**3GPP TSG- Meeting #**

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| *CR-Form-v12.3* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  |  | **CR** |  | **rev** |  | **Current version:** |  |  |
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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME |  | Radio Access Network | **X** | Core Network |  |

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|  | | | | | | | | | | |
| ***Title:*** | Correction of channel modeling enhancements for 7 - 24 GHz | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | , Nokia | | | | | | | | | |
| ***Source to TSG:*** |  | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** |  | | | | |  | ***Date:*** | | |  |
|  |  | | | |  | |  | | |  |
| ***Category:*** |  |  | | | | | ***Release:*** | | |  |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-17 (Release 17) Rel-18 (Release 18) Rel-19 (Release 19)  Rel-20 (Release 20)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | (1) max subscript typo in Table 7.3-2 has been identified and it may lead to incorrect understanding of angle range.  (2) incorrect copy of equation 7.3 to 7.3-3a has been identified and it may lead to incorrect implementation of antenna polarization model 1.  (3) In TR38.901, for angle scaling of CDL models, the scaling factors of ZOA in Table 7.7.5.1-1 are the same as these of ZOD, which is not correct. In addition, there is an typo in Appendix A.5 for angle scaling.  (4) incorrect section referenced in Note of Table 7..7.5.1-1.;  (5) Typo of “antenna” in Table 7.8-2A.  (6) In the current TR 38.901 [1], antenna element-wise angular-domain parameters are introduced to additionally model the antenna element-wise field patterns for the NLOS channel impulse response in the near-field channel model. However, the definitions of these antenna element-wise angular-domain parameters are missing, leading to ambiguity in their interpretation.  (7) Ambiguous application of antenna polarization for the handheld UT antenna.  (8) Table 7.8-7 is enumerated twice, and Table 7.8-8 and 7.8-9 appears before Table 7.8-7 and therefore require changes to the enumeration.  (9) Tdoc number R1-2404960 in Clause 4 is a mistake.  (10) Companies have provided updated channel model calibration results based on TR 38.901 v19.0.0. The updated calibration results is uncaptured in the TR.  (11) variable K is being used for Rician factor and number of blockers in the TR. However, Clause 3.3. definition for K clearly describes K being Rician factor. Causing potential confusion.  (12) Breaking up the cluster and ray scaling angles for CDL angle scaling, such that other WG may be able to reference the TR easily. Also improves readability of the angle scaling for CDL models.  (13) Ambiguous orientation antenna radiation power pattern for pattern defined in Table 7.3-2.  (14) spelling mistake for “probability” and “vegetation” in Table 7.8-1A of Clause 7.8.  (15) -25dB threshold to remove weak powered clusters may remove more than necessary number of clusters in case of LOS scenarios.  (16) The reference handheld UT antenna model after antenna placement has majority of the antenna field pattern strength in domain and therefore field strength is concentrated in polarization domain. This may not be able to reflect UE antenna design. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | (1) removal of max subscript from horizontal cut of radiation power pattern in Table 7.3-2.  (2) correction of sin theta prime to cos theta prime in equation 7.3-3a.  (3) In TR38.901, for angle scaling of CDL models, the scaling factors of ZOA in Table 7.7.5.1-1 are changed to correct values. In Appendix A.5, P\_m is changed to P\_n.  (4) correcting section reference from Annex A.3 to A.5 in in Note of Table 7.7.5.1-1.  (5) Correct typo for “antenna” in Table 7.8-2A.  (6) Add definitions for the antenna element-wise angular-domain parameters in equation 7.6-49 of TR 38.901 [1], which are introduced for modelling the antenna element-wise field patterns.  (7) Clarify the polarization equation for handheld UT  (8) Table 7.8-7 in Clause 7.8.3 is changed to Table 7.8-6A. Table 7.8-8 and 7.8-9 are changed to Table 7.8-6B and 7.8-6C.  (9) Correcting Tdoc number typo in Clause 4 from R1-2404960 to R1-2504960.  (10) Update the calibration result Tdoc from R1-2504791 to R1-2506406 in Section 7.8.  (11) Update variable K used for number of blockers in Clause 7.6.4 to Kblock.  (12) introduce an intermediate variable to represent cluster angles, which are the angles being scaled by the model.  (13) Clarify that antenna radiation power pattern in Table 7.3-2 is oriented in and direction and final antenna field pattern for each antenna element should be rotated according to descriptions in the TR.  (14) Correct the spelling mistake for “probability” and “vegetation” in Table 7.8-1A.  (15) Clarify the equation 7.5-6 is used for weak power cluster removal for all cases, NLOS and LOS.  (16) Add optional polarization rotation of 45 degree to the reference UT antenna model | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | (1) ambiguous math notation for range of angles.  (2) incorrect angle calculation for polarization model 1.  (3) Incorrect scaling of ZOA for CDL models.  (4) incorrect reference of the equations used to derivation of the scaling value for CDL model angle changes.  (5) mis-spelled word in TR.  (6) The expression for the angular-domain parameters in equation 7.6-49 of TR 38.901 [1] remains undefined, resulting in ambiguity and potential inconsistency in implementation.  (7) Polarization application for handheld UT is ambiguous and can lead to companies with different implementation.  (8) Duplicate Table numbers and wrong ordering of Tables.  (9) Reference to wrong Tdoc.  (10) outdated calibration results are present in the TR.  (11) Ambiguous usage of K variable for two different functionality.  (12) Difficult for WGs to identify scaled angle component in CDL models.  (13) Ambiguous antenna radiation power pattern orientation could lead to incorrect implementation of the final handheld UT antenna field patterns among companies.  (14) Spelling mistake in TR.  (15) Removal of too many weak powered clusters in case of LOS scenarios.  (16) Reference handheld UT antenna model captured in TR is unable to reflect antenna design that has antenna field strength in both polarization domain. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 4, 7.3.0, 7.3.2, 7.5, 7.6.4.1, 7.6.4.2, 7.6.13, 7.7.5.1, 7.8.1, 7.8.2, 7.8.3, A.5 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  |  | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | |  |  | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  |  | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

