80 | 700 Hz | Averaged over any 2 millisecond active transmission interval |
| 1605≤ f ≤ 1610 | -80 + 24/5 (f-1605) | 700Hz |  |
| 1559 ≤ f ≤ 1605 | -70 | 1MHz | Averaged over any 2 millisecond active transmission interval |
| 1605≤ f ≤ 1610 | -70 + 24/5 (f-1605) | 1MHz |  |
| NOTE 1: The EIRP requirement in regulation is converted to conducted requirement using a 0 dBi antenna. | | | |

##### 7.4.2.2.9 Transmit intermodulation

The transmit intermodulation limits specified in TS 38.101-1[17] sub-clause 6.5.4 (Table 7.4.2.2.9-1) would also be applicable to NTN satellite access UEs.

The requirement of transmit intermodulation is specified in Table 7.4.2.2.9-1.

Table 7.4.2.2.9-1: Transmit Intermodulation

|  |  |  |
| --- | --- | --- |
| Wanted signal  channel bandwidth | BWChannel | |
| Interference signal  frequency offset from channel center | BWChannel | 2\*BWChannel |
| Interference CW signal level | -40 dBc | |
| Intermodulation product | < -29 dBc | < -35 dBc |
| Measurement bandwidth | The maximum transmission bandwidth configuration among the different SCS's for the channel BW as defined in Table 6.5.2.4.1-1 from TS 38.101-1[17] | |
| Measurement offset from channel center | BWChannel and 2\*BWChannel | 2\*BWChannel and 4\*BWChannel |

##### 7.4.2.2.10 UE to UE coexistence issues between NTN and TN

In recent RAN4#102 and RAN4#103 meetings, the spurious emissions requirements (-50dBm/MHz) for protected bands UE co-existence (especially for band n256 UL: 1980~2010MHz DL: 2170~2200MHz) were widely discussed. The adjacent/overlapping TN bands to NTN band n256 are shown in Figure 5.2.1-1.

1) Coexistence protection for band n34 DL

The NS\_24 including associated A-MPR value as specified in TS 38.101-1[17] is reused to solve this issue in Release 17. However, other companies pointed out the n256 UL frequency range can’t be leveraged due to 5MHz guard band at the upper of n256 UL frequency range to protect band n34.If NS\_24 is used, n256 will be reduced due to the 5 MHz guard band that has been considered with NS\_24, frequency range 2005-2010 MHz can not be used anymore. Besides, when NS\_24 is indicated to protect the DL frequency range of band n34, satellite UE has to reduce the out power in band n256. It will lead to UL throughput loss and even UL radio link failure for some UL RB configurations.

2) Coexistence protection for band n39 DL

-50dBm/MHz co-existence requirement can be met considering 20MHz channel bandwidth for band n256 without A-MPR requirement, even if a band n65 duplexer is reused for band n256.

Based on extrapolating the SEM mask to the ACLR4 region which overlaps n39 for the lowest n256 20MHz channel it is feasible to specify -50dBm/MHz protection level for n39 by n256 even when using n65 duplexer (no filter help assumed). This assumes the maximum n256 bandwidth is 20MHz.

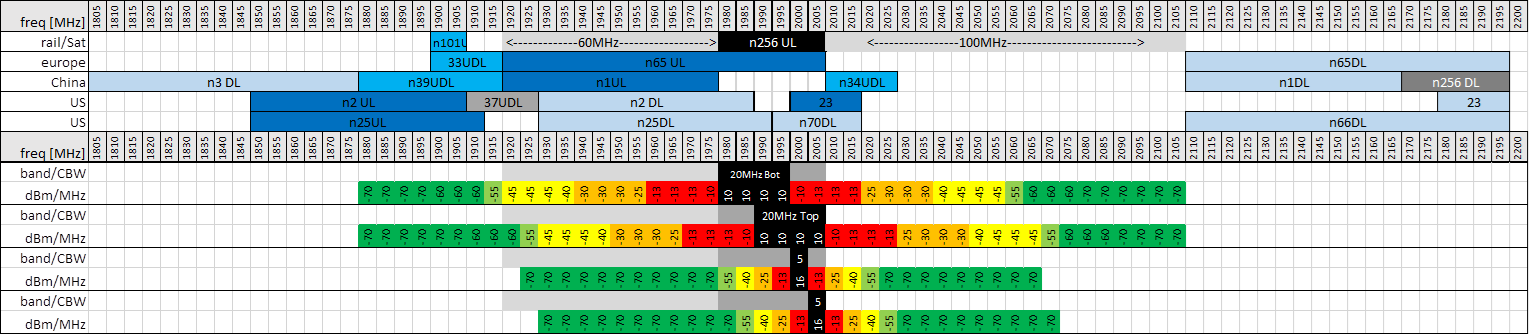


Figure 7.4.2.2.10-1: Coexistence analysis based on SEM mask extension for band n256

3) Coexistence protection for band n2, n25, n70 DL

From RAN4 perspective, UE co-existence requirements can’t be fulfilled (-50dBm/MHz) for the TN bands (i.e., n2, n25 and n70) which are overlapping n256. In Release 17, it is RAN4 understanding that the co-existence issue between n256 and those TN bands shall rely on regional or national regulation.

**Other proposals:**

Other proposals were submitted to solve the UE to UE coexistence issues between NTN and TN especially for the protected DL frequency range which is overlapping with UL frequency range of band n256 or next to the edge of band n256 UL filter.

For example:

- Isolation regions could be defined between NTN and TN coverage. And a corresponding signaling could be designed by RAN2.

- Before transmitting UL band n256 signals, satellite UE should determine (or be informed) whether the IMT services exist for the protected DL frequency range in the vicinity.

- Other potential mechanisms/solutions are not precluded.

Considering these proposals will have impacts on RAN1/RAN2 specifications, these proposals were not further discussed in Release 17.

#### 7.4.2.3 “Reserved” (for Radiated transmitter Characteristics)

### 7.4.3 UE Receiver characteristics for satellite access

#### 7.4.3.1 General

Unless otherwise stated the receiver characteristics are specified at the antenna connector(s) of the UE. For UE(s) with an integral antenna only, a reference antenna(s) with a gain of 0 dBi is assumed for each antenna port(s). UE with an integral antenna(s) may be taken into account by converting these power levels into field strength requirements, assuming a 0 dBi gain antenna. For UEs with more than one receiver antenna connector, identical interfering signals shall be applied to each receiver antenna port if more than one of these is used (diversity).

#### 7.4.3.2 Conducted receiver characteristics

##### 7.4.3.2.1 General and diversity characteristics

Unless otherwise stated the receiver characteristics are specified at the antenna connector(s) of the UE for satellite access.

The handheld UE for satellite access is required to be equipped with a minimum of two Rx antenna ports in all NTN satellite operating bands in FR1.

