**3GPP TSG-RAN WG4 Meeting # 98-bis-e R4-2106105**

**Electronic Meeting, 12th – 20th April, 2021**

**Agenda item:** 8.8.2

**Source:** Moderator (Samsung)

**Title:** Simulation assumptions for NTN co-existence study

**Document for:** Information

# Introduction

This document captures initial simulation assumptions for the NTN coexistence study in frequency bands around 2GHz.

Remaining issues for further discussion are with [] and highlighted in yellow mark.

# Discussion

## Co-existence simulation scenarios

It is proposed to have a phase-by-phase approach to conduct co-existence study considering scenarios.

The proposed scenarios for coexistence study are in the following table.

Table 2.1-1 Scenarios for NTN-NTN/TN co-existence

|  |  |  |  |
| --- | --- | --- | --- |
| **FR1: 2GHz** | **Set 1** | **Set 22** | **HAPS** |
| **GEO** | **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 Urban** | X | X | X | X | X | X | FFS |
| **Indoor** | X | X | X | X | X | X |  |
| **NTN1** | **GEO3** | **Set 1** | X | X | X | N/A | N/A | N/A | FFS |
| **LEO 1200km** | X | X | X | N/A | N/A | N/A | FFS |
| **LEO 600km** | X | X | X | N/A | N/A | N/A | FFS |
| **GEO** | **Set 22** | N/A | N/A | N/A | X | X | X | FFS |
| **LEO 1200km** | N/A | N/A | N/A | X | X | X | FFS |
| **LEO 600km** | N/A | N/A | N/A | X | X | X | FFS |
| Note 1: Start with Earth Fixed beam first, Earth Moving Beams could be further discussedNote 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: Further check the possibility to remove LEO 1200km cases in future RAN4 meetings.  |

The aggressor and victim combination is list in Table 2.1-2.

Table 2.1-2 Aggressor and victim

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No. | Combination | **Aggressor** | **Victim** | Notes | Study Phase |
| 1 | TN with NTN | TN DL | NTN DL |  | Phase 1 |
| 2 | TN with NTN | TN UL | NTN UL |  | Phase 1 |
| 3 | TN with NTN | NTN DL | TN DL |  | Phase 1 |
| 4 | TN with NTN | NTN UL | TN UL |  | Phase 1 |
| 5 | TN with NTN | NTN UL | TN DL | Applicable for satellite operating in S band, e.g. coexistence with Band 34 TDD.  | Phase 1 |
| 6 | TN with NTN | TN DL | NTN UL | Applicable for satellite operating in S band, e.g. coexistence with Band 34 TDD.  | Phase 1 |
| 7 | TN with NTN | TN UL | NTN DL |  | Phase 2 |
| 8 | TN with NTN | NTN DL  | TN UL |  | Phase 1 |
| 9 | NTN with NTN | NTN DL | NTN DL | LEO-LEO | Phase 1 |
| GEO-GEO | Phase 1 |
| GEO-LEO@600 or HAPS-HAPS | Phase 2 |
| NTN UL | NTN UL | LEO-LEO | Phase 1 |
| GEO-GEO | Phase 1 |
| GEO-LEO@600 or HAPS-HAPS | Phase 2 |

The proposed frequency and bandwidth are listed as table 2.1-3.

Table 2.1-3. 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]  |
| TN Dense Urban | 2 GHz | 20MHz | FDD, TDD | [1] |
| GEO | 2 GHz | [30] MHz for FR1 | FDD |  [2] or [3] |
| LEO | 2 GHz | [30] MHz for FR1 | FDD |  [2] or [3] |
| HAPS | 2 GHz | TBD | FDD | [1] |

## Network layout model

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

### Co-existence between NTN and TN

**Coordination System**

[Further discuss following options

* Option 1: Referring to TR 38.811 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).
* Option 2: There is no need to consider the curvature of earth for layout, assuming one satellite beam for the simulation. The distances for LEO-600, LEO-1200 and GEO can be assumed as 600km, 1200km and 35786km separately for any point under the 3dB satellite beam. ]

**Simulation Methodology**

Following simulation steps can be used for NTN-TN co-existence study.