# 4 Introduction

At TSG RAN #69 meeting the Study Item Description on "Study on channel model for frequency spectrum above 6 GHz" was approved [2]. This study item covers the identification of the status/expectation of existing information on high frequencies (e.g. spectrum allocation, scenarios of interest, measurements, etc), and the channel model(s) for frequencies up to 100 GHz. This technical report documents the channel model(s). The new channel model has to a large degree been aligned with earlier channel models for <6 GHz such as the 3D SCM model (TR 36.873) or IMT-Advanced (ITU-R M.2135). The new model supports comparisons across frequency bands over the range 0.5-100 GHz. The modelling methods defined in this technical report are generally applicable over the range 0.5-100 GHz, unless explicitly mentioned otherwise in this technical report for specific modelling method, involved parameters and/or scenario.

Subsequently, at the TSG RAN #81 meeting the Study Item Description "Study on Channel Modeling for Indoor Industrial Scenarios" was approved [23]. The findings from this study item is also captured in the present technical report. The Industrial channel model was developed by considering new measurements and information in the literature. An overview list of all such contributions and sources is available in tdoc R1-1909706.

Subsequently, at the TSG RAN #102 meeting the Study Item Description "Study on channel modelling enhancements for 7-24GHz for NR" was approved [24]. The findings from this study are also captured in the present technical report. Channel modeling was further updated by considering new measurements and information in the literature. An overview of the information sources is available in tdoc R1-2504960 [25].

*<unchanged text omitted>*

7.3.0 Antenna array structure

*<unchanged text omitted>*

- The antenna radiation power pattern of each antenna element for handheld UT is generated according to Table 7.3-2, which assumes antenna is oriented in and direction.