##### 7.4.3.2.2 Reference sensitivity

The reference sensitivity power level REFSENS is the minimum mean power applied to each one of the UE antenna ports for all UE categories, at which the throughput shall meet or exceed the requirements for the specified reference measurement channel. For below 6GHz, the REFSENS level can be calculated by the equation below in TR 38.817-01[32]:

Sensitivity = -174dBm(kT) + 10\*log(RX BW) + NF + SNR +IM – diversity gain

It is noted that the Rx BW is identical to the transmission bandwidth configuration, which is determined by the spectrum utilization. The RB values in the analysis of this contribution are based on the agreed SU for NR.

SNR in Nagoya meeting was agreed as -1dB for NR.

The REFSENS for E-UTRA assumes that the receiver is equipped with two Rx port as a baseline. If 2Rx is considered, the diversity gain is 3dB and the Implementation Margin (IM) uses 2.5dB. In the following calculation, same assumptions are used for NR NTN satellite bands.

For band n255, 9dB noise figure is assumed which is aligned with band n24.

Both dedicate 30MHz duplexer and n65 duplexer are allowed to be used for band n256. Finally, 9dB noise figure is assumed for band n256 as well.

The throughput shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in Annexes A.2.2.2 and A.3.2 from TS 38.101-1 [17] (with one sided dynamic OCNG Pattern OP.1 FDD for the DL-signal as described in Annex A.5.1.1 from TS 38.101-1 [17]) with parameters specified in Table 7.4.3.2.2-1 and Table 7.4.3.2.2-2.

Table 7.4.3.2.2-1: Two antenna port reference sensitivity QPSK REFSENS

| **Operating band / SCS / Channel bandwidth / Duplex-mode** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **NTN satellite band #** | **SCS kHz** | **5**  **MHz (dBm)** | **10**  **MHz (dBm)** | **15**  **MHz (dBm)** | **20**  **MHz (dBm)** | **Duplex Mode** |
|  | 15 | -100.0 | -96.8 | -95.0 | -93.8 |  |
| n255 | 30 |  | -97.1 | -95.1 | -94.0 | FDD |
|  | 60 |  | -97.5 | -95.4 | -94.2 |  |
|  | 15 | -100.0 | -96.8 | -95.0 | -93.8 |  |
| n256 | 30 |  | -97.1 | -95.1 | -94.0 | FDD |
|  | 60 |  | -97.5 | -95.4 | -94.2 |  |

Table 7.4.3.2.2-2: Uplink configuration for reference sensitivity

| **Operating band / SCS / Channel bandwidth / Duplex-mode** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **NTN satellite band #** | **SCS kHz** | **5**  **MHz (dBm)** | **10**  **MHz (dBm)** | **15**  **MHz (dBm)** | **20**  **MHz (dBm)** | **Duplex Mode** |
|  | 15 | 25 | 50 | 75 | 100 |  |
| n255 | 30 |  | 24 | 36 | 50 | FDD |
|  | 60 |  | 10 | 18 | 24 |  |
|  | 15 | 25 | 50 | 75 | 100 |  |
| n256 | 30 |  | 24 | 36 | 50 | FDD |
|  | 60 |  | 10 | 18 | 24 |  |

##### 7.4.3.2.3 Maximum input level

Maximum input level is defined as the maximum mean power received at the UE antenna port, at which the specified relative throughput shall meet or exceed the minimum requirements for the specified reference measurement channel. In defining requirements for maximum input level, there are two effects should be considered. One is the dynamic range for Rx link since the maximum input level would determine the high limit of dynamic range. The other is the maximum received input power at UE in real deployment. If the maximum received input signal level is increased, then pre-LNA attenuation is required, which adds complexity to UE RX chain. Similar as the method in TN system, in order to evaluate the level of maximum received power, the Min distance for consideration is given in Table 7.4.3.2.3-1.

Table 7.4.3.2.3-1: Min distance for conderation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Satellite Type | | |
|  | Parameters |
|  |  |  |
|  | GEO | LEO 1200 | LEO 600 |
| Carrier frequency [GHz] | 2 | 2 | 2 |
| Min Distance from Satellite D\_Min [Km] | 35786 | 1200 | 600 |
| The free space path loss (FSPL) (dB) | 189.5 | 160.1 | 154.0 |
| SET 1 | Satellite EIRP density (dBW/MHz) | 59 | 40 | 34 |
| Bandwidth (15kHz SCS) (MHz) | 20 | | |
| Rx signal at min Distance (dBm) | -87.7 | -77.2 | -77.2 |
| SET 2 | Satellite EIRP density (dBW/MHz) | 53.3 | 34 | 28 |
| Bandwidth (15kHz SCS) (MHz) | 20 | | |
| Rx signal at min Distance (dBm) | -93.4 | -83.2 | -83.2 |

From above table, the maximum received power is -77.2 dBm for 20 MHz which is very lower than -25dBm in TN. It is therefore the maximum input level can be relaxed by 15 dB compared with TN requirement.

##### 7.4.3.2.4 Adjacent channel selectivity

For ACS, the coexistence studies outcome shows that the same ACS values as for NR TN UE are appropriate, and therefore reused.

ACS test parameters in case 1 is applied. ACS requirements in case 2 can be specified based on the maximum input level of -40dBm.

##### 7.4.3.2.5 Blocking characteristics

For blocking characteristics, it is agreed, the same requirements as for NR TN UEs are applicable, and therefore reused. For NR satellite band n255, OOBB requirements of n24 are reused. For n256, to keep UE implementation freedom with both options (i.e., reusing n65 duplexer or dedicated 30MHz duplexer) is agreed. FFS for n256 OOBB requirements if the same hardware of n65 is expected to be reused.

##### 7.4.3.2.6 Spurious response

Spurious response is a measure of the ability of the receiver to receive a wanted signal on its assigned channel frequency without exceeding a given degradation due to the presence of an unwanted CW interfering signal at any other frequency for which a response is obtained, i.e. for which the out-of-band blocking limit is not met. To assume the same interfering signals for guaranteeing TN and NTN UE performance, TN spurious response requirements in section 7.7 of TS 38.101-1[17] could be applicable to NTN satellite access UEs.

##### 7.4.3.2.7 Intermodulation characteristics

Intermodulation response rejection is a measure of the capability of the receiver to receive a wanted signal on its assigned channel frequency in the presence of two or more interfering signals which have a specific frequency relationship to the wanted signal. To assume the same interfering signals for guaranteeing TN and NTN UE performance, TN wide-band intermodulation parameters in Table 7.8.2-1 of TS 38.101-1[17] could be applicable to NTN satellite access UEs.

##### 7.4.3.2.8 Rx Spurious emissions

The spurious emissions limits specified in TS 38.101-1[17] sub-clause 7.9 would also be applicable to NTN satellite access UEs referring to the ERC Recommendation 74-01[28] Annex 3 item 3.1.5 for Mobile Earth Stations (MES) (see Note 1bis) operating below 3 GHz: receivers, receive only MES and transmitters in the carrier-off state.

