3GPP TSG-RAN WG4 (Radio) Meeting # 95-e R4-2006107

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**Agenda Item:** **11.1.3**

**Source: Nokia, Nokia Shanghai Bell**

**Title:** **TP to TR 38.9xx: System level simulation methodology and assumptions for study on IMT parameters for frequency ranges 6.425-7.125GHz and 10.0-10.5GHz**

**Document for:** **Approval**

**1. Introduction**

The study item on IMT parameters for frequency ranges 6.425-7.125GHz and 10.0-10.5GHz was approved at TSG RAN#87-e [1]. The purpose of this study item is to study the IMT parameters relevant for sharing and compatibility for the following frequencies:

* 6425-7025MHz and 7025-7125MHz.
* 10000-10500MHz.

This study item aims as answering requests from ITU-R WP5D regarding NR in these frequencies for IMT [2]. Two set of parameters requested by ITU-R WP5D are the ACLR and ACS of BS and UE in these frequencies. Currently, different sets of ACLR and ACS are specified in RAN4 specifications [3, 4, 5] for NR BS and UE in FR1 and FR2 based on coexistence studies as recorded in TR 38.803 [6]. Therefore, coexistence studies will need to be carried out to provide answers to ITU-R WP5D on these parameters with sound technical justifications from coexistence perspective. The WF on the simulation assumptions for the coexistence study was agreed in RAN4#94-e-Bis [7], where most of the simulation assumptions were finalized, except the BS noise figure at 7GHz and the uplink transmission power control model. Note that the AAS BS antenna characteristics were pointed to the WF agreed in [8], where some parameters were FFS.

This contribution provides proposals to finalize the simulation assumptions of the BS noise figure at 7GHz and the uplink transmission power control model, and a TP to record the system level simulation methodology and assumptions in the agreed TR skeleton [9].

**2. Discussion**

For the urban macro BS noise figure at 7GHz, 5dB and 7dB were listed as options in [7]. This is like the situation in the NR SI phase when both 9dB and 11dB were listed as options in [6] where the recorded simulation results showed that there is marginal differences between these two values. Therefore, it is proposed to keep both options in order to progress the uplink simulation work.

**Proposal 1: To keep both 5dB and 7dB as options for the urban macro BS noise figure at 7GHz in the simulation assumptions.**

For the uplink transmission power control model, the current formula for CLx-ile in [6] is:

- CLx-ile = 88 + 10\*log10(200/X), where X is UL transmission BW (MHz)

Here the value 88 was calculated using 23dBm UE maximum output power, 200MHz channel bandwidth and 11dB BS noise figure to target 15dB uplink SINR:

- 88 = 23 – [10\*log10(200e6) + 11 – 174] – 15

As both the channel bandwidth and BS noise figure are changed, it is proposed to update the formula for CLx-ile to include the impact of the BS noise figure:

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

Note that the power control equation in [10] will wholly compensate for the path coupling loss CL, which is defined as max{path loss-G\_Tx-G\_Rx, MCL}, where path loss is propagation loss plus shadowfading, G\_TX is the transmitter antenna gain in the direction of the receiver, G\_RX is the receiver antenna gain in the direction of the transmitter. Therefore, any change in the AAS BS antenna characteristics should not impact the CLx-ile value.

**Proposal 2: To update the formula for CLx-ile to** **include the impact of the BS noise figure:**

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

**3. Conclusion**

This contribution has provided proposals to finalize the simulation assumptions of the urban macro BS noise figure at 7GHz and the uplink transmission power control model, and a TP to record the system level simulation methodology and assumptions in the agreed TR skeleton.

It is proposed to approve the TP in the following section. Note that the AAS BS antenna characteristics which were FFS in [8] are marked as TBD in the TP.

**4. Text proposal**

**<Start of text proposal>**

4.2 Co-existence simulation assumption

4.2.1 Network layout model

4.2.1.1 Urban macro

Details on urban macro network layout model are listed in Tables 4.2.1.1-1 and 4.2.1.1-2.

