3GPP TSG RAN Meeting #79 **RP-180524**
Chennai, India, 19 – 22 March 2018

Agenda item: 9.3.2

Source: Huawei

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

Document for: Approval

1 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.

2 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.

3 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.

4 Calibration parameters for self evaluation

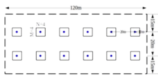
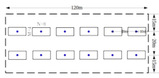
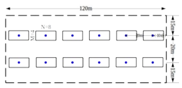
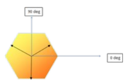
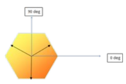
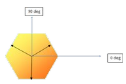
This section provides baseline calibration parameters and models for the five test environments defined in Report ITU-R M.2412 (see [3]). It should be noted that these parameters are used for calibration purpose only.

4.1 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)λ 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	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% indoor Randomly and uniformly distributed over the area	100% indoor Randomly and uniformly distributed over the area	100% indoor Randomly 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	5 dB	7dB	7dB

figure						
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 A Alt. 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 0 The UE panel with the best receive SNR is chosen. i.e. no combining is done between	Based on RSRP (formula as shown in Appendix 3) from port 0 The UE panel with the best receive SNR is chosen. i.e. no	Based on RSRP (formula as shown in Appendix 3) from port 0 The 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 0 The UE panel with the best receive SNR is chosen. i.e. no

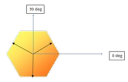
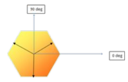
			panels.	combining is done between panels.		combining is done between panels.
Wrapping around method	No wrapping around	No wrapping around	No wrapping around	No wrapping around	No wrapping around	No wrapping around
Minimum distance of TRxP and UE	d_{2D_min}=0m	d_{2D_min}=0m	d_{2D_min}=0m	d_{2D_min}=0m	d_{2D_min}=0m	d_{2D_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 φ_i = [-3*pi/8, -1*pi/8, 1*pi/8, 3*pi/8] Zenith angle θ_j = [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 φ_i = [-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 φ_i = [-3*pi/8, -pi/8, pi/8, 3*pi/8]; Zenith angle θ_j = [pi/4, 3*pi/4]; NOTE: (azimuth, zenith)=(0, pi/2) is the direction perpendicular to the array. Precoder for beam at (φ_i, θ_j) is given by equation 1 in Appendix 1 (2D DFT beam)		For direction of UE analog beam steering (in LCS): Azimuth angle φ_i = [-3*pi/8, -pi/8, pi/8, 3*pi/8]; Zenith angle θ_j = [pi/4, 3*pi/4]; NOTE: (azimuth, zenith)=(0, pi/2) is the direction perpendicular to the array. Precoder for beam at (φ_i, θ_j) 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	

4.2 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)λ 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)
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/h Outdoor users (in-car): 30 km/h	Indoor users: 3km/h Outdoor 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 m Indoor UTs: 3(nfl – 1) + 1.5; nfl ~ uniform(1,Nfl) where Nfl ~ uniform(4,8)	Outdoor UEs: 1.5 m Indoor UTs: 3(nfl – 1) + 1.5; nfl ~ uniform(1,Nfl) where Nfl ~ uniform(4,8)
Channel model variant	Alt. 1: Channel model A Alt. 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 0 The 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	d_{2D_min}=10m	d_{2D_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 φ_i = [-5*pi/16, -3*pi/16, -pi/16, pi/16, 3*pi/16, 5*pi/16] Zenith angle θ_j = [5*pi/8, 7*pi/8] NOTE: (azimuth, zenith)=(0, pi/2) is the direction perpendicular to the array. Precoder for beam at (φ_i, θ_j) is given by equation 1 in Appendix 1 (2D DFT beam)	For direction of TRxP analog beam steering (in LCS): Azimuth angle φ_i = [-5*pi/16, -3*pi/16, -pi/16, pi/16, 3*pi/16, 5*pi/16] Zenith angle θ_j = [5*pi/8, 7*pi/8] NOTE: (azimuth, zenith)=(0, pi/2) is the direction perpendicular to the array. Precoder for beam at (φ_i, θ_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 φ_i = [-3*pi/8, -pi/8, pi/8, 3*pi/8]; Zenith angle θ_j = [pi/4, 3*pi/4]; NOTE: (azimuth, zenith)=(0, pi/2) is the direction perpendicular to the array. Precoder for beam at (φ_i, θ_j) 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