##### 7.4.3.2.9 Void

#### 7.4.3.3 “Reserved” (for Radiated receiver characteristics)

[To be updated]

### 7.4.4 UE antenna characteristics for satellite access

#### 7.4.4.1 Handheld UE antenna characteristics for satellite access

In Release 17, a reference antenna with a gain of 0dBi is assumed for handheld UE. However, the actual antenna gain can’t meet 0dBi in each direction considering the antenna efficiency which is not 100%. Since all the Tx and Rx requirements are specified at conduct connector for handheld UE, the actual antenna characteristic will have no impact on the RF specification for Release 17 handheld UE.

# 8 Conclusion

It is recommended to take due consideration of contents in Chapter 6 and Chapter 7 when developing Technical Specifications of RF requirements for SAN, HAPS and UE using NR to support non-terrestrial networks (NTN).

Annex A:  
Calibration results of NTN components

## A.1 Calibration assumptions at 2GHz

Assumptions in Section 6.2 are adopted as the baseline for calibration. It should be noted there are different parts which are listed in Table A.1-1.

Table A.1-1: NTN Assumptions for calibration

|  |  |  |
| --- | --- | --- |
| Propagation model 38.811[5] considerations | Basic path loss | Yes |
| Atmospheric loss | 0 |
| Ionospheric or scintillation loss | 0 |
| O2I / building-entry loss | N/A |
| NTN SINR | SINR statistics target | Central beam (UL/DL) |
| Interference | Co-channel interference from 6 adjacent beams |
| BW / #UE | 20MHz / 1 DL, 3UL |
| Polarization gain with 3dB | not considered |
| Elevation angle | 90 degrees for GEO and LEO |
| HAPS SINR | SINR statistics target | 7 cells for DL and UL, HAPS UE is uniformly distributed in 7 cells |
| Interference | Co- channel interference from other 6 cells |
| BW / #UE | 20MHz/1DL, 3UL and each UE BW is 0.36MHz |
| Polarization gain with 3dB | considered |
| Propagation model 38.811[5] considerations for HAPS | Basic path loss | yes |
| Atmospheric loss | 0 |
| Ionospheric or scintillation loss | 0 |
| O2I / building-entry loss | 0 |
| HAPS | power control parameter | gamma =1, CL-ile = 121.45 |
| rural vs. urban difference | only reflect on the propagation model. Other assumptions are the same. |

## A.2 Calibration results at 2GHz

The calibration results include SINR and coupling loss distributions in DL, and SINR, coupling loss and transmit power distributions in UL. Both rural and urban propagation models defined in TR 38.811[5] are considered. For NTN simulation, HAPS, LEO-600, LEO-1200 and GEO are calibrated and results are summarized in Table A.2-1, 2-2, 2-3 and 2-4.

NOTE: The “-” means the data was not provided by its corresponding contributor.

Table A.2-1: Calibration summary for NTN DL Rural cases

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Calibration metrics | | DL Coupling Loss | | | DL Geometry SINR | | |
| CDF percentile | | @5% | @50% | @95% | @5% | @50% | @95% |
| LEO-600 | Samsung | 123.60 | 125.25 | 126.98 | -2.49 | -0.41 | 2.23 |
| Qualcomm | 123.69 | 125.38 | 127.13 | -2.72 | -0.72 | 2.16 |
| CATT | 123.59 | 125.21 | 127.10 | -3.07 | -0.84 | 2.22 |
| THALES | 123.75 | 125.84 | 127.90 | -3.86 | -1.40 | 2.17 |
| Huawei | 123.54 | 125.63 | 129.16 | 7.44 | 10.91 | 12.97 |
| Xiaomi | 123.61 | 125.15 | 126.93 | -3.01 | -0.59 | 2.02 |
| ZTE | 123.66 | 125.57 | 127.64 | -3.05 | -0.22 | 3.65 |
| Nokia | 123.68 | 125.33 | 127.05 | -3.10 | -1.16 | 0.94 |
| Ericsson | - | - | - | -2.58 | 6.97 | 9.95 |
| FhG | 123.61 | 125.37 | 127.07 | -3.48 | -1.19 | 1.36 |
| Variance | 0.00 | 0.04 | 0.46 | 10.03 | 16.13 | 14.92 |
| Mean | 123.64 | 125.41 | 127.44 | -1.99 | 1.14 | 3.97 |
| LEO-1200 | Samsung | 129.61 | 131.27 | 132.99 | -2.47 | -0.40 | 2.23 |
| Qualcomm | 129.60 | 131.21 | 132.91 | -2.35 | -0.42 | 2.13 |
| CATT | 129.56 | 131.20 | 132.86 | -2.21 | -0.54 | 2.08 |
| THALES | 129.68 | 131.51 | 133.28 | -2.91 | -0.79 | 2.27 |
| Huawei | 129.48 | 131.28 | 133.83 | 1.47 | 7.62 | 12.76 |
| Xiaomi | 129.68 | 131.21 | 132.94 | -2.55 | -0.70 | 1.65 |
| ZTE | 129.71 | 131.53 | 133.31 | -2.42 | -0.18 | 3.66 |
| Nokia | 129.70 | 131.36 | 133.10 | -3.09 | -1.20 | 0.94 |
| Ericsson | - | - | - | -3.04 | 6.14 | 10.22 |
| FhG | 129.75 | 131.30 | 132.97 | -3.36 | -1.11 | 1.20 |
| Variance | 0.01 | 0.01 | 0.08 | 1.70 | 9.31 | 15.16 |
| Mean | 129.64 | 131.32 | 133.13 | -2.29 | 0.84 | 3.91 |
| GEO | Samsung | 138.15 | 139.85 | 141.61 | -3.77 | -1.79 | 0.50 |
| Qualcomm | 138.11 | 139.76 | 141.49 | -3.75 | -1.97 | 0.29 |
| CATT | 137.97 | 139.80 | 141.51 | -3.74 | -2.08 | 0.36 |
| THALES | 138.23 | 140.07 | 141.90 | -3.86 | -1.85 | 1.05 |
| Huawei | 139.45 | 140.61 | 142.00 | -1.04 | 0.26 | 1.27 |
| Xiaomi | 138.54 | 140.07 | 141.77 | -3.76 | -1.94 | 0.23 |
| ZTE | 137.81 | 140.36 | 142.92 | -3.81 | -2.24 | -0.02 |
| Nokia | 137.95 | 140.21 | 142.49 | -3.91 | -2.06 | -0.08 |
| Ericsson | - | - | - | -6.62 | -0.18 | 3.60 |
| FhG | 138.43 | 139.99 | 141.80 | -5.18 | -2.75 | -0.59 |
| Variance | 0.21 | 0.07 | 0.20 | 1.72 | 0.79 | 1.22 |
| Mean | 138.29 | 140.08 | 141.94 | -3.94 | -1.66 | 0.66 |
| HAPS | Nokia | 112.15 | 118.78 | 142.92 | -7.82 | 10.20 | 17.05 |
| Qualcomm | 114.14 | 118.70 | 141.92 | -12.54 | 10.19 | 18.46 |
| Variance | 0.99 | 0.00 | 0.25 | 5.58 | 0.00 | 0.50 |
| Mean | 113.14 | 118.74 | 142.42 | -10.18 | 10.20 | 17.75 |