**Table 4.2.1.1-1: Single operator layout for urban macro**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Values** | **Remark** |
| Network layout | hexagonal grid, 19 macro sites, 3 sectors per site with wrap around |   |
| Inter-site distance | 0.45 km (urban)0.9 km (suburban) | Based on cell radius:0.3 km (urban)0.6 km (suburban) |
| BS antenna height | 20 m (urban)25 m (suburban) |   |
| UE location [6] | Outdoor/indoor | Outdoor and indoor |   |
| Indoor UE ratio | 20% |  |
| Low/high Penetration loss ratio | 50% low loss, 50% high loss |   |
| LOS/NLOS | LOS and NLOS |  |
| UE antenna height | Same as 3D-UMa in TR 36.873 |   |
| UE distribution (horizontal) | Uniform |   |
| Minimum BS - UE distance (2D) | 35 m |   |
| Channel model | UMa |  |
| Shadowing correlation | Between cells: 1.0Between sites: 0.5 |   |

**Table 4.2.1.1-2: Multi operators layout for urban macro**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Values** | **Remark** |
| Multi operators layout | coordinated operation (0% Grid Shift) and un-coordinated operation (100% Grid Shift) | RAN4 has long been using un-coordinated operation in below 6GHz coexistence simulation |

|  |  |
| --- | --- |
| Coordinated Operation: each network with co-location of sites | zero grade shift macro |

**Figure 4.2.1.1-1: Coordinated operation**

|  |  |
| --- | --- |
| Uncoordinated Operation: second network’s sites are located at the first network’s cell edge | cell_layout2 |

**Figure 4.2.1.1-2: Uncoordinated operation**

4.2.1.2 Dense urban

It is agreed to down-prioritized the dense urban scenario in this coexistence study, because it has the least demanding ACIR requirements among the three simulated scenarios in TR 38.803.

4.2.1.3 Indoor

Details on indoor network layout model are listed in Tables 4.2.1.3-1 and 4.2.1.3-2.

**Table 4.2.1.3-1: Single operator layout for indoor**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Values** | **Remark** |
| Network layout | 50m x 120m, 12BSs |   |
| Inter-site distance | 20m |   |
| BS antenna height | 3 m | ceiling |
| UE location | Outdoor/indoor | Indoor |   |
| LOS/NLOS | LOS and NLOS |  |
| UE antenna height | 1 m |  |
| UE distribution (horizontal) | Uniform |   |
| Minimum BS - UE distance (2D) | 0 m |   |
| Channel model | Indoor Office |  |
| Shadowing correlation | NA |   |

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**Figure 4.2.1.3-1: Network layout for indoor**

**Table 4.2.1.3-2: Multi operators layout for indoor**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Values** | **Remark** |
| Multi operator layout | Coordinated operation (0% Grid Shift) |  |

4.2.2 Propagation model

4.2.2.1 Path loss

The pathloss models are summarized in Table 4.2.2.1-1 and the distance definitions are indicated in Figures 4.2.2.1-1 and 4.2.2.1-2. Note that the distribution of the shadow fading is log-normal, and its standard deviation for each scenario is given in Table 4.2.2.1-1.

|  |  |
| --- | --- |
|  |  |
| **Figure 4.2.2.1-1: Definition of *d2D* and *d3D* for outdoor UTs** | **Figure 4.2.2.1-2: Definition of *d2D-out*, *d2D-in* and *d3D-out*, *d3D-in* for indoor UTs.**  |

Note that

 (4.2.2-1)

**Table 4.2.2.1-1: Pathloss models**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Scenario** | **LOS/NLOS** | **Pathloss [dB], *fc* is in GHz and *d* is in meters, see note 4** | **Shadow** **fading** **std [dB]** | **Applicability range,** **antenna height** **default values**  |
| **UMa** | **LOS** | , see note 1 |  |  |
| **NLOS** | for  |  | Explanations: see note 3 |
| Optional  |  |  |
| **InH - Office** | **LOS** |  |  |  |
| **NLOS** |  |  |  |
| Optional  |  |  |
| **InF** | **LOS** |  |  |  |
| **NLOS** | InF-SL: |  |
| InF-DL: |  |
| InF-SH:  |  |
| InF-DH:  |  |
| Note 1: Breakpoint distance *d*'BP = 4 *h*'BS *h*'UT *f*c/*c*, where *f*c is the centre frequency in Hz, *c* = 3.0×108 m/s is the propagation velocity in free space, and *h*'BS and *h*'UT are the effective antenna heights at the BS and the UT, respectively. The effective antenna heights *h*'BS and *h*'UT are computed as follows: *h*'BS = *h*BS – *h*E, *h*'UT = *h*UT – *h*E, where *h*BS and *h*UT are the actual antenna heights, and hE is the effective environment height. For UMi *h*E = 1.0m. For UMa *h*E=1m with a probability equal to 1/(1+C(*d*2D, *h*UT)) and chosen from a discrete uniform distribution uniform(12,15,…,(*h*UT-1.5)) otherwise. With C(*d*2D, *h*UT) given by , where .  Note that *h*E depends on *d*2D and *h*UT and thus needs to be independently determined for every link between BS sites and UTs. A BS site may be a single BS or multiple co-located BSs.Note 2: The applicable frequency range of the PL formula in this table is 0.5 < *fc* < *f*H GHz, where *f*H = 30 GHz for RMa and *f*H = 100 GHz for all the other scenarios. It is noted that RMa pathloss model for >7 GHz is validated based on a single measurement campaign conducted at 24 GHz.Note 3: UMa NLOS pathloss is from TR36.873 with simplified format and PLUMa-LOS = Pathloss of UMa LOS outdoor scenario.Note 4: *fc* denotes the center frequency normalized by 1GHz, all distance related values are normalized by 1m, unless it is stated otherwise. |

