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**Agenda item: 9.3.2**

**Source: Huawei**

**Title: Summary of calibration results for IMT-2020 self evaluation**

**Document for: Approval**

# Introduction

At 3GPP TSG RAN#77 meeting, the general work plan of self evaluation is approved [1]. The three step work plan is proposed according to the agreed IMT-2020 submission timeplan as endorsed in [2]. As the first step, 3GPP agreed to conduct the calibration activity for IMT-2020 self evaluation through an email discussion in RAN ITU-R Ad-Hoc as follows

* The following email discussions are proposed for Step 1 after RAN#77
	+ Plan an email discussion in RAN ITU-R Ad-Hoc on calibration for self evaluation – Lead by Huawei (Rapporteur)
		- Including calibration detailed plan, calibration metrics, baseline parameter for calibration, test environments and evaluation configurations for calibration as defined in Report ITU-R M.[IMT-2020. EVAL], etc.
	+ ITU-R Ad-Hoc contact person will kick off the scope and timing of the E-mail discussion in the ITU-R Ad-Hoc mailing list

Based on the above agreement, ITU-R Ad-Hoc contact person set up an email discussion “[ITU-R AH 01] Calibration for self-evaluation”. This document provides the summary of the calibration activities and the calibration results derived by this email discussion.

# Scope of the discussion

The scope of this email discussion is set as follows.

* Goal: To calibrate simulations assumptions in view of self-evaluation, and provide the calibration results according to the baseline calibration parameters.

Based on the above scope, the calibration metrics and baseline parameters are discussed and captured as shown in Section 3 and 4, respectively.

# Calibration metrics for self evaluation

The following metrics are selected for calibration of self evaluation:

* DL Geometry (wideband SINR)
* Coupling gain

The above metrics are used with the cell association mechanism as defined in calibration assumptions in Section 4.

# Calibration parameters for self evaluation

This section provides baseline calibration parameters and models for the five test environments defined in Report ITU-R M.2412 (see [3]). It should be noted that these parameters are used for calibration purpose only.

## Indoor Hotspot - eMBB

The baseline parameters are provided in Table 1.