Table A.2-2: Calibration summary for NTN DL Urban cases

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Calibration metrics | | DL Coupling Loss | | | DL Geometry SINR | | |
| CDF percentile | | @5% | @50% | @95% | @5% | @50% | @95% |
| LEO-600 | Samsung | 118.57 | 125.31 | 132.31 | -2.67 | -0.50 | 2.17 |
| Qualcomm | 118.56 | 125.21 | 132.93 | -2.94 | -0.84 | 2.12 |
| CATT | 118.94 | 125.50 | 132.25 | -2.51 | -0.35 | 2.25 |
| THALES | 119.00 | 125.67 | 132.50 | -3.93 | -1.50 | 2.13 |
| Huawei | 120.16 | 125.74 | 131.63 | 1.80 | 9.01 | 15.14 |
| Xiaomi | 119.19 | 125.45 | 132.56 | -2.69 | -0.79 | 1.57 |
| ZTE | 118.90 | 125.58 | 132.40 | -3.05 | -0.61 | 3.37 |
| Ericsson | - | - | - | -3.66 | 4.92 | 13.77 |
| Nokia | 118.71 | 125.16 | 131.68 | -3.53 | -1.15 | 2.42 |
| FhG | 119.50 | 125.89 | 133.01 | -11.24 | -3.00 | 3.96 |
| Variance | 0.23 | 0.05 | 0.20 | 9.11 | 11.73 | 23.37 |
| Mean | 119.06 | 125.50 | 132.36 | -3.44 | 0.52 | 4.89 |
| LEO-1200 | Samsung | 124.61 | 131.33 | 138.34 | -2.64 | -0.50 | 2.17 |
| Qualcomm | 124.35 | 131.34 | 138.33 | -2.49 | -0.50 | 2.12 |
| CATT | 125.02 | 131.78 | 137.85 | -2.63 | -0.37 | 2.23 |
| THALES | 124.60 | 131.40 | 138.00 | -3.00 | -0.88 | 2.23 |
| Huawei | 123.64 | 131.62 | 139.59 | -4.73 | 6.35 | 14.64 |
| Xiaomi | 125.02 | 131.28 | 138.73 | -2.62 | -0.77 | 1.57 |
| ZTE | 124.71 | 131.52 | 138.22 | -2.40 | -0.32 | 3.45 |
| Ericsson | - | - | - | -3.67 | 4.81 | 14.30 |
| Nokia | 123.97 | 130.42 | 136.92 | -3.58 | -1.27 | 2.28 |
| FhG | 125.31 | 131.45 | 138.08 | -10.40 | -2.51 | 4.21 |
| Variance | 0.25 | 0.13 | 0.45 | 5.29 | 7.18 | 23.32 |
| Mean | 124.58 | 131.35 | 138.23 | -3.82 | 0.40 | 4.92 |
| GEO | Samsung | 133.18 | 139.90 | 146.93 | -5.72 | -2.09 | 1.10 |
| Qualcomm | 132.93 | 139.89 | 146.94 | -5.83 | -2.21 | 0.92 |
| CATT | 132.50 | 139.69 | 146.40 | -5.39 | -2.16 | 1.03 |
| THALES | 133.30 | 139.97 | 146.60 | -4.97 | -2.16 | 1.34 |
| Huawei | 132.43 | 138.44 | 145.29 | -5.93 | -0.54 | 6.53 |
| Xiaomi | 133.23 | 139.68 | 146.97 | -5.24 | -2.63 | -0.56 |
| ZTE | 133.72 | 140.50 | 146.99 | -5.23 | -2.51 | -0.11 |
| Ericsson | - | - | - | -7.49 | -0.59 | 7.41 |
| FhG | 132.74 | 139.69 | 146.97 | -11.58 | -3.57 | 4.35 |
| Variance | 0.17 | 0.30 | 0.30 | 3.86 | 0.81 | 7.54 |
| Mean | 133.00 | 139.72 | 146.64 | -6.38 | -2.05 | 2.45 |
| HAPS | Nokia | 111.39 | 145.66 | 164.30 | -29.10 | -10.47 | 16.29 |
| Qualcomm | 112.00 | 143.12 | 159.76 | -30.86 | -10.70 | 20.84 |
| Variance | 0.09 | 1.61 | 5.14 | 0.77 | 0.01 | 5.17 |
| Mean | 111.69 | 144.39 | 162.03 | -29.98 | -10.58 | 18.57 |