1. Generate aggressor and victim networks. [Details to be further discussed]
* [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.
* TN center is randomly generated within the NTN central beam on earth surface.
1. For following two cases, more TN sites might be needed due to large coverage per beam of NTN node. The number of TN networks needs further discussion. As an option, Figure 2.2.1-1 could be used to derive the number.

|  |  |  |  |
| --- | --- | --- | --- |
| No. | Combination | **Aggressor** | **Victim** |
| 1 | TN - NTN | TN DL (TN BS) | NTN UL (NTN satellite) |
| 2 | TN - NTN | TN UL (TN UE) | NTN UL (NTN satellite) |



Figure 2.2.1-1 The heterogeneous network layout

1. For other cases, 19-cell with wrap around will be used.]
2. 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 to be further discussed considering following options

[Option 1: NTN UE is randomly generated within the TN area depending on the NTN UE density.

Option 2: Distribute the NTN UEs within the TN network boundaries or centers randomly corresponding to Table 1.

Table 1: NTN UE distribution mapping

|  |  |  |
| --- | --- | --- |
| **Aggressor** | **Victim** | **NTN UE distribution** |
| TN DL | NTN DL | NTN UEs at TN centers |
| TN UL | NTN UL | NTN UEs at TN boundaries |
| NTN DL | TN DL | NTN UEs at TN boundaries |
| NTN UL | TN UL | NTN UEs at TN centers |
| NTN UL | TN DL | NTN UEs at TN boundaries |
| TN DL | NTN UL | NTN UEs at TN centers |

Option 3: First decide/down-scope the coexistence scenarios (victim and aggressor) and then decide the NTN UE and TN UE distribution

Option 4: NTN UE should be randomly generated within the NTN area. How does it co-locate with TN network depends on how we place the 2 networks.]

1. 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.
2. Throughput is computed in the victim systems without considering ACI as below:

- , where is the inter-cell interference.

1. Throughput is computed considering ACI as below:

- , where is the adjacent channel interference.

1. RF parameters are determined based on the degradation cause by ACI as below:

- .

### Co-existence between NTN and NTN

[The following 2 cases are considered as candidate options and to be further discussed.

* One satellite carries two neighbour carriers, where the footprints of the 2 carriers are the same and coordinated see figure 2.2-1.
* Two satellites (GEO and LEO) operate on two neighbour carriers but at different height, see figure 2.2-2. The number of LEO satellite and footprints are FFS.

Figure2.1-1 Layout for coexistence between NTN and TN (TBD)

Figure 2.2-2 Layout for coexistence between NTN systems

Figure 2.2-3 Layout for coexistence between NTN systems (different height satellites)

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### Co-existence between HAPS and HAPS

Referring to R4-2106106

### Co-existence between HAPS and TN

Referring to R4-2106106

## Simulation parameters

### NTN parameters

**Satellite parameters**

Two sets of satellite parameters are shown in Table 2.3-1 and Table 2.3-2 according to TR 38.821.

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

Table 2.3-1 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 Tx max Gain | 51 dBi | 30 dBi | 30 dBi |
| Satellite max TX power in dBm | [52.6dBm] | [54.6dBm] | [48.6dBm] |
| Channel bandwidth | [30MHz] | [30MHz] | [30MHz] |
| 3dB beamwidth | 0.4011 deg | 4.4127 deg | 4.4127 deg |
| Satellite beam diameter | 250 km | 90 km | 50 m |
| 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 2.3-2 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 |
| Satellite max TX power in dBm | [52.6dBm] | [54.6dBm] | [48.6dBm] |
| Channel bandwidth | [30MHz] | [30MHz] | [30MHz] |
| 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 2.3-3 Other parameters for NTN

|  |  |  |
| --- | --- | --- |
| **Parameters** | **NTN** | **Remark** |
| Carrier frequency | 2GHz |  |
| Channel bandwidth | 30MHz | TR 38.821 |
| The number of active UE (UL) (Note 1) | [1]/[3]/[10] |  |
| The number of active UE (DL) (Note 1) | [1]/[10] |  |
| Traffic model | Full buffer |  |
| DL power control | NO |  |
| UL power control | TBD | See Session 2.6.2 |
| NTN system Noise figure in dB | TBD |  |
| Handover margin | [0]/[3]dB |  |
| Note 1: Further down-scoping is needed |

**UE parameters**

UE parameters are shown in Table 2.3-4

Table 2.3-4 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 |

**HAPS parameters**

Refer to R4-2106106.