Table 1 Baseline parameter for Indoor Hotspot – eMBB

|  |  |  |  |
| --- | --- | --- | --- |
| **Indoor Hotspot - eMBB** | Config. A | Config. B | Config. C |
| Carrier frequency for evaluation | 4 GHz | 30GHz | 70GHz |
| BS antenna height | 3 m | 3 m | 3 m |
| Total transmit power per TRxP | Baseline: 21 dBm for 10MHz bandwdith | Baseline: 20 dBm for 40 MHz bandwidth | Baseline: 18 dBm for 40 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm | 21 dBm |
| Inter-site distance | 20m | 20 m | 20 m |
| Number of antenna elements per TRxP | 32Tx/Rx, (M,N,P,Mg,Ng) = (4,4,2,1,1), (dH,dV) = (0.5, 0.5)λ+45°, -45° polarization | 64Tx/Rx, (M,N,P,Mg,Ng) = (4,8,2,1,1), (dH,dV) = (0.5, 0.5)λ+45°, -45° polarization | 256Tx/Rx, (M,N,P,Mg,Ng) = (8,16,2,1,1), (dH,dV) = (0.5, 0.5)λ+45°, -45° polarization |
| Number of TXRU per TRxP | 32TXRU, (Mp,Np,P,Mg,Ng) = (4,4,2,1,1)(1-to-1 mapping) | 8TXRU, (Mp,Np,P,Mg,Ng) =(2,2,2,1,1) | 8TXRU, (Mp,Np,P,Mg,Ng)=(2,2,2,1,1) |
| Number of UE antenna elements  | 4Tx/Rx, (M,N,P,Mg,Ng) = (1,2,2,1,1), (dH,dV) = (0.5, N/A)λ0°,90° polarization | 32Tx/Rx, (M,N,P,Mg,Ng) = (2,4 ,2,1,2), (dH,dV) = (0.5, 0.5)λ(dg,V,dg,H) = (0, 0)λ. Θmg,ng=90; Ω0,1=Ω0,0+180;0°,90° polarization | 32Tx/Rx, (M,N,P,Mg,Ng) = (2,4 ,2,1,2), (dH,dV) = (0.5, 0.5)λ(dg,V,dg,H) = (0, 0)λ. Θmg,ng=90; Ω0,1=Ω0,0+180;0°,90° polarization |
| Number of TXRU per UE | 4TXRU, (Mp,Np,P,Mg,Ng) = (1,2,2,1,1)(1-to-1 mapping) | 4TXRU, (Mp,Np,P,Mg,Ng)=(1,1,2,1,2) | 4TXRU, (Mp,Np,P,Mg,Ng)=(1,1,2,1,2) |
| Device deployment | 100% indoorRandomly and uniformly distributed over the area | 100% indoorRandomly and uniformly distributed over the area | 100% indoorRandomly and uniformly distributed over the area |
| UE mobility model | Fixed and identical speed |v| of all UEs, randomly and uniformly distributed direction | Fixed and identical speed |v| of all UEs, randomly and uniformly distributed direction | Fixed and identical speed |v| of all UEs, randomly and uniformly distributed direction |
| UE speeds of interest | 3 km/h | 3 km/h | 3 km/h |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 7dB | 7dB |
| UE noise figure | 7 dB  | 10dB | 10dB |
| BS antenna element gain | 5dBi  | 5dBi | 5dBi |
| BS antenna element pattern | See Table 7 in Section 4.6 | See Table 7 in Section 4.6 | See Table 7 in Section 4.6 |
| UE antenna element gain | 0 dBi | 5dBi | 5dBi |
| UE antenna element pattern | Omni-directional | See Table 8 in Section 4.6 | See Table 8 in Section 4.6 |
| Thermal noise level | -174 dBm/Hz | -174 dBm/Hz | -174 dBm/Hz |
| Traffic model | Full buffer  | Full buffer  | Full buffer  |
| Simulation bandwidth | 10MHz | 40MHz | 40MHz |
| UE density | 10 UEs per TRxP | 10 UEs per TRxP | 10 UEs per TRxP |
| UE antenna height | 1.5m | 1.5m | 1.5m |
| Channel model variant | Alt. 1: Channel model AAlt. 2: Channel model B | (Channel model A or B is the same) | (Channel model A or B is the same) |
| TRxP number per site | 1 | 3 | 1 | 3 | 1 | 3 |
| Mechanic tilt  | 180° in GCS (pointing to the ground)Top view:  | [110°] in GCS | 180° in GCS (pointing to the ground)Top view: | [110°] in GCS | 180° in GCS (pointing to the ground)Top view: | [110°] in GCS |
| Electronic tilt | 90° in LCS | 90° in LCS | (According to Zenith angle in "Beam set at TRxP") | (According to Zenith angle in "Beam set at TRxP") | (According to Zenith angle in "Beam set at TRxP") | (According to Zenith angle in "Beam set at TRxP") |
