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| 3GPP TR 38.863 V0.2.0 (2022-01) |
| 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 17) |
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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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2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

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.

# 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] [To be updated: 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".

# 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

## 3.1 Symbols

[To be updated]

## 3.1 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 PowerRx Receiver

Rx Receiver

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 aspect

## 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 5.4).

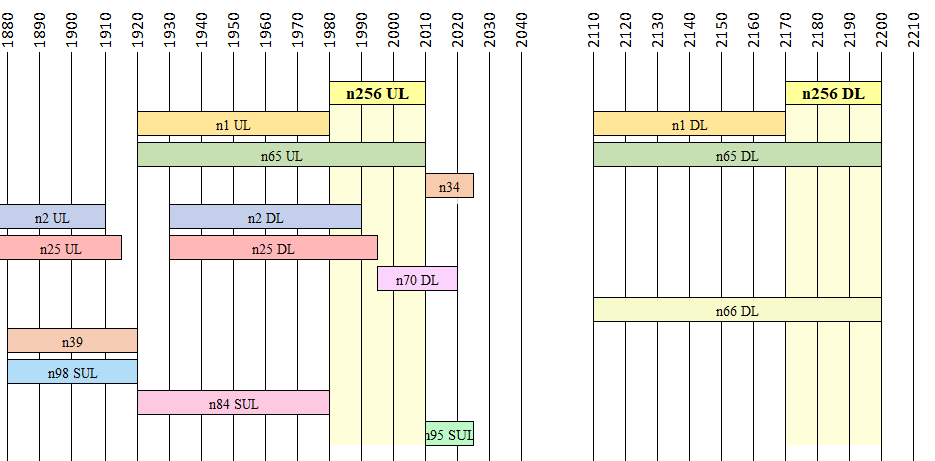
## 5.2 NTN Satellite band: UL: 1980–2010 MHz / DL: 2170–2200 MHz

The ITU-R Radio Regulations [3] specify the following service allocation for those frequency ranges, shown in Table 5.2-1:

Table 5.2-1 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 gives an overview of the NR TN bands adjacent to the NTN n256 band.



As shown in Figure 5.2-1, 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 overlap 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) operating in the upper 30 MHz portion of n65 could be simultaneously in CEPT countries.

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

[To be updated]

## 5.4 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 a lot 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 and may be used by high altitude platform stations as base stations to provide International Mobile Telecommunications (IMT), 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 below 2.7 GHz for HAPS as IMT Base Stations (HIBS). ITU 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 allocation decisions in WRC-23 in accordance with Resolution 247 [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 IMT Base Stations (HIBS).

|  |  |  |
| --- | --- | --- |
| Region | Spectrum | Remarks |
| Region 1 and 3 | 1885 – 1980 MHz  2010 – 2025 MHz  2110 – 2170 MHz | Previously identified HIBS designations and currently under study, for decision at WRC-23 |
| Region 2 | 1885 – 1980 MHz (NOTE 3)  2110 – 2160 MHz (NOTE 4) |
| Global | 694 – 960 MHz  1710 – 1885 MHz (NOTE 1)  2500 –2690 MHz (NOTE 2) | 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 | FFS |
| Urban macro | X | X | X | X | X | X | FFS |
| Dense Urban6 | N/A | N/A | N/A | N/A | N/A | N/A | FFS |
| HAPS | | FFS | FFS | FFS | FFS | FFS | FFS | FFS |
| [Note 1: Start with Earth Fixed beam first, Earth Moving Beams could be further discussed  [Note 2: Use Set 1 satellite antenna as the starting point for co-existence study. Set 2 might be used if any worst case in associate with Set 2 is found. ]  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: Rationale to exclude Dense Urban to be addressed in TR 38.863.] | | | | | | | | |

The aggressor and victim combination is 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 |

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 1: 2 phases will be considered for FRF: FRF=1 in phase 1 for simplification; FRF=3 in phase 2 or it is found FRF=1 is too stringent. | | | | |

## 6.2 Co-existence simulation assumption

### 6.2.1 Network layout model

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

Cellular cell structure is considered for both NTN 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 beams direction and location on the earth surface. It means the NTN beam location, TN randomly dropping location are generated with a set of three parameters (x,y,z).