**Table 7.3-2: Radiation power pattern of a single antenna element for handheld UT**

|  |  |
| --- | --- |
| **Parameter** | **Values** |
| Vertical cut of the radiation power pattern (dB) |  |
| Horizontal cut of the radiation power pattern (dB) |  |
| 3D radiation power pattern (dB) |  |
| Maximum directional gain of an antenna element *GE,max* | 5.3 dBi |
| NOTE: For UT antenna modelling of handheld devices, optional antenna imbalance can be modelled. If modelled, randomized loss is applied per UT antenna port and randomized loss can be applied independently for the UL and DL directions. No imbalance is modelled by default. | |

*<unchanged text omitted>*

7.3.2 Polarized antenna modelling

In general the relationship between radiation field and power pattern is given by:

. (7.3-2)

The following two models represent two options on how to determine the radiation field patterns based on a defined radiation power pattern.

**Model-1**:

In case of polarized antenna elements assume is the polarization slant angle where degrees corresponds to a purely vertically polarized antenna element and degrees correspond to a pair of cross-polarized antenna elements. Then the antenna element field components in and direction are given by

, (7.3-3)

where

, (7.3-3a)

. (7.3-3b)

Note that the zenith and the azimuth field components , , and are defined in terms of the spherical basis vectors of an LCS as defined in Clause 7.1. The difference between the single-primed and the double-primed components is that the single-primed field components account for the polarization slant and the double-primed field components do not. For a single polarized antenna (purely vertically polarized antenna) we can write and where is the 3D antenna radiation power pattern as a function of azimuth angle and zenith angle in the LCS as defined in Table 7.3-1 converted into linear scale.

**Model-2**:

In case of polarized antennas, the polarization is modelled as angle-independent in both azimuth and elevation, in an LCS. For a linearly polarized antenna, the antenna element field pattern, in the vertical polarization and in the horizontal polarization, are given by

(7.3-4)

and

, (7.3-5)

respectively, where  is the polarization slant angle and is the 3D antenna element power pattern as a function of azimuth angle, and elevation angle, in the LCS. Note that  degrees correspond to a purely vertically polarized antenna element. The vertical and horizontal field directions are defined in terms of the spherical basis vectors, and respectively in the LCS as defined in Clause 7.1.2. Also , and as defined in Table 7.1-1.

**Handheld UT Model:**

For cases when a candidate antenna placement location is used for one antenna field pattern:

- Reference radiation pattern of the UT antenna model is vertically polarized with all the gain in the theta field component, and , and referred to as the polarization direction along the axis.

For cases when a candidate antenna placement location is used for two distinct antenna polarization field patterns:

- Reference radiation pattern of the UT antenna model is,

- For first antenna field pattern: and .

- For second antenna field pattern: and .

Each polarized field component of the reference radiation pattern and should be rotated according to the orientation and polarization direction of the each of UT antennae to get , using equation

, (7.3-6)

, (7.3-7)

, (7.3-8)

where the 3D-rotation angles, , and , are obtained according to the orientation and polarization direction of each UT antenna *u*, the zenith and azimuth angles mapping between and are based on equations (7.1-7) and (7.1-8) using the same 3D-rotation angles, , and , and rotated based on the orientation of the UT in the global coordinate system to get and using Clause 7.1.3 equation (7.1-11).

For cases when a candidate antenna placement location is used for one antenna field pattern (e.g., single polarization):

- The polarization direction is indicated by the arrow in Figure 7.3-7, which is parallel with the plane of the handheld UT and perpendicular to the direction from the UT center to the candidate antenna location.

- Optionally, polarization direction can additionally rotate 45 degrees about the direction from the UT center to the candidate antenna location (i.e. rotated using the direction from the UT center to the candidate antenna location as the rotational axis). An example for candidate antenna location (6) is given in Figure 7.3-8.

****

**Figure 7.3-7: Handheld UT antenna polarization directions for one antenna field pattern (top down view)**

For cases when a candidate antenna placement location is used for two antenna field patterns (e.g., dual polarization) (not intended for FR1):

- For the first antenna field pattern, the polarization direction is indicated by the arrows in Figure 7.3-7 but additionally rotated 45 degrees about the direction from the UT center to the candidate antenna location (i.e. rotated using the direction from the UT center to the candidate antenna location as the rotational axis).