| Handover margin (dB) | 0 (i.e., the strongest cell is selected) | 0 (i.e., the strongest cell is selected) | 0 (i.e., the strongest cell is selected) | 0 (i.e., the strongest cell is selected) | 0 (i.e., the strongest cell is selected) | 0 (i.e., the strongest cell is selected) |
| TRxP boresight   | - | 30 / 150 / 270 degrees  | - | 30 / 150 / 270 degrees | - | 30 / 150 / 270 degrees |
| UT attachment | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 | Based on RSRP (formula as shown in Appendix 3) from port 0The UE panel with the best receive SNR is chosen. i.e. no combining is done between panels. | Based on RSRP (formula as shown in Appendix 3) from port 0The UE panel with the best receive SNR is chosen. i.e. no combining is done between panels. | Based on RSRP (formula as shown in Appendix 3) from port 0The UE panel with the best receive SNR is chosen. i.e. no combining is done between panels. | Based on RSRP (formula as shown in Appendix 3) from port 0The UE panel with the best receive SNR is chosen. i.e. no combining is done between panels. |
| Wrapping around method | No wrapping around | No wrapping around | No wrapping around | No wrapping around | No wrapping around | No wrapping around |
| Minimum distance of TRxP and UE | d2D\_min=0m | d2D\_min=0m | d2D\_min=0m | d2D\_min=0m | d2D\_min=0m | d2D\_min=0m |
| Polarized antenna model | Model-2 in TR36.873 | Model-2 in TR36.873 | Model-2 in TR36.873 | Model-2 in TR36.873 | Model-2 in TR36.873 | Model-2 in TR36.873 |
| Beam set at TRxP(Constraints for the range of selective analog beams per TRxP) | - | - | For direction of TRxP analog beam steering (in LCS):Azimuth angle φi = [-3\*pi/8, -1\*pi/8, 1\*pi/8, 3\*pi/8]Zenith angle θj = [pi/4 3\*pi/4]NOTE: (azimuth, zenith)=(0, pi/2) is the direction perpendicular to the array.Precoder for beam at (phai\_i, theta\_j) is given by equation 1 in Appendix 1 (2D DFT beam) | For direction of TRxP analog beam steering (in LCS):Azimuth angle φi = [-7\*pi/16, -5\*pi/16, -3\*pi/16, -1\*pi/16, 1\*pi/16, 3\*pi/16, 5\*pi/16, 7\*pi/16]Zenith angle theta\_j = [pi/8 3\*pi/8 5\*pi/8 7\*pi/8]NOTE: (azimuth, zenith)=(0, pi/2) is the direction perpendicular to the array.Precoder for beam at (phai\_i, theta\_j) is given by equation 1 in Appendix 1 (2D DFT beam) |
| Beam set at UE(Constraints for the range of selective analog beams for UE) | - | - | For direction of UE analog beam steering (in LCS):Azimuth angle φi = [-3\*pi/8, -pi/8, pi/8, 3\*pi/8];Zenith angle θj = [pi/4, 3\*pi/4];NOTE: (azimuth, zenith)=(0, pi/2) is the direction perpendicular to the array.Precoder for beam at (φi, θj) is given by equation 1 in Appendix 1 (2D DFT beam) | For direction of UE analog beam steering (in LCS):Azimuth angle φi = [-3\*pi/8, -pi/8, pi/8, 3\*pi/8];Zenith angle θj = [pi/4, 3\*pi/4];NOTE: (azimuth, zenith)=(0, pi/2) is the direction perpendicular to the array.Precoder for beam at (φi, θj) is given by equation 1 in Appendix 1 (2D DFT beam) |
| Criteria for selection for serving TRxP | - | - | Maximizing RSRP with best analog beam pair, where the digital beamforming is not considered | Maximizing RSRP with best analog beam pair, where the digital beamforming is not considered |
| Criteria for analog beam selection for serving TRxP | - | - | Select the best beam pair among the set of DFT beams, based on the criteria of maximizing receive power after beamforming. | Select the best beam pair among the set of DFT beams, based on the criteria of maximizing receive power after beamforming. |
| Criteria for analog beam selection for interfering TRxP | - | - | Random selecting the random beams for non-serving TRxP | Random selecting the random beams for non-serving TRxP |