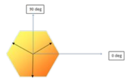
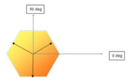
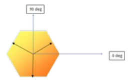
4.3 Rural – eMBB

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)λ 0°,90° polarization	4Tx/Rx, (M,N,P,Mg,Ng) = (1,2,2,1,1), (dH,dV) = (0.5, N/A)λ 0°,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	1.5 m	1.5 m	1.5 m

height			
Channel model variant	Alt. 1: Channel model A Alt. 2: Channel model B	Alt. 1: Channel model A Alt. 2: Channel model B	Alt. 1: Channel model A Alt. 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	d_{2D_min}=10m	d_{2D_min}=10m	d_{2D_min}=10m
Polarized antenna model	Model-2 in TR36.873	Model-2 in TR36.873	Model-2 in TR36.873

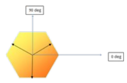
4.4 Urban Macro - mMTC

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]	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/Rx 0° polarization	1Tx/Rx 0° polarization
Number of TXRU per UE	1TXRU	1TXRU
Device deployment	80% indoor, 20% outdoor Randomly and uniformly distributed over the area	80% indoor, 20% outdoor 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.

[1] This parameter(s) is/are used for cell association

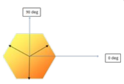
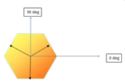
UE speeds of interest	3 km/h for indoor and outdoor	3 km/h for indoor and outdoor
Inter-site interference modeling	Explicitly modelled	Explicitly modelled
BS noise figure	5 dB	5 dB
UE noise figure	7 dB	7 dB
BS antenna element gain	8 dBi	8 dBi
BS antenna element pattern	See Table 6 in Section 4.6	See 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 A Alt. 2: Channel model B	Alt. 1: Channel model A Alt. 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	d_{2D_min}=10m	d_{2D_min}=10m
Polarized antenna model	Model-2 in TR36.873	Model-2 in TR36.873

4.5 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)λ 0°, 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% indoor Randomly and uniformly distributed over the area	80% outdoor, 20% indoor 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
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 A Alt. 2: Channel model B	Alt. 1: Channel model A Alt. 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	d_{2D_min}=10m	d_{2D_min}=10m
Polarized antenna model	Model-2 in TR36.873	Model-2 in TR36.873

4.6 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)	$A_{E,V}(\theta'') = -\min\left[12\left(\frac{\theta''-90^0}{\theta_{3dB}}\right)^2, SLA_V\right], \theta_{3dB}=65^0, SLA_V=30$
Antenna element horizontal radiation pattern (dB)	$A_{E,H}(\phi'') = -\min\left[12\left(\frac{\phi''}{\phi_{3dB}}\right)^2, A_m\right], \phi_{3dB}=65^0, A_m=30$
Combining method for 3D antenna element pattern (dB)	$A''(\theta'',\phi'') = -\min\left\{-\left[A_{E,V}(\theta'')+A_{E,H}(\phi'')\right], A_m\right\}$
Maximum directional gain of an antenna element $G_{E,max}$	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)	$A_{E,V}(\theta'') = -\min\left[12\left(\frac{\theta''-90^0}{\theta_{3dB}}\right)^2, SLA_V\right], \theta_{3dB}=90^0, SLA_V=25$
Antenna element horizontal radiation pattern (dB)	$A_{E,H}(\phi'') = -\min\left[12\left(\frac{\phi''}{\phi_{3dB}}\right)^2, A_m\right], \phi_{3dB}=90^0, A_m=25$
Combining method for 3D antenna element pattern (dB)	$A''(\theta'',\phi'') = -\min\left\{-\left[A_{E,V}(\theta'')+A_{E,H}(\phi'')\right], A_m\right\}$
Maximum directional gain of an antenna element $G_{E,max}$	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)	$A_{E,V}(\theta'') = -\min\left[12\left(\frac{\theta''-90^0}{\theta_{3dB}}\right)^2, SLA_V\right], \theta_{3dB}=90^0, SLA_V=25$
Antenna element radiation pattern in φ'' dim (dB)	$A_{E,H}(\phi'') = -\min\left[12\left(\frac{\phi''}{\phi_{3dB}}\right)^2, A_m\right], \phi_{3dB}=90^0, A_m=25$

Combining method for 3D antenna element pattern (dB)	$A''(\theta'',\phi'')=-\min\left\{-\left[A_{E,V}(\theta'')+A_{E,H}(\phi'')\right],A_m\right\}$
Maximum directional gain of an antenna element $G_{E,max}$	5 dBi

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

5 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.