4.2.2.2 LOS probability

The Line-Of-Sight (LOS) probabilities are given in Table 4.2.2.2-1.

**Table 4.2.2.2-1 LOS probability**

|  |  |
| --- | --- |
| **Scenario** | **LOS probability (distance is in meters)** |
| UMa | where |
| Indoor - Mixed office |  |
| Indoor - Open office |  |
| Note: The LOS probability is derived with assuming antenna heights of 3m for indoor, 10m for UMi, and 25m for UMa |

* + 1. O-to-I penetration loss

4.2.2.3.1 O-to-I building penetration loss

The pathloss incorporating O2I building penetration loss is modelled as in the following:

 (4.2.2-2)

where is the basic outdoor path loss given in Section 4.2.2.1, where is replaced by . is the building penetration loss through the external wall, is the inside loss dependent on the depth into the building, and σ*P* is the standard deviation for the penetration loss.

 is characterized as:

 (4.2.2-3)

 is an additional loss is added to the external wall loss to account for non-perpendicular incidence; , is the penetration loss of material *i*, example values of which can be found in Table 4.2.2.3-1; is proportion of *i*-th materials, where ; and *N* is the number of materials.

**Table 4.2.2.3-1: Material penetration losses**

|  |  |
| --- | --- |
| **Material** | **Penetration loss [dB]** |
| Standard multi-pane glass |  |
| IRR glass |  |
| Concrete |  |
| Wood |  |
| Note: f is in GHz |

Table 4.2.2.3-2 gives , and σ*P* for two O2I penetration loss models. The O2I penetration is UT-specifically generated and is added to the SF realization in the log domain.

**Table 4.2.2.3-2: O2I building penetration loss model**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Path loss through external wall:** **in [dB]** | **Indoor loss:** **in [dB]** | **Standard deviation:****σ*P* in [dB]** |
| **Low-loss model** |  | 0.5  | 4.4 |
| **High-loss model** |  | 0.5  | 6.5 |

 is minimum of two independently generated uniformly distributed variables between 0 and 25 m for UMa and UMi-Street Canyon, and between 0 and 10 m for RMa. shall be UT-specifically generated.

Both low-loss and high-loss models are applicable to UMa and UMi-Street Canyon.

Only the low-loss model is applicable to RMa.

Only the high-loss model is applicable to InF.

4.2.2.3.2 O-to-I car penetration loss

The pathloss incorporating O2I car penetration loss is modelled as in the following:

 (4.2.2-4)

where is the basic outdoor path loss given in Section 4.2.2.1. *μ* = 9, and σ*P* = 5. The car penetration loss shall be UT-specifically generated. Optionally, for metallized car windows, *μ* = 20 can be used. The O2I car penetration loss models are applicable for at least 0.6-60 GHz.

4.2.3 Antenna and beam forming pattern modelling

4.2.3.1 General

A general antenna model is a uniform rectangular panel array, comprising MgNg panels, as illustrated in Figure 4.2.3.1-1.

- Mg is number of panels in a column

- Ng is number of panels in a row

- Antenna panels are uniformly spaced in the horizontal direction with a spacing of *dg,H* and in the vertical direction with a spacing of *dg,V*.

- On each antenna panel, antenna elements are placed in the vertical and horizontal direction, where N is the number of columns, M is the number of antenna elements with the same polarization in each column.

- Antenna numbering on the panel illustrated in Figure 4.2.3.1-1 assumes observation of the antenna array from the front (with x-axis pointing towards broad-side and increasing y-coordinate for increasing column number).

- The antenna elements are uniformly spaced in the horizontal direction with a spacing of *dH* and in the vertical direction with a spacing of *dV*.

- The antenna panel is either single polarized (P=1) or dual polarized (P=2).

The rectangular panel array antenna can be described by the following tuple .