## Dense urban - eMBB

The baseline parameters are provided in Table 2.

Table 2 Baseline parameter for Dense Urban – eMBB

|  |  |  |
| --- | --- | --- |
| **Dense Urban - eMBB** | Config. A | Config. B |
| Carrier frequency for evaluation | 1 layer (Macro) with 4 GHz | 1 layer (Macro) with 30 GHz |
| BS antenna height | 25 m | 25 m |
| Total transmit power per TRxP | 41 dBm for 10 MHz bandwidth | 37 dBm for 40 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm |
| Percentage of high loss and low loss building type  | 20% high loss, 80% low loss (applies to Channel model B) | 20% high loss, 80% low loss |
| Inter-site distance | 200 m | 200 m |
| Number of antenna elements per TRxP | 128Tx/Rx, (M,N,P,Mg,Ng) = (8,8,2,1,1), (dH,dV) = (0.5, 0.8)λ+45°, -45° polarization | 256Tx/Rx, (M,N,P,Mg,Ng) = (4,8,2,2,2), (dH,dV) = (0.5, 0.5)λ. (dg,H,dg,V) = (4.0, 2.0)λ+45°, -45° polarization |
| Number of TXRU per TRxP | 4TXRU, (Mp,Np,P,Mg,Ng) = (2,1,2,1,1) | 8TXRU, (Mp,Np,P,Mg,Ng) =(1,1,2,2,2) |
| Number of UE antenna elements  | 4Tx/Rx, (M,N,P,Mg,Ng) = (1,2,2,1,1), (dH,dV) = (0.5, N/A)λ0°,90° polarization | 32Tx/Rx, (M,N,P,Mg,Ng) = (2,4,2,1,2), (dH,dV) = (0.5, 0.5)λ(dg,V,dg,H) = (0, 0)λ. Θmg,ng=90; Ω0,1=Ω0,0+180;0°,90° polarization |
| Number of TXRU per UE | 4TXRU, (Mp,Np,P,Mg,Ng) = (1,2,2,1,1)(1-to-1 mapping) | 4TXRU, (Mp,Np,P,Mg,Ng)=(1,1,2,1,2) |
| Device deployment | 80% indoor, 20% outdoor (in car)Randomly and uniformly distributed over the area under Macro layer | 80% indoor, 20% outdoor (in car)Randomly and uniformly distributed over the area under Macro layer |
| UE mobility model | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction |
| UE speeds of interest | Indoor users: 3km/hOutdoor users (in-car): 30 km/h | Indoor users: 3km/hOutdoor users (in-car): 30 km/h |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 7 dB |
| UE noise figure | 7 dB  | 10 dB |
| BS antenna element gain | 8 dBi | 8 dBi |
| BS antenna element pattern | See Table 6 in Section 4.6 | See Table 6 in Section 4.6 |
| UE antenna element gain | 0 dBi | 5 dBi |
| UE antenna element pattern | Omni-directional | See Table 8 in Section 4.6 |
| Thermal noise level | -174 dBm/Hz | -174 dBm/Hz |
| Traffic model | Full buffer | Full buffer |
| Simulation bandwidth | 10 MHz | 40 MHz |
| UE density | 10 UEs per TRxP | 10 UEs per TRxP |
| UE antenna height | Outdoor UEs: 1.5 mIndoor UTs: 3(nfl – 1) + 1.5; nfl ~ uniform(1,Nfl) where Nfl ~ uniform(4,8) | Outdoor UEs: 1.5 mIndoor UTs: 3(nfl – 1) + 1.5; nfl ~ uniform(1,Nfl) where Nfl ~ uniform(4,8) |
| Channel model variant | Alt. 1: Channel model AAlt. 2: Channel model B | (Channel model A or B is the same) |
| TRxP number per site | 3 | 3 |
| Mechanic tilt  | 90° in GCS (pointing to horizontal direction) | 90° in GCS (pointing to horizontal direction) |
| Electronic tilt | (According to Zenith angle in "Beam set at TRxP") | (According to Zenith angle in "Beam set at TRxP") |
| Handover margin (dB) | 0 (i.e., the strongest cell is selected) | 0 (i.e., the strongest cell is selected) |
| TRxP boresight   | 30 / 150 / 270 degrees  | 30 / 150 / 270 degrees  |
| UT attachment | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 | Based on RSRP (formula as shown in Appendix 3) from port 0The UE panel with the best receive SNR is chosen. i.e. no combining is done between panels. |
| Wrapping around method | Geographical distance based wrapping | Geographical distance based wrapping |
| Minimum distance of TRxP and UE | d2D\_min=10m  | d2D\_min=10m  |
| Polarized antenna model | Model-2 in TR36.873 | Model-2 in TR36.873 |
| Beam set at TRxP(Constraints for the range of selective analog beams per TRxP) |  For direction of TRxP analog beam steering (in LCS):Azimuth angle φi = [-5\*pi/16, -3\*pi/16, -pi/16, pi/16, 3\*pi/16, 5\*pi/16] Zenith angle θj = [5\*pi/8, 7\*pi/8]NOTE: (azimuth, zenith)=(0, pi/2) is the direction perpendicular to the array.Precoder for beam at (φi, θj) is given by equation 1 in Appendix 1 (2D DFT beam) | For direction of TRxP analog beam steering (in LCS):Azimuth angle φi = [-5\*pi/16, -3\*pi/16, -pi/16, pi/16, 3\*pi/16, 5\*pi/16] Zenith angle θj = [5\*pi/8, 7\*pi/8]NOTE: (azimuth, zenith)=(0, pi/2) is the direction perpendicular to the array.Precoder for beam at (φi, θj) is given by equation 1 in Appendix 1 (2D DFT beam) |
| Beam set at UE(Constraints for the range of selective analog beams for UE) | - | For direction of UE analog beam steering (in LCS):Azimuth angle φi = [-3\*pi/8, -pi/8, pi/8, 3\*pi/8];Zenith angle θj = [pi/4, 3\*pi/4];NOTE: (azimuth, zenith)=(0, pi/2) is the direction perpendicular to the array.Precoder for beam at (φi, θj) is given by equation 1 in Appendix 1 (2D DFT beam) |
| Criteria for selection for serving TRxP | Maximizing RSRP with best analog beam pair, where the digital beamforming is not considered  | Maximizing RSRP with best analog beam pair, where the digital beamforming is not considered |
| Criteria for analog beam selection for serving TRxP | Select the best beam pair among the limited set of DFT analog beams, based on the criteria of maximizing receive power after beamforming. | Select the best beam pair among the limited set of DFT analog beams, based on the criteria of maximizing receive power after beamforming. |
| Criteria for analog beam selection for interfering TRxP | Random selecting the random beams for non-serving TRxP | Random selecting the random beams for non-serving TRxP |

## Rural – eMBB

The baseline parameters are provided in Table 3.