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

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 | 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 | 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 | 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 | 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 | 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 | 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. | All active TN cells in central NTN beam |

### 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

|  |  |  |
| --- | --- | --- |
| Parameters | NTN | Remark |
| Carrier frequency | 2GHz |  |
| The number of active UE (UL) | 9 UEs and 2RBs per UE for GEO and LEO1 |  |
| The number of active UE (DL) | 1 | Same with TN |
| Traffic model | Full buffer |  |
| DL power control | NO |  |
| UL power control | See Session 2.6.2 |  |
| NTN satellite Noise figure in dB | See Table 2.3-3-1 |  |
| Handover margin | 3dB |  |
| Note 1: 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 bufffer 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  [Editor’s note: Axis to be added in the figure] | | |

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

[To be updated]

#### 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, check Table 2.3-6. |
| 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 2.3-6 |
| System loading and activity | Full buffer 100% | See Table 6.2.1.1-1 |
| Network location | FFS | 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 2.9  Throughtput-SINR mapping |
| UE distribution |  | Uniform |
| Evaluation metrics | SINR vs ACS (as victim) | See Section 2.9  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

#### 6.2.2.1 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, 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 6.2.2.1-1 and 6.2.2.1-2.



Figure 6.2.2.1-1: Antenna pattern for LEO 600KM and 1200KM (4.4127 deg for 3dB beamwidth)



Figure 6.2.2.1-2 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 6.2.2.1-1.

Table 6.2.2.1-1: 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  Interested companies can bring analysis and results for other values. | | |
|  | 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). | | | |

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

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

Table 2.4.2-1 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 2.4.2-1 are used for 2GHz BS antenna pattern in the NTN system simulation.

Table 2.4.2-1 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.

#### 6.2.2.3 HAPS antenna model

[To be updated]

### 6.2.4 ACIR model

The following ACIR model is used to derive ACIR values for co-ex study between NTN and TN.

The number of RBs in Table 6.2.4-1 should be updated and aligned with the agreed number of UL UE in NTN and TN assumptions.

ACLR modelling for TN and NTN co-existence referring to clause 5.1.1.4.1 and 5.1.1.4.2 in TR 36.942[8] is to be used.



Figure 6.2.4-1 ACIR model

Table 6.2.4-1 Uplink ACIR value

|  |  |
| --- | --- |
| Frequency offset between aggressor (105 RBs) and victim (105 RBs) | ACIR value |
| 0-[34] RBs | 30 + X |
| [35-69] RBs | 43 + X |
| >[69] RBs | 43+ X |

### 6.2.5 Propagation model

#### 6.2.5.1 Propagation model between NTN and UE

Propagation model between NTN and UE could be referred 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 could be referred to section 7.4 in TR 38.901[10].

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

Propagation model between NTN BS 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

[To be updated]

### 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 but needs to revise CLx-ile to align with UE UL power control parameters used in TR 38.821[6]. [The CLx-ile value should be adapted for rural scenario.]

#### 6.2.6.3 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

[To be updated]

## 6.3 Co-existence simulation methodology

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-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:



## 6.4 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 worst case 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 following sub-clauses of this section captures the processed results by adopting above principles and methodologies for scenarios 1 to 6 which are identified in Table 6.1-2. It is noted that due to the space limitation, only part of the simulation results for each case are presented, 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 6.4-1 Worst case 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 ACLR |
| 4 | NTN GEO UL | TN UL | Urban | NTN UE ACLR |
| 5 | NTN GEO UL | TN DL | Rural | NTN UE ACLR |
| 6 | NR-TN DL | NTN [TBD] UL | [TBD] | NTN SAN ACS |

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

The co-ex results from all concerned options in this scenario were evaluated, and it has been agreed to select the NR DL equipped with 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

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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

Table 6.4.1-2 Simulation results for 5%-tile throughput loss

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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

Table 6.4.1-3 Interpolated ACIR values for Scenario 1 to meet the 5% throughput loss criteria

|  |  |  |
| --- | --- | --- |
| 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 values in the above worse case for Scenario 1

|  |  |
| --- | --- |
|  | Scenario 1 |
| ACIR value [dB] | 23.18 |

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

The co-ex 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

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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

Table 6.4.2-2 Simulation results for 5%-tile throughput loss

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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

Table 6.4.2-3 Interpolated ACIR values for Scenario 2 to meet the 5% throughput loss criteria

|  |  |  |
| --- | --- | --- |
| 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

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

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

The co-ex 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.

Table 6.4.3-1 Simulation results for average throughput loss

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 Simulation results for average throughput loss

Table 6.4.3-2 Simulation results for 5%-tile throughput loss

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 6.4.3-2 Simulation results for average throughput loss

Table 6.4.3-3 Interpolated ACIR values for Scenario 3 to meet the 5% throughput loss criteria

|  |  |  |
| --- | --- | --- |
| 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 6.4.3-4 Average ACIR values in the above worse case for Scenario 3

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

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

The co-ex 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 AAS antenna that deployed in urban environment as the most stringent case.

Table 6.4.4-1 Simulation results for average throughput loss

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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

Table 6.4.4-2 Simulation results for 5%-tile throughput loss

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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

Table 6.4.4-3 Interpolated ACIR values for Scenario 4 to meet the 5% throughput loss criteria

|  |  |  |
| --- | --- | --- |
| 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 values in the above worse case for Scenario 4

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

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

The co-ex 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 AAS antenna that deployed in rural environment as the most stringent case.