### TN parameters

[Table 2.3-5 Simulation assumptions of TN respectively based on NB-IoT and NR

|  | NB-IoTstandalone | NR |
| --- | --- | --- |
|  |  | Option 1 (R4-2106476 CATT) | Option 2(R4-2105045 Samsung) |  |
| Carrier frequency in GHz |  2 |  2 | 2 |  |
| Size of each nominal channel BW in MHz | 0.2 | 20 | 20 |  |
| Transmission bandwidth in MHz | 0.18 | 9 |  |  |
| Environment | Urban macroSub-urbanRural | Urban macroSub-urbanRural | Deployment scenario related, check Table 2.3-6. |  |
| Network layout | 19-sites [57 sectors] with wrap-around | 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 | 500 for 2GHz band for UMA | Deployment scenario related, check Table 2.3-6 |  |
| System loading and activity | Full buffer 100% | Full buffer 100% | Full buffer 100% |  |
| Network location | FFS | FFS | TN as victim: Randomly generated in NTN central beam |  |
| DL subcarrier spacing | 15kHz | 15kHz | 15kHz |  |
| UL | See RP-152284 | OFDMA | OFDMA |  |
| DL power control | No | No | No |  |
| UL power control | 36.942 section 5.1.1.6 (set 1) by bandwidth scale, target SNR at BS is 15 dB | 36.942 section 5.1.1.6 (set=1) | 36.942 Section 9.1 |  |
| Frequency reuse | 1 | 1 | 1 |  |
| Number of scheduled UE per cell (DL) | 1 | 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 | 3 |  |
| UE antenna height in meter | 1.5 | 1.5 | Deployment scenario related, check Table 2.3.6 |  |
| UE TX power in dBm | -40 to 23 | -40 to 23 | -40 to 23 |  |
| UE antenna gain in dBi | 0 | 0 | 0 |  |
| Building penetration loss | 45.820 Annex D.1  | n/a | In Pathloss model, TR 38.901 |  |
| Cell selection margin in dB | 3 | 3 | 3 |  |
| BS-MS min couple loss in dB | 70 | 70 | Proposed ‘Minimum BS-UE distance in meter’ instead of MCL.Deployment scenario related, check Table 2.3-6. |  |
| BS noise figure in dB | 5 | 5 | 5 |  |
| UE noise figure in dB | 9 | 9 | 9 |  |
| BS-UE path-loss model | TR36.942 macro urban | TR38.803  | TR 38.901 |  |
| Standard deviation of BS-UE log-normal shadow fading in dB | 10 | 10 | Deployment scenario related, referring to TR 38.901. |  |
| Shadowing correlation | Inter-cell 0.5 intra-cell 1 | Inter-cell 0.5 intra-cell 1 |  |  |
| Link-level performance model |  |  section 2.9  |  |  |
| UE distribution |  |  | Uniform |  |
| Evaluation metrics | SINR vs ACS (as victim) | SINR and throughput loss vs standalone NB-IoT ACLR (as victim);  | Throughput loss, referring to TR 38.803 section 5.2.7 |  |

Table 2.3-6 Deployment-related parameters of TN (2 GHz) (Used with ‘Option-2’ above, R4-2105045 Samsung)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Urban Macro | Suburban Macro | Rural Macro | Remarks |
| Cell radius in meters | 500 | 1000 | 5000 | ITU-R Report M.2292 |
| BS Antenna height in meters | 25 | 30 | 30 |
| **Base Station Antenna Characteristics** |
| Antenna Pattern | TR 37.842 Section 5.3.3 | TR 37.842 |
| Element Gain in dBi | 6.4 | 7.1 | 7.1 | 3GPP LS to ITU-R WP5D RP-200559andITU-R WP5D[IMT\_Parameters] |
| H and V 3dB beamwidth of single element in degree | 90º for H65º for V | 90º for H54º for V | 90º for H54º for V |
| H and V front-to-back ratio in dB | 30 for both H/V | 30 for both H/V | 30 for both H/V |
| Antenna polarization | Linear ±45º | Linear ±45º | Linear ±45º |
| Antenna array configuration (Row × Column) | 8 x 8 elements | 8 x 8 elements | 8 x 8 elements |
| Horizontal/Vertical radiating element spacing | 0.5 of wavelength for H, 0.7 of wavelength for V | 0.5 of wavelength for H, 0.9 of wavelength for V | 0.5 of wavelength for H, 0.9 of wavelength for V |
| Conducted power per antenna element in dBm | 25 | 25 | 25 |
| Mechanical downtilt in degree | 10 | 6 | 3 |
| **UE Parameters** |
| UE Outdoor/indoor | 100% Outdoor |  |
| UE height in meter | 1.5 | 1.5 | 1.5 | 3GPP LS to ITU-R WP5D RP-200559andITU-R WP5D[IMT\_Parameters] |
| Minimum BS-UE distance in meter | 35 | 35 | 35 |