Table 3 Baseline parameter for Rural – eMBB

|  |  |  |  |
| --- | --- | --- | --- |
| **Rural - eMBB** | Config. A | Config. B | Config. C(LMLC) |
| Carrier frequency for evaluation | 700 MHz  | 4 GHz | 700 MHz |
| BS antenna height | 35 m | 35 m | 35 m |
| Total transmit power per TRxP | 46 dBm for 10 MHz bandwidth | 46 dBm for 10 MHz bandwidth | 46 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm | 23 dBm |
| Percentage of high loss and low loss building type  | 100% low loss (applies to Channel model B) | 100% low loss (applies to Channel model B) | 100% low loss (applies to Channel model B) |
| Inter-site distance | 1732 m | 1732 m | 6000 m |
| Number of antenna elements per TRxP | 64 Tx/Rx, (M,N,P,Mg,Ng) = (8,4,2,1,1), (dH,dV) = (0.5, 0.8)λ+45°, -45° polarization | 128Tx/Rx, (M,N,P,Mg,Ng) = (8,8,2,1,1), (dH,dV) = (0.5, 0.8)λ+45°, -45° polarization | 64 Tx/Rx, (M,N,P,Mg,Ng) = (8,4,2,1,1), (dH,dV) = (0.5, 0.8)λ+45°, -45° polarization |
| Number of TXRU per TRxP | 8TXRU, (Mp,Np,P,Mg,Ng) = (1,4,2,1,1) | 16TXRU, (Mp,Np,P,Mg,Ng) = (1,8,2,1,1) | 8TXRU, (Mp,Np,P,Mg,Ng) = (1,4,2,1,1) |
| Number of UE antenna elements  | 2Tx/Rx, (M,N,P,Mg,Ng) = (1,1,2,1,1)0°,90° polarization | 4Tx/Rx, (M,N,P,Mg,Ng) = (1,2,2,1,1), (dH,dV) = (0.5, N/A)λ0°,90° polarization | 4Tx/Rx, (M,N,P,Mg,Ng) = (1,2,2,1,1), (dH,dV) = (0.5, N/A)λ0°,90° polarization |
| Number of TXRU per UE | 2TXRU (1-to-1 mapping) | 4TXRU (1-to-1 mapping) | 4TXRU (1-to-1 mapping) |
| Device deployment | 50% indoor, 50% outdoor (in car)Randomly and uniformly distributed over the area | 50% indoor, 50% outdoor (in car)Randomly and uniformly distributed over the area | 40% indoor,40% outdoor (pedestrian), 20% outdoor (in-car)Randomly and uniformly distributed over the area |
| UE mobility model | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction |
| UE speeds of interest | Indoor users: 3 km/h;Outdoor users (in-car): 120 km/h; | Indoor users: 3 km/h;Outdoor users (in-car): 120 km/h; | Indoor users: 3 km/h;Outdoor users (pedestrian): 3 km/h;Outdoor users (in-car): 30 km/h |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB | 5 dB |
| UE noise figure | 7 dB  | 7 dB  | 7 dB  |
| BS antenna element gain | 8 dBi | 8 dBi | 8 dBi |
| BS antenna element pattern | See Table 6 in Section 4.6 | See Table 6 in Section 4.6 | See Table 6 in Section 4.6 |
| UE antenna element gain | 0 dBi | 0 dBi | 0 dBi |
| UE antenna element pattern | Omni-directional | Omni-directional | Omni-directional |
| Thermal noise level | -174 dBm/Hz | -174 dBm/Hz | -174 dBm/Hz |
| Traffic model | Full buffer | Full buffer | Full buffer |
| Simulation bandwidth | 10 MHz | 10 MHz | 10 MHz |
| UE density | 10 UEs per TRxP | 10 UEs per TRxP | 10 UEs per TRxP |
| UE antenna height | 1.5 m | 1.5 m | 1.5 m |
| Channel model variant | Alt. 1: Channel model AAlt. 2: Channel model B | Alt. 1: Channel model AAlt. 2: Channel model B | Alt. 1: Channel model AAlt. 2: Channel model B |
| TRxP number per site | 3 | 3 | 3 |
| Mechanic tilt  | 90° in GCS (pointing to horizontal direction) | 90° in GCS (pointing to horizontal direction) | 90° in GCS (pointing to horizontal direction) |
| Electronic tilt | [100°] in LCS | [100°] in LCS | [96°] in LCS |
| Handover margin (dB) | 0 (i.e., the strongest cell is selected) | 0 (i.e., the strongest cell is selected) | 0 (i.e., the strongest cell is selected) |
| TRxP boresight   | 30 / 150 / 270 degrees  | 30 / 150 / 270 degrees  | 30 / 150 / 270 degrees  |
| UT attachment | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 |
| Wrapping around method | Geographical distance based wrapping | Geographical distance based wrapping | Geographical distance based wrapping |
| Minimum distance of TRxP and UE | d2D\_min=10m  | d2D\_min=10m  | d2D\_min=10m  |
| Polarized antenna model | Model-2 in TR36.873 | Model-2 in TR36.873 | Model-2 in TR36.873 |

## Urban Macro - mMTC

The baseline parameters are provided in Table 4.