Table A.2-3: Calibration summary for NTN UL Rural cases

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Calibration metrics | | UL Coupling Loss | | | UL Geometry SINR | | | UL UE Tx Power | | |
| CDF percentile | | @5% | @50% | @95% | @5% | @50% | @95% | @5% | @50% | @95% |
| LEO-600 | Samsung | 123.60 | 125.25 | 126.98 | -5.51 | -3.07 | -0.70 | 23.00 | 23.00 | 23.00 |
| Qualcomm | 123.64 | 125.37 | 127.14 | -5.43 | -2.92 | -0.42 | 23.00 | 23.00 | 23.00 |
| CATT | 123.68 | 125.47 | 127.29 | -7.22 | -1.78 | 0.42 | - | - | - |
| THALES | 123.75 | 125.84 | 127.90 | -6.16 | -3.76 | -1.31 | 23.00 | 23.00 | 23.00 |
| Huawei | 123.54 | 125.63 | 129.16 | -5.12 | -1.31 | 0.60 | 23.00 | 23.00 | 23.00 |
| Xiaomi | 123.66 | 125.22 | 126.92 | -5.14 | -2.60 | 0.18 | 23.00 | 23.00 | 23.00 |
| ZTE | 123.83 | 125.65 | 127.46 | -5.45 | -3.04 | -0.55 | 23.00 | 23.00 | 23.00 |
| Ericsson | - | - | - | -14.64 | -8.63 | -3.87 | - | - | - |
| FhG | 123.85 | 125.27 | 127.12 | -5.98 | -3.47 | -1.38 | 23.00 | 23.00 | 23.00 |
| Variance | 0.01 | 0.04 | 0.48 | 8.19 | 3.96 | 1.63 | 0.00 | 0.00 | 0.00 |
| Mean | 123.69 | 125.46 | 127.50 | -6.74 | -3.40 | -0.78 | 23.00 | 23.00 | 23.00 |
| LEO-1200 | Samsung | 129.62 | 131.27 | 132.99 | -9.44 | -7.60 | -5.83 | 23.00 | 23.00 | 23.00 |
| Qualcomm | 129.56 | 131.18 | 132.89 | -9.40 | -7.61 | -5.78 | 23.00 | 23.00 | 23.00 |
| CATT | 129.72 | 131.31 | 132.85 | -8.84 | -6.97 | -5.28 | - | - | - |
| THALES | 129.68 | 131.51 | 133.28 | -9.46 | -7.68 | -5.75 | 23.00 | 23.00 | 23.00 |
| Huawei | 129.48 | 131.28 | 133.83 | -9.48 | -6.85 | -5.18 | 23.00 | 23.00 | 23.00 |
| Xiaomi | 129.61 | 131.23 | 132.93 | -7.97 | -6.09 | -4.20 | 23.00 | 23.00 | 23.00 |
| ZTE | 129.60 | 131.38 | 133.25 | -9.27 | -7.32 | -5.63 | 23.00 | 23.00 | 23.00 |
| Ericsson | - | - | - | -19.05 | -13.42 | -9.84 | - | - | - |
| FhG | 129.68 | 131.28 | 133.06 | -9.51 | -7.69 | -5.98 | 23.00 | 23.00 | 23.00 |
| Variance | 0.01 | 0.01 | 0.09 | 9.87 | 4.03 | 2.16 | 0.00 | 0.00 | 0.00 |
| Mean | 129.62 | 131.31 | 133.14 | -10.27 | -7.91 | -5.94 | 23.00 | 23.00 | 23.00 |
| GEO | Samsung | 138.15 | 139.85 | 141.59 | -20.31 | -18.54 | -16.85 | 23.00 | 23.00 | 23.00 |
| Qualcomm | 138.06 | 139.73 | 141.47 | -20.21 | -18.47 | -16.78 | 23.00 | 23.00 | 23.00 |
| CATT | 138.07 | 139.61 | 141.26 | -19.86 | -18.24 | -16.70 | - | - | - |
| THALES | 138.23 | 140.07 | 141.90 | -20.37 | -18.55 | -16.68 | 23.00 | 23.00 | 23.00 |
| Huawei | 139.45 | 140.61 | 142.00 | -17.89 | -16.73 | -15.61 | 23.00 | 23.00 | 23.00 |
| Xiaomi | 138.10 | 139.59 | 141.16 | -18.98 | -17.45 | -15.92 | 23.00 | 23.00 | 23.00 |
| ZTE | 137.76 | 140.33 | 142.91 | -18.35 | -15.72 | -13.37 | 23.00 | 23.00 | 23.00 |
| Ericsson | - | - | - | -30.59 | -25.37 | -21.63 | - | - | - |
| FhG | 138.33 | 139.76 | 141.56 | -20.26 | -18.49 | -17.06 | 23.00 | 23.00 | 23.00 |
| Variance | 0.22 | 0.12 | 0.27 | 12.84 | 6.56 | 4.15 | 0.00 | 0.00 | 0.00 |
| Mean | 138.27 | 139.94 | 141.73 | -20.76 | -18.62 | -16.73 | 23.00 | 23.00 | 23.00 |
| HAPS | Nokia | 112.20 | 118.96 | 143.51 | -11.47 | 10.01 | 14.49 | 13.75 | 20.51 | 23.00 |
| Qualcomm | 114.14 | 118.70 | 141.92 | -9.93 | 10.59 | 14.85 | 15.69 | 20.25 | 23.00 |
| Variance | 0.94 | 0.02 | 0.64 | 0.60 | 0.09 | 0.03 | 0.93 | 0.02 | 0.00 |
| Mean | 113.17 | 118.83 | 142.72 | -10.70 | 10.30 | 14.67 | 14.72 | 20.38 | 23.00 |

Table A.2-4: Calibration summary for NTN UL Urban cases

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Calibration metrics | | UL Coupling Loss | | | UL Geometry SINR | | | UL UE Tx Power | | |
| CDF percentile | | @5% | @50% | @95% | @5% | @50% | @95% | @5% | @50% | @95% |
| LEO-600 | Samsung | 118.58 | 125.30 | 132.31 | -11.38 | -3.64 | 3.57 | 23.00 | 23.00 | 23.00 |
| Qualcomm | 118.71 | 125.16 | 132.66 | -11.83 | -3.91 | 2.64 | 23.00 | 23.00 | 23.00 |
| CATT | 118.41 | 125.45 | 132.54 | -11.13 | -3.89 | 2.97 | - | - | - |
| THALES | 119.00 | 125.67 | 132.50 | -11.15 | -3.92 | 2.70 | 23.00 | 23.00 | 23.00 |
| Huawei | 120.16 | 125.74 | 131.63 | -11.52 | -4.25 | 1.70 | 23.00 | 23.00 | 23.00 |
| Xiaomi | 118.63 | 125.29 | 132.62 | -11.20 | -3.19 | 4.57 | 23.00 | 23.00 | 23.00 |
| ZTE | 118.92 | 125.71 | 132.43 | -11.19 | -3.75 | 3.56 | 23.00 | 23.00 | 23.00 |
| Ericsson | - | - | - | -17.17 | -8.77 | 0.15 | - | - | - |
| FhG | 117.88 | 125.14 | 132.15 | -11.34 | -4.04 | 3.87 | 23.00 | 23.00 | 23.00 |
| Variance | 0.37 | 0.05 | 0.10 | 3.40 | 2.49 | 1.52 | 0.00 | 0.00 | 0.00 |
| Mean | 118.79 | 125.43 | 132.35 | -11.99 | -4.37 | 2.86 | 23.00 | 23.00 | 23.00 |
| LEO-1200 | Samsung | 124.60 | 131.32 | 138.32 | -15.10 | -7.94 | -1.13 | 23.00 | 23.00 | 23.00 |
| Qualcomm | 124.40 | 131.30 | 138.36 | -15.23 | -8.01 | -0.95 | 23.00 | 23.00 | 23.00 |
| CATT | 123.95 | 131.27 | 137.95 | -13.61 | -6.83 | -0.26 | - | - | - |
| THALES | 124.60 | 131.40 | 138.00 | -14.36 | -7.79 | -1.27 | 23.00 | 23.00 | 23.00 |
| Huawei | 123.64 | 131.62 | 139.59 | -16.30 | -7.25 | -0.41 | 23.00 | 23.00 | 23.00 |
| Xiaomi | 124.84 | 131.32 | 138.61 | -13.72 | -6.53 | 0.40 | 23.00 | 23.00 | 23.00 |
| ZTE | 124.73 | 131.47 | 138.22 | -14.30 | -7.40 | -0.51 | 23.00 | 23.00 | 23.00 |
| Ericsson | - | - | - | -21.09 | -13.52 | -5.47 | - | - | - |
| FhG | 124.30 | 130.66 | 137.02 | -14.02 | -7.35 | -0.89 | 23.00 | 23.00 | 23.00 |
| Variance | 0.15 | 0.07 | 0.45 | 4.83 | 3.93 | 2.55 | 0.00 | 0.00 | 0.00 |
| Mean | 124.38 | 131.30 | 138.26 | -15.30 | -8.07 | -1.17 | 23.00 | 23.00 | 23.00 |
| GEO | Samsung | 133.17 | 139.89 | 146.92 | -25.64 | -18.62 | -11.90 | 23.00 | 23.00 | 23.00 |
| Qualcomm | 132.96 | 139.86 | 146.90 | -25.69 | -18.61 | -11.73 | 23.00 | 23.00 | 23.00 |
| CATT | 133.28 | 139.84 | 147.04 | -24.99 | -18.36 | -11.24 | - | - | - |
| THALES | 133.30 | 139.97 | 146.60 | -25.25 | -18.47 | -11.80 | 23.00 | 23.00 | 23.00 |
| Huawei | 132.43 | 138.44 | 145.29 | -24.06 | -17.38 | -11.26 | 23.00 | 23.00 | 23.00 |
| Xiaomi | 133.03 | 139.55 | 146.75 | -24.19 | -17.39 | -10.63 | 23.00 | 23.00 | 23.00 |
| ZTE | 133.58 | 140.24 | 146.91 | -22.79 | -15.32 | -8.86 | 23.00 | 23.00 | 23.00 |
| Ericsson | - | - | - | -32.17 | -25.29 | -17.44 | - | - | - |
| FhG | 133.46 | 140.15 | 147.08 | -25.79 | -18.93 | -12.26 | 23.00 | 23.00 | 23.00 |
| Variance | 0.11 | 0.28 | 0.30 | 6.22 | 6.50 | 4.73 | 0.00 | 0.00 | 0.00 |
| Mean | 133.15 | 139.74 | 146.69 | -25.62 | -18.71 | -11.90 | 23.00 | 23.00 | 23.00 |
| HAPS | Nokia | 111.39 | 145.66 | 164.30 | -28.44 | -10.17 | 14.88 | 12.94 | 23.00 | 23.00 |
| Qualcomm | 111.89 | 143.11 | 158.93 | -26.02 | -8.42 | 14.90 | 13.44 | 23.00 | 23.00 |
| Variance | 0.06 | 1.62 | 7.21 | 1.46 | 0.76 | 0.00 | 0.06 | 0.00 | 0.00 |
| Mean | 111.64 | 144.38 | 161.61 | -27.23 | -9.29 | 14.89 | 13.19 | 23.00 | 23.00 |