Table 6.4.5-1 Simulation results for average throughput loss

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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

Table 6.4.5-2 Simulation results for 5%-tile throughput loss

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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

Table 6.4.5-3 Interpolated ACIR values for Scenario 5 to meet the 5% throughput loss criteria

|  |  |  |
| --- | --- | --- |
| 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 values in the above worse case for Scenario 5

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

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

The co-ex results from all concerned options in this scenario were evaluated, and it has been agreed to select the [TBD] in [TBD] environment as the most stringent case.

[To be updated]

## 6.5 Summary of co-existence study

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

Table 6.5-1 Average ACIR values for each scenario

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Scenario | 1 | 2 | 3 | 4 | 5 | 6 |
| ACIR value [dB] | 23.18 | 28.03 | 23.32 | 28.11 | 26.43 | [TBD] |

Then, by considering the following ACLR and ACS of TN BS and UE in Table 6.5-2, the suggested ACLR and ACS of NTN SAN and UE from each scenario are given in Table 6.5-3. It should be noted that the values in Table 6.5-3 are directly derived from the worst case option of each scenario, and it is limited by the nature of assumptions and methodologies adopted in the co-ex studies.

Table 6.5-2 ACLR and ACS of TN

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

Table 6.5-3 Co-ex results suggested ACLR and ACS of NR-NTN

|  |  |  |
| --- | --- | --- |
| Scenario | Contributing | ACLR ACS values |
| 1 | NTN UE ACS | 23.21 dB |
| 2 | NTN SAN ACS | 32.41 dB |
| 3 | NTN SAN ACLR | 23.81 dB |
| 4 | NTN UE ACLR | 28.18 dB |
| 5 | NTN UE ACLR | 27.51 dB |
| 6 | NTN SAN ACS | [TBD] |

Considering the above suggested values, the agreed ACLR and ACS of NR-NTN are given in Table 6.5-3.

Table 6.5-3 ACLR and ACS of NR-NTN

|  |  |  |
| --- | --- | --- |
| NR-NTN | | Values |
| SAN | ACLR | [TBD] |
| ACS | [TBD] |
| UE | ACLR | 30 dB |
| ACS | 33 dB |

# 7 RF requirements

## 7.1 Reference points for RF requirements

[To be updated]

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

### 7.2.1 Operating bands

The following bands in Table 7.2.1-1 are agreed as exemplary NTN bands in Rel-17. Regarding the band numbering for NTN bands, it is agreed to start from the largest band number in FR1 range for NTN bands which fully within FR1 frequency ranges to better differentiate NTN band and TN bands and ensure contiguous band number allocation for NTN bands, the number can be taken in a decreased order with first come, first service.

Table 7.2.1-1: NTN bands in FR1

|  |  |  |  |
| --- | --- | --- | --- |
| **NTN satellite*band #*** | 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. | | | |

### 7.2.2 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 system].

The supported channel bandwidth per operating band should be defined based on NTN operator input. The details are given in Table 7.2.2-1.

Table 7.2.2-1: C*hannel bandwidths* and SCS per NTN 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 |

### 7.2.3 Channel raster and sync raster

#### 7.2.3.1 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 bands below 3 GHz.

The applicable ARFCNs per operating and for satellite access node are defined in table 7.2.3.1-2.

Table 7.2.3.1-2 ARFCNs per operating band satellite access node

|  |  |  |  |
| --- | --- | --- | --- |
| NR *operating 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 |

#### 7.2.3.2 Sync raster

The applicable SS raster entries per operating band are defined in Table 7.2.3.1-2.

Table 7.2.3.1-2 Applicable SS raster entries per *operating band*

|  |  |  |  |
| --- | --- | --- | --- |
| NTN *satellite 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

[Note: Titles of Section 7.3, 7.3.1.1 need to be aligned with the name to be discussed and determined in TS 38.181 and 38.08]

### 7.3.1 General

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

#### 7.3.1.1 Satellite access node class

[To be updated]

### 7.3.2 Transmission characteristics

#### 7.3.2.1 General

*<Reference point needs to be added in this section>*

#### 7.3.2.2 Conducted transmitter requirements

##### 7.3.2.2.1 Base station output power

[To be updated]

##### 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 BS 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

|  |  |  |  |
| --- | --- | --- | --- |
| *BS 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 7.3.2.2.3.1-1 shall be met.