Table 4 Baseline parameter for Urban Macro – mMTC

|  |  |  |
| --- | --- | --- |
| **Urban Macro - mMTC** | Config. A | Config. B |
| Carrier frequency for evaluation | 700 MHz | 700 MHz |
| BS antenna height | 25 m | 25 m |
| Total transmit power per TRxP[[1]](#footnote-1) | 46 dBm for 10 MHz bandwidth | 46 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm |
| Percentage of high loss and low loss building type  | 20% high loss, 80% low loss (applies to Channel model B) | 20% high loss, 80% low loss (applies to Channel model B) |
| Inter-site distance | 500 m | 1732 m |
| Number of antenna elements per TRxP | 16 Tx/Rx, (M,N,P,Mg,Ng) = (8,1,2,1,1), (dH,dV) = (N/A, 0.8)λ+45°, -45° polarization | 16 Tx/Rx, (M,N,P,Mg,Ng) = (8,1,2,1,1), (dH,dV) = (N/A, 0.8)λ+45°, -45° polarization |
| Number of TXRU per TRxP | 2TXRU, (Mp,Np,P,Mg,Ng) = (1,1,2,1,1) | 2TXRU, (Mp,Np,P,Mg,Ng) = (1,1,2,1,1) |
| Number of UE antenna elements  | 1Tx/Rx0° polarization | 1Tx/Rx0° polarization |
| Number of TXRU per UE | 1TXRU | 1TXRU |
| Device deployment | 80% indoor, 20% outdoorRandomly and uniformly distributed over the area | 80% indoor, 20% outdoorRandomly and uniformly distributed over the area |
| UE mobility model | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction. | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction. |
| UE speeds of interest | 3 km/h for indoor and outdoor | 3 km/h for indoor and outdoor |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB |
| UE noise figure | 7 dB  | 7 dB  |
| BS antenna element gain | 8 dBi | 8 dBi |
| BS antenna element pattern | See Table 6 in Section 4.6 | See Table 6 in Section 4.6 |
| UE antenna element gain | 0 dBi | 0 dBi |
| UE antenna element pattern | Omni-directional | Omni-directional |
| Thermal noise level | -174 dBm/Hz | -174 dBm/Hz |
| Traffic model | Full buffer | Full buffer |
| Simulation bandwidth | 10 MHz | 10 MHz |
| UE density | 10 UEs per TRxP | 10 UEs per TRxP |
| UE antenna height | 1.5 m | 1.5 m |
| Channel model variant | Alt. 1: Channel model AAlt. 2: Channel model B | Alt. 1: Channel model AAlt. 2: Channel model B |
| TRxP number per site | 3 | 3 |
| Mechanic tilt  | 90° in GCS (pointing to horizontal direction) | 90° in GCS (pointing to horizontal direction) |
| Electronic tilt | [99°] in LCS | [93°] in LCS |
| Handover margin (dB) | 0 (i.e., the strongest cell is selected) | 0 (i.e., the strongest cell is selected) |
| TRxP boresight | 30 / 150 / 270 degrees  | 30 / 150 / 270 degrees  |
| UT attachment | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 |
| Wrapping around method | Geographical distance based wrapping | Geographical distance based wrapping |
| Minimum distance of TRxP and UE | d2D\_min=10m  | d2D\_min=10m  |
| Polarized antenna model | Model-2 in TR36.873 | Model-2 in TR36.873 |

## Urban Macro – URLLC

The baseline parameters are provided in Table 5.

Table 5 Baseline parameter for Urban Macro – URLLC

|  |  |  |
| --- | --- | --- |
| **Urban Macro - URLLC** | Config. A | Config. B |
| Carrier frequency for evaluation | 4 GHz | 700 MHz |
| BS antenna height | 25 m | 25 m |
| Total transmit power per TRxP | 46 dBm for 10 MHz bandwidth | 46 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm |
| Percentage of high loss and low loss building type  | 100% low loss (applies to Channel model B) | 100% low loss (applies to Channel model B) |
| Inter-site distance | 500 m | 500 m |
| Number of antenna elements per TRxP | 64 Tx/Rx, (M,N,P,Mg,Ng) = (8,4,2,1,1), (dH,dV) = (0.5, 0.8)λ+45°, -45° polarization | 16 Tx/Rx, (M,N,P,Mg,Ng) = (8,1,2,1,1), (dH,dV) = (N/A, 0.8)λ+45°, -45° polarization |
| Number of TXRU per TRxP | 8TXRU, (Mp,Np,P,Mg,Ng) = (1,4,2,1,1) | 2TXRU, (Mp,Np,P,Mg,Ng) = (1,1,2,1,1) |
| Number of UE antenna elements  | 4Tx/Rx, (M,N,P,Mg,Ng) = (1,2,2,1,1), (dH,dV) = (0.5, N/A)λ0°, 90° polarization | 2Tx/Rx, (M,N,P,Mg,Ng) = (1,1,2,1,1)0°, 90° polarization |
| Number of TXRU per UE | 4TXRU (1-to-1 mapping) | 2TXRU (1-to-1 mapping) |
| Device deployment | 80% outdoor, 20% indoorRandomly and uniformly distributed over the area | 80% outdoor, 20% indoorRandomly and uniformly distributed over the area |
| UE mobility model | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction |
| UE speeds of interest | 3 km/h for indoor and 30 km/h for outdoor | 3 km/h for indoor and 30 km/h for outdoor |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB |
| UE noise figure | 7 dB  | 7 dB  |
| BS antenna element gain | 8 dBi | 8 dBi |
| BS antenna element pattern | See Table 6 in Section 4.6 | See Table 6 in Section 4.6 |
| UE antenna element gain | 0 dBi | 0 dBi |
| UE antenna element pattern | Omni-directional | Omni-directional |
| Thermal noise level | -174 dBm/Hz | -174 dBm/Hz |
| Traffic model | Full buffer | Full buffer |
| Simulation bandwidth | 10 MHz | 10 MHz |
| UE density | 10 UEs per TRxP | 10 UEs per TRxP |
| UE antenna height | 1.5 m | 1.5 m |
| Channel model variant | Alt. 1: Channel model AAlt. 2: Channel model B | Alt. 1: Channel model AAlt. 2: Channel model B |
| TRxP number per site | 3 | 3 |
| Mechanic tilt  | 90° in GCS (pointing to horizontal direction) | 90° in GCS (pointing to horizontal direction) |
| Electronic tilt | [99°] in LCS | [99°] in LCS |
| Handover margin (dB) | 0 (i.e., the strongest cell is selected) | 0 (i.e., the strongest cell is selected) |
| TRxP boresight | 30 / 150 / 270 degrees  | 30 / 150 / 270 degrees  |
| UT attachment | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 |
| Wrapping around method | Geographical distance based wrapping | Geographical distance based wrapping |
| Minimum distance of TRxP and UE | d2D\_min=10m  | d2D\_min=10m  |
| Polarized antenna model | Model-2 in TR36.873 | Model-2 in TR36.873 |