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**Figure 4.2.3.1-1: General antenna model**

For a uniformly distributed array (ULA) antenna, as shown in Figure 4.2.3.1-2, the radiation elements are placed uniformly along the vertical **z**-axis in the Cartesian coordinate system. The **x-y** plane constructs the horizontal plane. A signal acting at the array elements is in the direction of **u**. The elevation angle of the signal direction is denoted as (defined between 0° and 180°, 90° represents perpendicular angle to the array antenna aperture) and the azimuth angle is denoted as (defined between -180° and 180°).

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**Figure 4.2.3.1-2: Antenna Array Geometry**

The linear phase progression-based beamforming is assumed, as described in Table 4.2.3.1-1.

**Table 4.2.3.1-1: Composite antenna pattern**

|  |  |
| --- | --- |
| **Parameter** | **Values** |
| Composite Array radiation pattern in dB  | For beam i:the super position vector is given by:the weighting is given by: |

In this simulation, there is one beam formed using all the antenna elements. Each beam is directed to one scheduled UE.

Note the above gives the correct antenna array radiation pattern, however the correct gain is only achieved if the element pattern is selected for the exact element spacing. For other element spacings, the element pattern must be separately calculated such that it is correct for the element spacing (*dg,H and dg,V*). If is not linked to the element spacing, then the calculated absolute gain may diverge from the correct value in a manner that varies as the beam is steered.

The correct composite array radiation pattern directivity(D) is given by:

 ,

The composite array radiation pattern gain can then be calculated as:

Where L is the Loss associated with the antenna. This is currently included in the estimate for element gain , and is 1.8dB.

4.2.3.2 BS Antenna modelling

4.2.3.2.1 Urban macro scenario

**Table 4.2.3.2.1-1: BS antenna modelling for Urban macro scenario**

|  |  |
| --- | --- |
| **Parameter** | **Values** |
| Antenna element vertical radiation pattern (dB) |  |
| Antenna element horizontal radiation pattern (dB) |  |
| Combining method for 3D antenna element pattern (dB) |  |
| Maximum directional gain of an antenna element *GE,max* | 5.5 dBi |
| (Mg, Ng, M, N, P) note | (1, 1, 8, 8, 2) |
| (dv, dh) | (0.5λ, 0.5λ) |
| Note: An additional 3dB gain is added to the total beamforming gain to account for the two polarization directions. Boresight direction is horizontal. |

4.2.3.2.2 Dense urban scenario

It is agreed to down-prioritized the dense urban scenario in this coexistence study, because it has the least demanding ACIR requirements among the three simulated scenarios in TR 38.803.

4.2.3.2.3 Indoor scenario

Omnidirectional antenna with 0dBi gain.

4.2.3.3 UE antenna element pattern

Omnidirectional antenna with 0dBi gain.

4.2.4 Transmission power control model

For downlink scenario, no power control scheme is applied.

For uplink scenario, TPC model specified in Section 9.1 TR 36.942 is applied with following parameters.

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

- γ = 1

4.2.5 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).

4.2.6 ACLR and ACS modelling

For DL it seems reasonable from the perspective of simulating worst case scenarios that we assume BS ACLR is modelled as flat in space, and the UE ACS can be modelled flat in space.

If this assumption is for DL, then the similar assumption could be made for the UL because:

- UE has a much small number of antennas, thus the effect of directivity should be smaller for ACLR (or the adjacent channel interference). It can also be reasonably assumed that the UE ACLR will play a dominant role than the BS ACS in the adjacent channel interference.

- Again, BS ACS flat in space might mean worse coexistence performance than actual performance because BS has better capability of steering its receive antennas to suppress interference.

If a UE occupies a smaller bandwidth than the channel bandwidth for transmission, a two stop ACLR model could be considered in frequency to avoid overly estimating interference, as done in E-UTRA coexistence study (as recorded in TR 36.942).

Therefore, it is assumed that both ACLR (or the adjacent channel interference) and ACS are flat in both space and frequency. The ACIR model can be express as

 

(assuming ACLR, ACS and ACIR to be linear).