6 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.

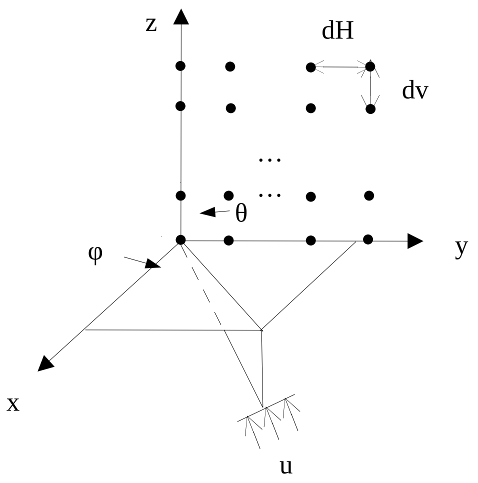


Figure 5.4.4.1.3-1: Geometry distribution of AAS with multiple columns array

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 (φ_i, θ_j) is given by equation 1 as follows

$$\mathbf{g}(\varphi_i, \theta_j) = \mathbf{v}_s \otimes \mathbf{w}_o \qquad (1)$$

- The length of $\mathbf{w}_o$ is given by $K = M/M_p$, M_p is the number of TXRU in vertical domain, M is the number of antenna elements in one polarization in vertical domain;
- The length of $\mathbf{v}_i$ is given by $L = N/N_p$, N_p is the number of TXRU in horizontal domain, N is the number of antenna elements in one polarization in horizontal domain.
- $\mathbf{w}_o$ (vertical virtualization weight vector) for $o = 1,\ldots,M_p$ is given by

$$w_{k,o} = \frac{1}{\sqrt{K}} exp\left(-j\frac{2\pi}{\lambda}(k-1)d_V \cos\theta_j \right) \quad for\ k = 1,\ldots,K$$

- $\mathbf{v}_s$ (horizontal virtualization weight vector) for $s = 1,\ldots,N_p$ is given by

$$v_{l,s} = \frac{1}{\sqrt{L}} exp\left(-j\frac{2\pi}{\lambda}(l-1)d_H \sin(\theta_j)\cdot\sin(\varphi_i) \right) \quad for\ l = 1,\ldots,L$$

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 9Error: Reference source not found.

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, $F_{rx,u,\theta}(\theta_{n,m,ZOA},\varphi_{n,m,AOA})$ and $F_{rx,u,\varphi}(\theta_{n,m,ZOA},\phi_{n,m,AOA})$, replaced by the following (see also, e.g., [4][5])

$$F_{rx,u,\theta}(\theta_{n,m,ZOA},\phi_{n,m,AOA}) = \sum_{l=1}^{N_R} g_l \exp\left(j2\pi\lambda_0^{-1}\left(\hat{r}_{rx,n,m}^T.\bar{d}_{rx,l}\right)\right) F_{rx,l,\theta}(\theta_{n,m,ZOA},\phi_{n,m,AOA})$$

$$F_{rx,u,\varphi}(\theta_{n,m,ZOA},\phi_{n,m,AOA}) = \sum_{l=1}^{N_R} g_l \exp\left(j2\pi\lambda_0^{-1}\left(\hat{r}_{rx,n,m}^T.\bar{d}_{rx,l}\right)\right) F_{rx,l,\varphi}(\theta_{n,m,ZOA},\phi_{n,m,AOA})$$

where $F_{rx,l,\theta}(\theta_{n,m,ZOA},\phi_{n,m,AOA})$ and $F_{rx,l,\varphi}(\theta_{n,m,ZOA},\phi_{n,m,AOA})$ 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; $\hat{r}_{rx,n,m}$ is the spherical unit vector at receiver side with azimuth arrival angle $\phi_{n,m,AOA}$ and elevation arrival angle $\theta_{n,m,ZOA}$, $\bar{d}_{rx,l}$ is the location vector of receive antenna element l, and $\mathbf{g}=[g_1, \ldots, g_l, \ldots g_{NR}]^T$ is the analog beamformer vector which is given by equation (1) in Appendix 1, at pre-defined analog beam direction of (azimuth, zenith)=(φ_i, θ_j) at UE side as given in Section 4.1 and 4.2.