## Antenna element pattern

The antenna element pattern is defined in Report ITU-R M.2412.

For BS side, the TRxP antenna element pattern is defined in Table 8-6 in Report ITU-R M.2412 for Dense Urban – eMBB, Rural – eMBB, Urban Macro – mMTC, and Urban macro – URLLC test environments. For Indoor Hotspot, the TRxP antenna element pattern is defined in Table 8-7 in Report ITU-R M.2412. They are copied in Table 6 and Table 7 for reference.

Table 6\*

BS antenna element radiation pattern for
Dense Urban – eMBB, Rural – eMBB, Urban Macro – mMTC, and Urban Macro - URLLC

|  |  |
| --- | --- |
| Parameters | 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* | 8 dBi |

\* Note: This is a copy of Table 8-6 in Report ITU-R M.2412

Table 7\*

BS antenna element radiation pattern for Indoor Hotspot - eMBB

|  |  |
| --- | --- |
| Parameters | 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 dBi |

\* Note: This is a copy of Table 8-7 in Report ITU-R M.2412

For UE side, the UE antenna element pattern is Omni-directional for 4 GHz and 700 MHz; while for 30 GHz and 70 GHz, it is defined in Table 8-8 in Report ITU-R M.2412, which is copied to Table 8 for reference.

Table 8\*

UE antenna element radiation pattern for 30 GHz and 70 GHz

|  |  |
| --- | --- |
| Parameters | Values |
| Antenna element radiation pattern in $θ''$ dim (dB) |  |
| Antenna element radiation pattern in $φ''$ dim (dB) |  |
| Combining method for 3D antenna element pattern (dB) |  |
| Maximum directional gain of an antenna element *GE,max* | 5 dBi |

\* Note: This is a copy of Table 8-8 in Report ITU-R M.2412

# Calibration results

The calibration results are provided in the attachment. Twenty-one 3GPP members provided the calibration results, including CATR, CATT, CEWiT, China Telecom, CMCC, Ericsson, Huawei, Intel, ITRI, LG Electronics, MediaTek, Motorola Mobility/Lenovo, NEC, Nokia, NTT DOCOMO, OPPO, Qualcomm, Samsung, Sharp, vivo and ZTE.

It is observed that most of the calibration results are well aligned according to the results collected. The results of DL geometry (wideband SINR) from the independent samples are typically within 1~2 dB of the average SINR. A summary on samples collected of each test environment and evaluation configuration is shown in Appendix 2.

***Attachment***: Calibration results for IMT-2020 submission.

# Summary

In the email discussion “[ITU-R AH 01] Calibration for self-evaluation”, the calibration metrics and calibration parameters are discussed and captured in section 3 and 4. The calibration results are provided in section 5. It is observed that the calibration results are well aligned according to the results collected. The results of DL geometry (wideband SINR) from the independent samples are typically within 1~2 dB of the average SINR.

# References

1. RP-172101, “WF on Work plan of Self Evaluation SI”, Huawei, Ericsson, Telecom Italia, September 2017.
2. RP-172098, “3GPP submission towards IMT-2020”, ITU-R Ad-Hoc Contact person, September 2017.
3. Report ITU-R M.2412, “Guidelines for evaluation of radio interface technologies for IMT-2020”, ITU-R WP 5D, June 2017, available in RP-171559.
4. RP-172536, “Consideration on IMT-2020 self evaluation: mobility”, Huawei, HiSilicon, December 2017.
5. R1-1802446, “Discussion on the RSRP calculation”, China Telecom, Feb 2018.