- For the second antenna field pattern, the polarization direction is perpendicular to the polarization direction of the first filed pattern and perpendicular to the direction from the UT center to the candidate antenna location

- An example for candidate antenna location (6) is given in Figure 7.3-8.

****

**Figure 7.3-8: Handheld UT polarization direction for two antenna filed pattern (side view)**

*<unchanged text omitted>*

## 7.5 Fast fading model

*<unchanged text omitted>*

where δ(.) is Dirac's delta function and *KR* is the Ricean *K*-factor as generated in Step 4 converted to linear scale. These power values are used *only* in equations (7.5-9) and (7.5-14), but *not* in equation (7.5-22).

Assign the power of each ray within a cluster as *Pn/ M*, where *M* is the number of rays per cluster.

Remove clusters with less than -25 dB power compared to the maximum cluster power based on equation (7.5-6). The scaling factors need not be changed after cluster elimination.

*<unchanged text omitted>*

#### 7.6.4.1 Blockage model A

Model A adopts a stochastic method for capturing human and vehicular blocking.

Step a: Determine the number of blockers.

Multiple 2-dimensional (2D) angular blocking regions, in terms of centre angle, azimuth and elevation angular span are generated around the UT. There is one self-blocking region, and = 4 non-self-blocking regions, where may be changed for certain scenarios (e.g., higher blocker density). Note that the self-blocking component of the model is important in capturing the effects of human body blocking.

Step b: Generate the size and location of each blocker.

*<unchanged text omitted>*

#### 7.6.4.2 Blockage model B

Model B adopts a geometric method for capturing e.g., human and vehicular blocking.

Step a: Determine blockers

A number, *,* ofblockers are modelled as rectangular screens that are physically placed on the map. Each screen has the dimension by height () and width (), with the screen centre at coordinate .

Note:

- The number of blockers (), their vertical and horizontal extensions ( and ), locations , density, and movement pattern (if non-stationary) are all simulation assumptions, to allow different blocking scenarios to be constructed depending on the need of the particular simulation study.

Recommended parameters for typical blockers are provided in Table 7.6.4.2-5.

- The blocking effect diminishes with increasing distance to the blocker. For implementation purposes it may be sufficient to consider only the nearest blockers or the blockers closer than some distance from a specific UT.

*<unchanged text omitted>*

7.6.13 Near-field channel model

The near-field channel model is to support the simulations that involve the impacts of the spherical wavefront from the perspective of antenna array.

To model the antenna element-wise channel parameters, in the Step 11 in Clause 7.5, the following updates are considered to generate the channel impulse response:

For the NLOS channel impulse response, determine the NLOS channel coefficient for the two strongest clusters, say *n* = 1 and 2, instead of the equation (7.5-28) and forthe N – 2 weakest clusters, say n = 3, 4,…, N, using instead of equation (7.5-22).

- To model the antenna element-wise phase at TRP side, the NLOS channel coefficient, , is given by:

(7.6-47)

where, the is the spherical unit vector with azimuth departure angle and elevation departure angle for ray m of cluster n. is the vector pointing from reference point to transmit antenna element s, wherein the reference point is the physical center of the antenna array/center at Tx side. The is the distance calculated as:

,

where the refers to the 3D distance between reference point at TRP and UT side. The refers to the excess delay, which is only applicable when it’s not in LOS case, and generated according to the Clause 7.6.9, otherwise is assumed to be 0. The refers to the delay of *i*-th sub-cluster mapping to the rays defined in Table 7.5-5. The ray index, *m*, should be determined based on the sub-cluster information in Table 7.5-5. For the , if the nth cluster is one of the strongest cluster, 1, otherwise is generated according to the . The corresponding value of and Beta distribution is defined in Table 7.6-13-1, respectively.