Table 7.3.2.2.3.1-1: EVM requirements for *satellite access node type 1-H*

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

##### 7.3.2.2.4 Unwanted emissions

[To be updated]

7.3.2.2.4.1 ACLR

[To be updated]

7.3.2.2.4.2 Operating band unwanted emissions

[To be updated]

##### 7.3.2.2.5 Transmitter spurious emission

[To be updated]

#### 7.3.2.3 “Reserved” (for Radiated transmitter requirements)

### 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]

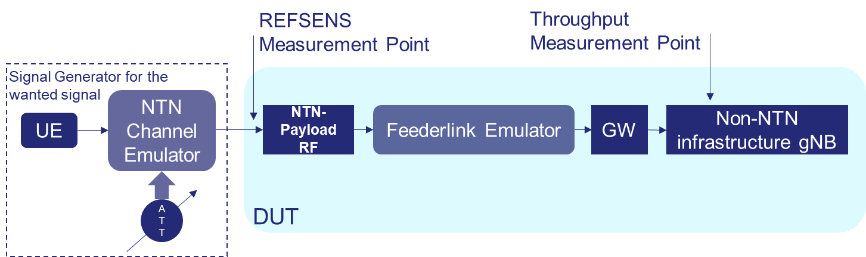


Figure 7.3.3.1-1: Reference points for measurement of Rx requirements

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.

#### 7.3.3.2 Conducted receiver characteristics

##### 7.3.3.2.1 Reference sensitivity level

[To be updated]

##### 7.3.3.2.2 Dynamic range

[To be updated]

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

[To be updated]

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

[To be updated]

##### 7.3.3.2.5 Receiver spurious emissions

[To be updated]

##### 7.3.3.2.6 Receiver intermodulation

[To be updated]

##### 7.3.3.2.7 In-channel selectivity

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

#### 7.3.3.3 Radiated receiver characteristics

##### 7.3.3.3.1 OTA sensitivity

[To be updated]

##### 7.3.3.3.2 OTA reference sensitivity level

[To be updated]

##### 7.3.3.3.3 OTA dynamic range

[To be updated]

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

[To be updated]

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

[To be updated]

##### 7.3.3.3.6 OTA receiver spurious emissions

[To be updated]

##### 7.3.3.3.7 OTA receiver intermodulation

[To be updated]

##### 7.3.3.3.8 OTA in-channel selectivity

[To be updated]

### 7.3.4 Others

[To be updated]

## 7.4 NTN UE requirements

### 7.4.1 General

[To be updated]

### 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 Rel-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/-33 |
| NOTE 1: PPowerClass is the maximum UE power specified without taking into account the tolerance  NOTE 2: Powerclass 3 is default power class unless otherwise stated  NOTE 3: Refers to the transmission bandwidths confined within FUL\_low and FUL\_low + 4 MHz or FUL\_high – 4 MHz and FUL\_high, the maximum output power requirement is relaxed by reducing the lower tolerance limit by 1.5 dB. | | |

##### 7.4.2.2.2 MPR/AMPR

[To be updated]

##### 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

[To be updated]

##### 7.4.2.2.6 Spectrum emission mask

[To be updated]

##### 7.4.2.2.7 ACLR

[To be updated]

##### 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.

##### 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 |

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

### 7.4.3 UE Receiver characteristics for satellite access

#### 7.4.3.1 General

[To be updated]

#### 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:

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.

FFS the assumed duplexer for band n256.

The throughput shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in [TBD] 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** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Operating 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 |  |

Table 7.4.3.2.2-2: Uplink configuration for reference sensitivity

| **Operating band / SCS / Channel bandwidth / Duplex-mode** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Operating 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 |  |

##### 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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | 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 [20] dB compared with TN requirement.

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

[To be updated]

### 7.4.4 Others

[To be updated]

Annex A:  
Calibration results of NTN components

## A.1 Calibration assumptions

Assumptions in Section 6.2 are adopted as 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

|  |  |  |
| --- | --- | --- |
| Propagatoin 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 |
| Propagatoin 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

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

Assumptions in Section 6.2 are adopted as 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

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 |
| Variance | 0.95 | 0.04 | 1.88 | 1.50 | 0.81 | 0.04 |
| Mean | 71.70 | 99.32 | 112.43 | -3.42 | 5.55 | 14.77 |
| 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 |
| Variance | 6.43 | 0.37 | 3.58 | 3.78 | 3.81 | 0.00 |
| Mean | 90.44 | 126.70 | 140.82 | -6.85 | 3.14 | 15.41 |

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.2-3 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 |
| Variance | 1.32 | 0.15 | 1.94 | 12.98 | 0.22 | 0.39 | 4.79 | 5.32 | 0.00 |
| Mean | 71.39 | 99.22 | 112.34 | -5.59 | 3.65 | 8.60 | -13.33 | 14.59 | 23.00 |
| 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 |
| Variance | 6.55 | 0.49 | 3.54 | 9.66 | 6.07 | 0.03 | 22.71 | 0.00 | 0.00 |
| Mean | 90.39 | 126.77 | 140.81 | -21.15 | -6.40 | 14.58 | 6.22 | 23.00 | 23.00 |

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:  
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:  R4-2202988, 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 |