4.2.7 Link level performance for 5G NR coexistence

The throughput of a modem with link adaptation can be approximated by an attenuated and truncated form of the Shannon bound. (The Shannon bound represents the maximum theoretical throughput than can be achieved over an AWGN channel for a given SNIR). The following equations approximate the throughput over a channel with a given SNIR, when using link adaptation:

Where:

S(SNIR) Shannon bound, S(SNIR) =log2(1+SNIR) bps/Hz
α Attenuation factor, representing implementation losses
SNIRMIN Minimum SNIR of the code set, dB
SNIRMAX Maximum SNIR of the code set, dB

The parameters α, SNIRMIN and SNIRMAX can be chosen to represent different modem implementations and link conditions. The parameters proposed in Table 4.2.7-1 represent a baseline case, which assumes:

- 1:1 antenna configuration

- AWGN channel model

- Link Adaptation (see Table 4.2.7-1 for details of the highest and lowest rate codes)

- No HARQ

**Table 4.2.7-1: Parameters describing baseline Link Level performance for 5G NR**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter**  | **DL**  | **UL**  | **Notes**  |
| α, attenuation  | 0.6  | 0.4  | Represents implementation losses  |
| SNIRMIN, dB  | -10  | -10  | Based on QPSK, 1/8 rate (DL) & 1/5 rate (UL)  |
| SNIRMAX, dB  | 30  | 22  | Based on 256QAM 0.93(DL) & 64QAM 0.93 (UL)  |

Note that the parameters proposed in Table 4.2.7-1 are targeted for eMBB coexistence scenario.

4.2.8 Other simulation parameters

**Table 4.2.8-1: Other simulation parameters**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Indoor** | **Urban macro** | **Dense urban** |
| **Carrier frequency** | 7GHz, 10GHz | 7GHz, 10GHz | Down-prioritized |
| **Channel bandwidth** | 100MHz | 100MHz | Down-prioritized  |
| **Scheduled channel bandwidth per UE (DL)** | 100MHz | 100MHz | Down-prioritized  |
| **Scheduled channel bandwidth per UE (UL)** | 100MHz | 100MHz | Down-prioritized  |
| **The number of active UE (DL)** | Same as the number of BS beam | Same as the number of BS beam | Down-prioritized |
| **The number of active UE (UL)** | Same as the number of BS beam | Same as the number of BS beam | Down-prioritized |
| **Traffic model** | Full buffer | Full buffer | Down-prioritized |
| **DL power control** | NO | NO | Down-prioritized |
| **UL power control** | YES | YES | Down-prioritized |
| **BS max TX power in dBm** | 24 | 43 | Down-prioritized |
| **UE max TX power in dBm** | 23 or 20 (Note 1) | 23 or 20 (Note 1) | Down-prioritized |
| **UE min TX power in dBm** | -33 | -33 | Down-prioritized |
| **BS Noise figure in dB** | 7 | 6 (@7GHz)7 (@10GHz) | Down-prioritized |
| **UE Noise figure in dB** | 9 | 9 | Down-prioritized |
| **Handover margin** | 3dB | 3dB | Down-prioritized |
| Note 1: 20dBm as optional case where CLx-ile should be reduced by 3dB |

4.2.9 Co-existence simulation methodology

Adopt following simulation steps.

1. Aggressor and victim network are generated.

- UEs are distributed randomly across the network.

2. UE associations: UEs are associated to base station based on coupling loss.

- Associations are made assuming a single element at both UE and BS.

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.

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

- , where is the inter-cell interference.

5. Throughput is computed considering ACI as below:

- , where is the adjacent channel interference.

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

- .

**<End of text proposal>**

**References**

[1] RP-200513, “New SI proposal: Study on IMT parameters for 6.425-7.025GHz, 7.025-7.125GHz and 10.0-10.5GHz”, Ericsson, Huawei, HiSilicon.

[2] RP-200042, “LS on parameters of terrestrial component of IMT for sharing and compatibility studies in preparation for WRC-23”, ITU-R WP5D.

[3] 3GPP TS 38.101-1 v16.3.0, “NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone”.

[4] 3GPP TS 38.101-2 v16.3.0, “NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone”.

[5] 3GPP TS 38.104 v16.3.0, “NR; Base Station (BS) radio transmission and reception”.

[6] 3GPP TR 38.803 v14.2.0, “Study on new radio access technology: Radio Frequency (RF) and co-existence aspects”.

[7] R4-2005174, “WF on Simulation Assumptions for the SI on 6.425-7.125GHz and 10.0-10.5GHz”, Nokia, Ericsson, ZTE.

[8] R4-2005173, “WF on BS Antenna parameters for the SI on 6.425-7.125GHz and 10.0-10.5GHz”, Huawei.

[9] R4-2004477, “TR Skeleton on parameters for IMT studies on 6.425-7.025GHz, 7.025-7.125GHz and 10.0-10.5 GHz”, Huawei, HiSilicon.

[10] 3GPP TR 36.942 v15.0.0, “Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Frequency (RF) system scenarios”.