**Table 7.6-13-1: Parameters for Uma, Umi, Indoor-Office and Indoor-Factory**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Scenarios** | | **UMa** | **UMi** | **InH** | **InF** |
| *k1* | | 2 | 2 | 4 | 4 |
| Beta distribution |  | 1.93 | 1.53 | 1.25 | 1.38 |
|  | 1.33 | 1.42 | 1.27 | 1.26 |

Optionally,

- To model the antenna element-wise phase at UT side additionally, the is given by:

(7.6-48)

where is the spherical unit vector with azimuth arrival angle and elevation arrival angle for ray m of cluster n. is the vector pointing from reference point to receive antenna element u, wherein the reference point is the physical center of the antenna array/center at Rx side. The is the distance calculated as:

where , if the nth cluster is one of the strongest cluster, otherwise . Note that it is assumed that only single non-specular interaction along with specular reflection(s) is considered in the propagation channel and most of the sources of non-specular interaction are assumed to be a point scatterer or diffractions.

- To model the antenna element-wise antenna field patterns additionally, the is given by:

, (7.6-49)

where and are the antenna element-wise elevation arrival angles and azimuth arrival angles, respectively, for ray *m* of cluster *n* for receive antenna element *u*, and and are the antenna element-wise elevation departure angles and azimuth departure angles, respectively, for ray *m* of cluster *n* for transmit antenna element *s*.

In the LOS channel impulse response, determine the LOS channel coefficient as:

- To model the antenna element-wise phase, the equation (7.5-29) in Clause 7.5 is replaced by:

(7.6-50)

where, the refers to the vector determined by the location of the th antenna element at receiver and the th antenna element at transmitter. The refers to the 3D distance between reference point at TRP and UT side, wherein the the reference point is the physical center of the antenna array/center of the device.

Optionally,

- To model the element-wise antenna field patterns additionally, the equation (7.5-29) in Clause 7.5 is replaced by:

(7.6-51)

where , , , are the respective antenna element-wise elevation arrival angles, azimuth arrival angles, elevation departure angles and azimuth departure angles of LOS path between the transmit antenna element s and receive antenna element u.

*<unchanged text omitted>*

#### 7.7.5.1 CDL extension: Scaling of angles

The angle values of CDL models are fixed, which is not very suitable for MIMO simulations for several reasons; The PMI statistics can become biased, and a fixed precoder may perform better than open-loop and on par with closed-loop or reciprocity beamforming. Furthermore, a CDL only represents a single channel realization. The predefined angle values in the CDL models can be generalized by introducing angular translation and scaling. By translation, mean angle can be changed to and angular spread can be changed to match by scaling. The translated and scaled ray angles can be obtained according to the following equation:

(7.7-5)

(7.7-5a)

(7.7-5b)

(7.7-5c)

(7.7-5d)

in which:

- is the cluster mean angle calculated using Annex A.4 with and as the input cluster angles,

- is the intermediate cluster mean angle calculated using Annex A.4 with and as input cluster angles,

- s is a scale factor chosen to change the distribution of the angles based on calculation in Annex A.5. Table 7.7.5.1-1 shows required scale factor for typical desired angular spread values for AOD, AOD, ZOA, and ZOD,

- is the tabulated CDL cluster angle,



- is the rms cluster angular spread of the tabulated CDL including the offset ray angles, calculated using the angular spread definition in Annex A.3,



- is the desired cluster mean angle,



- is the desired rms cluster angular spread,



- is the scaled CDL cluster angle of the *n*th cluster,



- is the resulting scaled ray angle that corresponds to *m*th subpath angle of *n*th cluster,



- is the cluster-wise RMS angular spread of either custer ASA, ASD, ZSA, or ZSD from Table 7.7.1-1, 7.7.1-2, 7.7.1-3, 7.7.1-4, and 7.7.1-5,

- is the offset angles from Table 7.5-3,

- is a function which wraps an azimuth angle to the half-open interval (-180, 180].