 ]

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

Table 2.3-7 ACLR/ACS for TN (2GHz)

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

## Antenna and beam forming pattern modelling

### 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 38.821.

**Satellite antenna pattern**

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 normalized gain pattern for a = 10 c/f (aperture radius of 10 wavelengths) is shown in Figure 2.4.1-1.

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**Figure 2.4.1-1: Satellite antenna gain pattern for aperture radius 10 wavelengths, *a*=10 *c*/*f***

**Satellite and UE beam forming pattern**

The following table is agreed for the beam layout definition for a single satellite simulation in S-Band.

Table 2.4.1-1: 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 = sqrt(3) x sin(HPBW/2 [rad]) |
| Central beam bore sight direction definition | Baseline: Case 1: Central beam center is considered at nadir point |
| Frequency re-use factor | Option 1: 1Option 2: 3Option 3: 2 if polarization re-use is enabled |
| Polarization re-use | Option 1: DisableOption 2: EnableNote: Polarization re-use should apply only if circular polarization for terminal antenna is considered  |
| ~~Channel model~~ | ~~Large scale model of [2] (Note 2)~~ |
| ~~Deployment scenarios~~ | ~~Base-line: Rural~~~~Additional deployment scenario results can be provided~~ |
| ~~Propagation conditions~~ | ~~Base-line:~~ ~~Clear Sky~~~~Line of sight~~ |
| UEs outdoor/indoor distribution | 100% outdoor distribution for UEs |
| UE distribution | ~~Base-line for calibration: at least X=10 UEs per beam with uniform distribution in all the Voronoi cell area associated to each beam.~~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 | ~~VSAT and Others: Ideal Tracking serving beam;~~Handheld: Random |
| ~~Handover Margin~~ | ~~0 dB~~ |
| UE attachment | RSRP |
| ~~Metrics for calibration~~ | ~~Base-line: Coupling loss, Geometry~~~~Note: Coupling loss is defined as the signal loss from the antenna port to the antenna port~~ |
| 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). The atmospheric absorptions loss shall be considered. |

### HAPS antenna and beam forming pattern modeling

Refer to R4-2106106.

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

**BS antenna**

For AAS antennas, refer to Table 2.3-2.

Non-AAS antennas also needs to be considered. [To consider one candidate as below:

For non-AAS antennas, the parameter in Table 2.4.3-1 can be used for 2GHz BS antenna pattern in the NTN system simulation. For UE antenna, an omni-directional radiation pattern with antenna gain 0dBi is assumed

Table 2.4.3-1 FR1 BS 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* | 12 dBi  |

**]**

**UE antenna**

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

## Propagation model

### Propagation model between NTN and UE

Propagation model between NTN and UE could be referred to section 6.6 in TR 38.811.

### 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.

### Propagation model between NTN BS and TN BS

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

### Propagation model between HAPS BS and UE

Propagation model between HAPS BS and UE is defined in TR 38.811

## Transmission power control model

### TN UL TPC

For uplink scenario, TPC model specified in Section 9.1 TR 36.942 could be 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,

### NTN UL TPC

[FFS: Adopt the same TPC model of TN for NTN UL scenarios but needs to revise CLx-ile to align with UE UL power control parameters used in TR38.821.]

### DL TPC

For downlink scenario, no power control scheme is applied.

## 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).

## Performance metric

**For NR,**

The average throughput loss and 5%-ile throughput loss should be less than 5%.

**For NB-IOT,**

The average throughput loss and SNR loss, 5%-ile throughput loss and SNR loss should be according to 36.802

**For NTN,**

[FFS: Apply same criteria with TN if NTN performance metrics values can be considered different as for TN.]

## Throughput ~ SNR mapping

Adopt Section 5.2.7 of TR 38.803 as the SINR-Throughput performance metrics, but α, SNIRMIN, and SNIRMAXneed to be further studied and decided for NR NTN.

# Conclusion

It is proposed to use the simulation assumptions in this paper as the starting point for NTN co-existence study.

# Reference

[1] [R4-21060148\_Summary\_308\_2nd round]