Annex B:  
Calibration results of TN components

## B.1 Calibration assumptions at 2GHz

Assumptions in Section 6.2 are adopted as the baseline for calibration. It should be noted there are different parts which are listed in Table B.1-1.

Table B.1-1: TN Assumptions for calibration

|  |  |  |
| --- | --- | --- |
| Calibration assumptions | | |
| TN AAS | Rural | Element gain: 7.1 dBi |
| 3dB: H 90 / V 54 |
| Front-back: 30 H/V |
| Array: 8x8 |
| Element spacing: H 0.5/V 0.9 |
| Conducted Tx: 25 dBm |
| Ohmic loss: 2 dB |
| Mechanical downtilt: 3 deg |
| Polarization gain 3 dB |
| #UE: 1 DL/ 3 UL |
| 100% Outdoor |
| ISD 7.5 KM |
| Urban | Element gain: 6.4 dBi |
| 3dB: H 90 / V 65 |
| Front-back: 30 H/V |
| Array: 8x8 |
| Element spacing: H 0.5/V 0.7 |
| Conducted Tx: 25 dBm |
| Ohmic loss: 2 dB |
| Mechanical downtilt: 10 deg |
| Polarization gain 3 dB |
| #UE: 1 DL/ 3 UL |
| 100% Outdoor |
| ISD 0.75 KM |
| TN non-AAS | Antenna gain | 17 dBi |
| Conducted Tx | 46 dBm |
| 3dB | R4-2108645 Section 2.4.2 |
| Front-back |
| Mechanical downtilt | Rural 3 / Urban 10 |

## B.2 Calibration results at 2GHz

The calibration results include SINR and coupling loss distributions in DL, and SINR, coupling loss and transmit power distributions in UL. Both rural macro and urban macro propagation models defined in TR 38.901[10] are considered. NR BS with AAS and non-AAS antennas are calibrated separately and results are summarized in Table B.2-1, 2-2 and 2-3. NB-IoT scenarios are not calibrated.

NOTE: The “-” means the data was not provided by its corresponding contributor.

Table B.2-1: Calibration summary for TN NR AAS DL cases

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Calibration metrics | | DL Coupling Loss | | | DL Geometry SINR | | |
| CDF percentile | | @5% | @50% | @95% | @5% | @50% | @95% |
| Urban Macro | Samsung | 60.05 | 88.58 | 98.98 | 8.47 | 24.01 | 45.77 |
| Huawei | 52.84 | 85.79 | 103.53 | 5.75 | 22.23 | 43.40 |
| Qualcomm | 57.89 | 87.11 | 100.61 | 5.08 | 19.51 | 43.65 |
| Nokia | 59.04 | 87.59 | 99.32 | 12.42 | 20.15 | 36.50 |
| Ericsson | - | - | - | 6.66 | 19.58 | 39.57 |
| ZTE | 58.76 | 86.90 | 99.74 | 5.63 | 20.56 | 45.14 |
| Variance | 6.42 | 0.83 | 2.69 | 6.35 | 2.62 | 10.70 |
| Mean | 57.72 | 87.19 | 100.44 | 7.33 | 21.01 | 42.34 |
| Rural Macro | Samsung | 78.09 | 116.25 | 127.96 | 4.52 | 16.53 | 37.71 |
| Huawei | 77.53 | 114.99 | 128.13 | 3.02 | 15.15 | 31.35 |
| Qualcomm | 78.27 | 116.81 | 131.58 | 0.17 | 12.60 | 35.83 |
| Nokia | 78.55 | 116.18 | 127.72 | 5.60 | 14.93 | 28.23 |
| Ericsson | - | - | - | 10.03 | 20.17 | 37.72 |
| Variance | 0.14 | 0.44 | 2.51 | 10.51 | 6.21 | 14.21 |
| Mean | 78.11 | 116.06 | 128.85 | 4.67 | 15.87 | 34.17 |