**Table 7.7.5.1-1: Scale factor values for each CDL model**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **CDL Type** | **Desired AOD Spread（°）** | **Scale Factor (AOD)** | **Desired AOA Spread（°）** | **Scale Factor (AOA)** | **Desired ZOA Spread（°）** | **Scale Factor (ZOA)** | **Desired ZOD Spread（°）** | **Scale Factor (ZOD)** |
| CDL-A | 5 | 0.0680 | 30 | 0.3531 | 5 | 0.2397 | 1 | 0.0352 |
| 10 | 0.1360 | 45 | 0.5268 | 10 | 0.4802 | 3 | 0.1056 |
| 15 | 0.2041 | 60 | 0.6981 | 15 | 0.7225 | 5 | 0.1761 |
| 25 | 0.3405 |  |  |  |  |  |  |
| CDL-B | 5 | 0.1238 | 30 | 0.5417 | 5 | 0.6519 | 1 | 0.1940 |
| 10 | 0.2475 | 45 | 0.8081 | 10 | 1.3018 | 3 | 0.5822 |
| 15 | 0.3710 | 60 | 1.0709 | 15 | 1.9480 | 5 | 0.9705 |
| 25 | 0.6168 |  |  |  |  |  |  |
| CDL-C | 5 | 0.1281 | 30 | 0.4307 | 5 | 0.6476 | 1 | 0.3643 |
| 10 | 0.2568 | 45 | 0.6447 | 10 | 1.2971 | 3 | 1.0929 |
| 15 | 0.3864 | 60 | 0.8585 | 15 | 1.9504 | 5 | 1.8219 |
| 25 | 0.6513 |  |  |  |  |  |  |
| CDL-D | 5 | 0.3231 | 30 | 9.8888 | 5 | 4.3268 | 1 | 0.4477 |
| 10 | 0.6652 | 45 | N/A | 10 | 8.8868 | 3 | 1.3469 |
| 15 | 1.0594 | 60 | N/A | 15 | 14.0344 | 5 | 2.2579 |
| 25 | 5.8637 |  |  |  |  |  |  |
| CDL-E | 5 | 0.3950 | 30 | 2.9733 | 5 | 6.9195 | 1 | 0.9714 |
| 10 | 0.8009 | 45 | N/A | 10 | 14.8378 | 3 | 2.9180 |
| 15 | 1.2330 | 60 | N/A | 15 | 27.2849 | 5 | 4.8774 |
| 25 | 2.3627 |  |  |  | 0.2397 |  |  |
| NOTE: Values of Table 7.7.5.1-1 were computed based on scaling factor calculation method described in Annex A.5. | | | | | | | | |

Alternatively, for CDL-D and CDL-E, if maintaining the LOS angle is desired, the translated and scaled ray angles can be obtained according to the following equation instead of using equation (7.7-5) and (7.7-5a):

(7.7-6)

(7.7-6a)

(7.7-6b)

in which:

- is the LOS path angle of the model,

- is the scaled CDL cluster angle of the *n*th cluster.



The angular scaling is applied on the cluster angles including offsets from the tabulated cluster angles. Typical angular spreads for different scenarios can be obtained from the system-level model.

Example scaling values are:

- AOD spread (ASD) for each CDL model: {5, 10, 15, 25} degrees.

- AOA spread (ASA) for each CDL model: {30, 45, 60} degrees.

- ZOA spread (ZSA) for each CDL model: {5, 10, 15} degrees.

- ZOD spread (ZSD) for each CDL model: {1, 3, 5} degrees.

The angular scaling and translation can be applied to some or all of the azimuth and zenith angles of departure and arrival.

Note: The azimuth angles may need to be wrapped around to be within [0, 360] degrees, while the zenith angles may need to be clipped to be within [0, 180] degrees.

*<unchanged text omitted>*

### 7.8.1 Large scale calibration

*<unchanged text omitted>*

Additional calibration parameters can be found in Table 7.8-1A. It is assumed that parameters from Table 7.8-1 is used if unspecified by the additional calibration parameters in Table 7.8-1A. In addition, calibration of UMa and UMi-Street Canyon at 6 GHz carrier frequency using simulation assumptions in Table 7.8-1 with updated channel modeling is part of the additional calibration. The calibration results based on additional calibration parameters can be found in R1-2506406.