# Appendix 1: 2D DFT precoder

The TRxP planar array (or linear array) is illustrated in Figure 5.4.4.1.3-1 in TR37.840. In this plot, the steering azimuth angle is φ, and the steering zenith angle is θ.

dH

z

u

dv

φ

θ

x

y

……

Figure 5.4.4.1.3-1: Geometry distribution of AAS with multiple columns array

The 2D DFT beam precoder (virtualization weight vector) is used for the calibration purpose. The 2D sub-array partition model is assumed for generating the virtualization weight vector. And one TXRU is only connected to antenna elements with the same polarization. In this case, the weight vector for the TXRU mapping to KxL antenna elements at the direction of (φi, θj) is given by equation 1 as follows

**g**(φi, θj)= **v**s⊗**wo (1)**

- The length of **wo** is given by K = M/Mp, Mp is the number of TXRU in vertical domain, M is the number of antenna elements in one polarization in vertical domain;

- The length of **v**i is given by L = N/Np, Np is the number of TXRU in horizontal domain, N is the number of antenna elements in one polarization in horizontal domain.

**- wo** (vertical virtualization weight vector) for  is given by



**- v**s (horizontal virtualization weight vector) for is given by



# Appendix 2: Collected samples

Twenty-one 3GPP members provided the calibration results, including CATR, CATT, CEWiT, China Telecom, CMCC, Ericsson, Huawei, Intel, ITRI, LG Electronics, MediaTek, Motorola Mobility/Lenovo, NEC, Nokia, NTT DOCOMO, OPPO, Qualcomm, Samsung, Sharp, vivo and ZTE. A summary of the collected samples of each test environment and evaluation configuration is shown in Table 9.

Table 9 Sample statistics for ITU-R test environments

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test environment** | **Evaluation configuration**  | **Channel model / Topology** | **Number of samples** | **DL wideband SINR difference compared to average SINR (at 50%-tile CDF point)** |
| Indoor Hotspot - eMBB | Config. A (4 GHz) | Channel model A | 12TRxP | 16 | <0.8 dB |
| 36TRxP | 15 | <0.5 dB |
| Channel model B | 12TRxP | 18 | <0.9 dB |
| 36TRxP | 16 | <0.4 dB |
| Config. B (30 GHz) | Channel model A/B | 12TRxP | 17 | <2.2 dB |
| 36TRxP | 14 | <2.2 dB |
| Config. C (70 GHz) | Channel model A/B | 12TRxP | 16 | <1.6 dB |
| 36TRxP | 12 | <1.9 dB |
| Dense Urban - eMBB | Config. A (4 GHz) | Channel model A | 16 | <1.3 dB |
| Channel model B | 18 | <1.3 dB |
| Config. B (30 GHz) | Channel model A/B | 18 | <2.4 dB |
| Rural - eMBB | Config. A (1732 m, 700 MHz) | Channel model A | 18 | <0.8 dB |
| Channel model B | 20 | <0.9 dB |
| Config. B (1732 m, 4 GHz) | Channel model A | 18 | <0.9 dB |
| Channel model B | 20 | <1.2 dB |
| Config. C (LMLC, 6000 m, 700 MHz) | Channel model A | 15 | <0.9 dB |
| Channel model B | 16 | <1.0 dB |
| Urban Macro - mMTC | Config. A (500 m, 700 MHz) | Channel model A | 15 | <0.9 dB |
| Channel model B | 16 | <0.6 dB |
| Config. B (1732 m, 700 MHz) | Channel model A | 15 | <1.2 dB |
| Channel model B | 16 | <0.6 dB |
| Urban Macro - URLLC | Config. A (4 GHz) | Channel model A | 15 | <0.9 dB |
| Channel model B | 17 | <1.0 dB |
| Config. B (700 MHz) | Channel model A | 15 | <0.9 dB |
| Channel model B | 16 | <1.3 dB |

# Appendix 3: RSRP calculation for UE with analog beamforming

The RSRP calculation for UE with analog beamforming is given by formula (8.1-1) in TR36.873, with *U* being the number of receive TXRU, and the zenith and azimuth field components of the *u*-th receiving port,  and , replaced by the following (see also, e.g., [4][5])





where  and  are the zenith and azimuth field pattern of the *l*-th receive antenna element, *N*R is the number of receive antenna elements that forms the virtualization of receive port *u*;  is the spherical unit vector at receiver side with azimuth arrival angle *ϕn,m,AOA* and elevation arrival angle *θn,m,ZOA*, is the location vector of receive antenna element *l*, and **g**=[*g*1, …, *gl*, …*g*NR]T is the analog beamformer vector which is given by equation (1) in Appendix 1, at pre-defined analog beam direction of (azimuth, zenith)=(φi, θj) at UE side as given in Section 4.1 and 4.2.

1. This parameter(s) is/are used for cell association [↑](#footnote-ref-1)