Table B.2-2: Calibration summary for TN NR non-AAS DL cases

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Calibration metrics | | DL Coupling Loss | | | DL Geometry SINR | | |
| CDF percentile | | @5% | @50% | @95% | @5% | @50% | @95% |
| Urban Macro | Samsung | 73.23 | 99.36 | 110.33 | -1.76 | 6.99 | 14.85 |
| Huawei | 70.73 | 99.50 | 113.81 | -5.02 | 5.47 | 14.44 |
| Qualcomm | 71.85 | 99.44 | 113.47 | -4.03 | 4.52 | 14.81 |
| ZTE | 71.00 | 99.00 | 112.09 | -2.89 | 5.24 | 14.99 |
| THALES | 71.84 | 100.22 | 112.26 | -3.03 | 4.25 | 14.40 |
| Variance | 0.95 | 0.04 | 1.88 | 1.50 | 0.81 | 0.04 |
| Mean | 71.73 | 99.50 | 112.39 | -3.35 | 5.29 | 14.70 |
| Rural Macro | Samsung | 87.82 | 125.94 | 138.22 | -4.25 | 5.77 | 15.42 |
| Huawei | 93.87 | 126.75 | 141.60 | -8.93 | 1.10 | 15.33 |
| Qualcomm | 89.63 | 127.43 | 142.65 | -7.37 | 2.54 | 15.47 |
| THALES | 88.83 | 127.81 | 139.57 | -5.31 | 2.57 | 15.24 |
| Variance | 6.43 | 0.37 | 3.58 | 3.78 | 3.81 | 0.00 |
| Mean | 90.04 | 126.98 | 140.51 | -6.47 | 3.00 | 15.37 |

Table B.2-3: Calibration summary for TN NR AAS UL cases

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Calibration metrics | | UL Coupling Loss | | | UL Geometry SINR | | | UL UE Tx Power | | |
| CDF percentile | | @5% | @50% | @95% | @5% | @50% | @95% | @5% | @50% | @95% |
| Urban Macro | Samsung | 60.00 | 88.58 | 99.02 | 3.42 | 14.01 | 14.96 | -25.77 | 2.81 | 13.25 |
| Huawei | 52.84 | 85.79 | 103.53 | 7.53 | 13.89 | 14.89 | -31.46 | 4.14 | 16.51 |
| Qualcomm | 62.00 | 91.09 | 104.80 | 1.33 | 10.10 | 13.87 | -23.77 | 5.32 | 19.03 |
| Nokia | 59.04 | 87.59 | 99.32 | 10.98 | 14.55 | 15.10 | -27.23 | 1.32 | 13.05 |
| Ericsson | - | - | - | 6.83 | 12.94 | 15.08 | -28.52 | -1.70 | 13.98 |
| ZTE | 58.43 | 87.22 | 98.46 | 5.47 | 13.42 | 14.81 | -27.59 | 1.20 | 12.44 |
| Variance | 9.37 | 3.11 | 6.81 | 9.41 | 2.11 | 0.18 | 5.61 | 5.14 | 5.41 |
| Mean | 58.46 | 88.05 | 101.03 | 5.93 | 13.15 | 14.78 | -27.39 | 2.18 | 14.71 |
| Rural Macro | Samsung | 78.00 | 116.25 | 127.95 | -4.86 | 7.03 | 14.96 | -7.77 | 23.00 | 23.00 |
| Huawei | 77.53 | 114.99 | 128.13 | -10.84 | 4.42 | 14.86 | -3.46 | 23.00 | 23.00 |
| Qualcomm | 82.05 | 120.47 | 135.46 | -13.41 | 2.07 | 14.69 | -3.72 | 23.00 | 23.00 |
| Nokia | 78.42 | 116.20 | 127.85 | -4.15 | 7.69 | 15.17 | -7.85 | 22.99 | 22.99 |
| Ericsson | - | - | - | 3.30 | 13.55 | 15.14 | -8.00 | 21.55 | 23.00 |
| Variance | 3.20 | 4.32 | 10.50 | 33.91 | 14.88 | 0.03 | 4.41 | 0.34 | 0.00 |
| Mean | 79.00 | 116.98 | 129.85 | -5.99 | 6.95 | 14.96 | -6.16 | 22.71 | 23.00 |

Table B.2-4: Calibration summary for TN NR non-AAS UL cases

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Calibration metrics | | UL Coupling Loss | | | UL Geometry SINR | | | UL UE Tx Power | | |
| CDF percentile | | @5% | @50% | @95% | @5% | @50% | @95% | @5% | @50% | @95% |
| Urban Macro | Samsung | 73.18 | 99.31 | 110.33 | -10.99 | 4.31 | 9.49 | -12.59 | 13.54 | 23.00 |
| Huawei | 70.73 | 99.50 | 113.81 | -6.46 | 3.08 | 8.88 | -10.26 | 18.51 | 23.00 |
| Qualcomm | 71.53 | 99.51 | 113.45 | -3.52 | 3.36 | 8.00 | -14.24 | 13.74 | 23.00 |
| ZTE | 70.11 | 98.57 | 111.77 | -1.39 | 3.87 | 8.01 | -16.23 | 12.57 | 23.00 |
| THALES | 71.84 | 100.22 | 112.26 | -0.01 | 4.13 | 6.80 | -14.05 | 14.90 | 22.76 |
| Variance | 1.32 | 0.15 | 1.94 | 12.98 | 0.22 | 0.39 | 4.79 | 5.32 | 0.00 |
| Mean | 71.48 | 99.42 | 112.32 | -4.48 | 3.75 | 8.24 | -13.47 | 14.65 | 22.95 |
| Rural Macro | Samsung | 87.78 | 125.93 | 138.22 | -17.23 | -3.82 | 14.65 | 2.01 | 23.00 | 23.00 |
| Huawei | 93.87 | 126.75 | 141.60 | -24.83 | -9.72 | 14.75 | 12.88 | 23.00 | 23.00 |
| Qualcomm | 89.53 | 127.64 | 142.62 | -21.39 | -5.65 | 14.33 | 3.76 | 23.00 | 23.00 |
| THALES | 88.83 | 127.81 | 139.57 | -17.29 | -5.16 | 14.26 | 3.55 | 22.42 | 22.94 |
| Variance | 6.55 | 0.49 | 3.54 | 9.66 | 6.07 | 0.03 | 22.71 | 0.00 | 0.00 |
| Mean | 90.00 | 127.03 | 140.50 | -20.18 | -6.09 | 14.50 | 5.55 | 22.86 | 22.99 |

Annex C:  
Summary of NR-NTN co-existence study

All NR-NTN co-existence study results have been captured in the list as attached.



Annex D:  
Summary of simulation results for the IoT derivation

In this annex, simulations results used to derive the IoT value were collected.