Table 7.8-1A: Simulation assumptions for large scale calibration

|  |  |
| --- | --- |
| **Parameter** | **Values** |
| Scenarios | UMa, UMi-Street Canyon, SMa |
| Carrier Frequency | 7 GHz |
| BS antenna downtilting | Mechanical downtilt of 95 degrees for SMa for ISD = 1299m  Mechanical downtilt of 92 degrees for SMa for ISD = 1732m  Electrical downtilt in Table 7.8-1 for UMa and UMi-Street Canyon |
| BS antenna configurations | Mg = Ng = 1; (M,N,P) = (10, 1, 1), dV = 0.5λ |
| BS port mapping | Mp = 1, Np = 1, i.e., 10 elements are mapped to a single port  Mp and Np are the number of vertical, horizontal TXRUs within a panel and polarization |
| BS Tx power | 49 dBm for SMa |
| Bandwidth | 20 MHz |
| UT distribution | For SMa, 20% of UT outdoor, 80% of UT indoor. Among indoor UT, 90% of indoor UT are within residential buildings, and 10% of indoor UT in commercial buildings. Indoor UTs are uniformly distributed across all floors for a building type. |
| LOS probability | For SMa, 0% vegetation |
| O2I penetration loss | For SMa, Low-loss A model |
| O2I car penetration loss | For SMa, non-metallic car window |
| Wrapping method | For UMa, UMi-Street Canyon, SMa:  - geographical distance based wrapping (mandatory)  - radio distance (optional) |

7.8.2 Full calibration

*<unchanged text omitted>*

Additional full calibration parameters can be found in Table 7.8-2A. It is assumed that parameters from Table 7.8-2 is used if unspecified by the additional full calibration parameters in Table 7.8-2A. In addition, calibration of UMa and UMi-Street Canyon at 6 GHz carrier frequency using simulation assumptions in Table 7.8-2 with updated channel modeling is part of the additional calibration. For calibration of UMa and UMi-Street Canyon at 6 GHz, the following is additionally assumed.

- SCS of 15 kHz

- UT attachment is based on RSRP (formula) from BS port 0

- BS antenna configuration 1 and 2 both apply

- UT antenna configuration, pattern, and polarization modeling are labeled as UT antenna config A

The calibration results based on additional calibration parameters can be found in R1-2506406.