[To be updated]

Annex E  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2021-11 | RAN4# 101-e | R4-2120776 |  |  |  | Added approved TPs in RAN4#101-e including:  R4-2120759, draft TP to TR 38.863: Operating bands and channel arrangements  R4-2120760, TP for 38.863 on system parameters on satellite bands  R4-2120761,TP to TR 38.863 – Regulatory aspects  R4-2120762, TP to TR 38.863: node class, RF RX (6.2)  R4-2120763, TP for 38.863 on NTN UE transmission characteristics  R4-2120772, Draft text proposal to update TR 38.863 NTN related RF and co-existence aspects | 0.1.0 |
| 2022-01 | RAN4#101-bis-e |  |  |  |  | Added approved TPs in RAN4#101-bis-e including:  R4-2201257, TP for 38.863 on system parameters to clarify “NTN satellite bands”  R4-2201838, Draft proposal to update TR 38.863 NTN related RF and co-existence aspects  R4-2202988, Draft Text Proposal for TR 38.863  R4-2203037, TP for 38.863 on UE transmission characteristics for satellite access  R4-2203038, TP for 38.863 on maximum input level for NTN UE  R4-2203039, TP for 38.863 on UE Receiver characteristics for satellite access  R4-2203040, TP to TR 38.863 on transmitter characteristics for satellite access node  R4-2203081, Draft text proposal to update TR 38.863 Chapter 3  R4-2203082, TP to TR 38.863 on channel raster and sync raster  R4-2203084, TP to TR 38.863 Regulatory aspects for HAPS  R4-2203085, TP to TR 38.863 on general aspects  R4-2203129, TP to TR 38.863 – Regulatory aspects | 0.2.0 |
| 2022-03 | RAN4#102-e |  |  |  |  | Added approved TPs in RAN4#102--e including:  R4-2205557,  R4-2207330, TP TR 38.863 7.4.1 NTN UE Requirement (General)  R4-2207333, TP to TR 38.863 on Section 5.2 NTN Satellite band  R4-2207338, TP for TR 38.863: Regulatory aspects for NTN satellite access nodes and Ues operating in UL1626.5-1660.5 MHz and DL 1525-1559 MHz frequencies ranges  R4-2207339, TP to TR 38.863 Regulatory aspects for HAPS  R4-2207345, Draft text proposal for Clauses 7, 7.1, 7.2, 7.3 in TR 38.863  R4-2207351, Draft text proposal to update TR 38.863 Chapter 6  R4-2207353, Draft text proposal for Clauses 6.4 and 6.5 in TR 38.863 to include simulation results based on Non-AAS antenna assumption  R4-2207360, Draft text proposal for Clause 7.3.4.7.3 OTA ACLR in TR 38.863  R4-2207367, Draft text proposal for Clause 7.3.5.6 OTA Out-of-band blocking in TR 38.863  R4-2207379, Draft text proposal for Clause 7.3.3.2.4 Out-of-band blocking in TR 38.863  R4-2207381, Draft text proposal for Clauses 7.3.3.2.3.1 Adjacent Channel Selectivity (ACS) and 7.3.3.2.3.2 In-band blocking in TR 38.863  R4-2207397, TP on TR 38.863 for NTN UE Tx requirements  R4-2207398, Draft TP to update TR 38.863 clause 7.4.3.2 on NTN UE ACS  R4-2207399, Draft TP to update TR 38.863 clause 7.4.3.2 on Blocking characteristics  R4-2207401, TP for TR38.863 on Intermodulation characteristics for NTN UE  R4-2207402, TP for 38.863 on spurious response for NTN UE  R4-2207403, TP for TR 38.863: Unwanted emissions for NTN satellite Ues transmitting in 1626.5 to 1660.5 MHz  R4-2207406, TP for TR 38.863: Updates to UE Maximum Output Power for n255  R4-2207414, TP for 38.863 on UE Receiver characteristics for satellite access  R4-2207460, Draft text proposal for Clause 7.3.2.2.4.1 ACLR in TR 38.863 | 0.3.0 |
| 2022-05 | RAN4#103-e |  |  |  |  | Added approved TPs in RAN4#103e including:  R4-2209089, TP for 38.863 on general part for NTN UE conducted receiver characteristics  R4-2209364, TP for 38.863 on UE Rx spurious emission requirements for satellite access  R4-2209365, TP for 38.863 on UE antenna characteristics for satellite access  R4-2210228, Draft text proposal for Clauses 6.4 and 6.5 Corrections Typos - TR 38.863  R4-2210636, TP to TR 38.863: coexistence issues between NTN and TN from Rel-17 RAN4 study.  R4-2210847, TP to TR 38.863 - Updates  R4-2210848, Draft text proposal for Clause 6.1 Coexistence Figures - TR 38.863  R4-2210853, TP for 38.863: clause 7.3.2 Conducted transmission characteristics  R4-2210858, TP to TR 38.863: Conducted reference sensitivity  R4-2210859, TP to TR 38.863: Conducted Rx dynamic range  R4-2210860, Draft text proposal for Clause 7.3.2.2.5 Transmitter spurious emissions - TR38.863  R4-2210865, Tentative draft pCR for Clause 7.3.2.2.4.2 Operating band unwanted emissions - TR 38.863  R4-2210866, Draft text proposal for Clause 7.3.2.2.1 SAN output power   - TR 38.863  R4-2210867, Draft text proposal for Clause 7.3.3.3.1 OTA sensitivity   - TR 38.863  R4-2210868, Draft text proposal for Clause 7.3.3.3.2 OTA reference sensitivity - TR 38.863  R4-2210869, Draft text proposal for Clause 7.3.3.3.3 OTA dynamic range - TR 38.863  R4-2210870, Draft text proposal for Clause 7.3.3.3.7 OTA receiver intermodulation - TR 38.863  R4-2210871, Draft text proposal for Clause 7.3.3.3.8 OTA in-channel selectivity - TR 38.863  R4-2210872, Draft text proposal for Clause 7.3.3.3.4 OTA in-band selectivity and blocking - TR 38.863  R4-2210875, TP for TR 38.863: Updates to n255 A-MPR Clause  R4-2211133, Draft Text Proposal to Update TR 38.863 Chapter 3,6 and 8  R4-2211134, Draft Text Proposal to Update TR 38.863 structure  R4-2211146, Draft text proposal for Clause 7.3.3.3.2 OTA reference sensitivity - TR 38.863 | 0.4.0 |

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| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-06 | RAN#96 |  |  |  |  | Approved by plenary – Rel-17 spec under change control | 17.0.0 |
| 2022-09 | RAN#97 | RP-222035 | 0001 |  | F | CR for 38.863 to maintain UE RF parts | 17.1.0 |
| 2022-09 | RAN#97 | RP-222035 | 0002 | 1 | F | Correction to TR 38.863 on Regulatory aspects for HAPS | 17.1.0 |
| 2023-03 | RAN#99 | RP-230516 | 0005 |  | F | CR for TR 38.863 to maintain SAN parts | 17.2.0 |
| 2023-12 | RAN#102 | RP-233349 | 0009 | 1 | F | CR for TR 38.863, Correction on Satellite and UE Antenna and beam forming pattern modelling | 17.3.0 |

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| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2023-12 | RAN#102 | RP-233362 | 0010 |  | B | NTN enhancement: CR to TR 38.863 NTN Ka-band Regulatory aspects | 18.0.0 |