**Table 7.8-2A: Simulation assumptions for full calibration**

|  |  |
| --- | --- |
| **Parameter** | **Values** |
| Scenarios | UMa, UMi-Street Canyon, SMa |
| Carrier Frequency | 7 GHz,  (optional) 15 GHz |
| BS antenna downtilting | Mechanical downtilt of 95 degrees for SMa for ISD = 1299m  Mechanical downtilt of 92 degrees for SMa for ISD = 1732m  Electrical downtilt as in Table 7.8-1 for UMa and UMi-Street Canyon |
| BS antenna configurations | Config 3 for UMi, UMa, SMa at 7 GHz: Mg = Ng = 1, M = 8, N = 16, P = 2, dH = dV = 0.5λ … calibration metrics 1), 2), 3), 4) are calibrated  (optional) Config 4 for UMa at 7 and 15 GHz: Mg = Ng = 1, M = 64, N = 16, P = 2, Mg = 1, Ng = 1, dH = dV = 0.5λ … calibration metrics 1), 2), 3), 4) are calibrated |
| BS Polarized antenna modelling | Model-2 in Clause 7.3.2 |
| BS port mapping | Config 3 for UMi, UMa, SMa at 7 GHz: Mp = 8, Np = 16, each antenna element is mapped to one port  (optional) Config 4 for UMa at 7 and 15 GHz: Mp = 16, Np = 16  Mp and Np are the number of vertical, horizontal TXRUs within a panel and polarization |
| BS Tx power | 49 dBm for SMa |
| Bandwidth | 20 MHz for 7 GHz  (optional) 200 MHz for 7 and 15 GHz |
| UT attachment | Based on RSRP (formula) from BS port 0 |
| UT distribution | For SMa,  20% of UT outdoor, 80% of UT indoor. Among indoor UT, 90% of indoor UT are within residential buildings, and 10% of indoor UT in commercial buildings. Indoor UTs are uniformly distributed across all floors for a building type. |
| UT array orientation | Config B, C: Ω*UT,a* uniformly distributed on [0,360] degree, Ω*UT,b* = 45 degree, Ω*UT,g* = 0 degree  Config D: Ω*UT,a* = 0 degree, Ω*UT,b* = 0 degree, Ω*UT,g* = 0 degree |
| UT antenna configurations | Config B for 7 GHz: 4 antenna port with single polarization for calibration based on handheld device antenna model using candidate antenna locations (1,7,3,5) as described in Clause 7.3  (optional) Config C for 15 GHz: 16 antenna port with dual polarization based on handheld device antenna model using candidate antenna locations in (1,2,3,4,5,6,7,8) as described in Clause 7.3  (only for metric 5) Config D: 8 antenna port with single polarization based on handheld device antenna model using candidate antenna locations in (1,2,3,4,5,6,7,8) as described in Clause 7.3 |
| UT antenna pattern | Config B, C, D: Based on directional antenna for handheld UT described in Clause 7.3 |
| UT Polarized antenna modelling | Config B, C, D: Based on directional antenna for handheld UT described in Clause 7.3 |
| O2I penetration loss | For SMa, low-loss A model |
| SCS assumption | 30 kHz |
| Additional metrics | 5) Antenna field pattern of handheld UT, and , in UT LCS using UT antenna configuration D |

### 7.8.3 Calibration of additional features

The calibration parameters for the calibration of oxygen absorption, large bandwidth and large antenna array, spatial consistency, and blockage can be respectively found in Table 7.8-3, 7.8-4, 7.8-5, and 7.8-6. Unspecified parameters in these tables are the same as those in Tables 7.8-1 and 7.8-2. When P=2, X-pol (+/-45 degree) is used for BS antenna configuration 1 and X-pol (0/+90 degree) is used for UT antenna configuration. The calibration results based on TR 38.900 V14.0.0 can be found in R1-1700990.

The additional calibration parameters for the calibration of near field channel modeling, BS side spatial non-stationarity, and UT side spatial non-stationarity can be respectively found in Table 7.8-6A, 7.8-6B, and 7.8-6C. For the assumption on the aperture size of the antenna array, the following guidance is considered:

- Up to 1.5 m for UMa with maximum antenna elements in the array is 5k for single Polarization.

- Up to 1 m for UMi with maximum antenna elements in the array is 2.22k for single Polarization.

- Up to 0.71 m for Indoor factory with maximum antenna elements in the array is 1.12k for single Polarization.

- Up to 0.25 (for rectangular antenna array), 0.5 (for linear antenna array) m for Indoor office with maximum antenna elements in the array is 256, 80 for single Polarization, respectively.

The additional calibration results can be found in R1-2506406.

*<unchanged text omitted>*

Table 7.8-6A: Simulation assumptions for calibration for near field channel modeling

*<unchanged text omitted>*

Table 7.8-6B: Simulation assumptions for calibration for BS side spatial non-stationarity

*<unchanged text omitted>*

Table 7.8-6C: Simulation assumptions for calibration for UT side spatial non-stationarity

*<unchanged text omitted>*

A.5 Calculation of scaling factor for changing CDL model angular spread

The following expression for the computing scaling factor, , to achieve a specific angular spread, AS, in degrees is given by

(A-5)

(A-6)

where is the power for the *n*th cluster path, is the input cluster path angle (either AOA, AOD, ZOA, ZOD) given in degrees, is the power for the input LOS path, and is the input LOS path angle (either AOA, AOD, ZOA, ZOD) given in degrees. If input LOS path does not exist, is assumed.

*<unchanged text omitted>*