|  |  |
| --- | --- |
| **Radiocommunication Study Groups** |  |
|  |  |
|  |  |
| Source: TCOE | **Document IMT-2020/ZZZ** |
| **11 February 2019** |
| **English only** |
| Telecom Centers of Excellence (TCOE) | |
| Initial evaluation Report from TCOE on the IMT-2020 proposal in Documents IMT-2020/3 (Rev. 2) for DENSE URBAN TEST ENVIRONMENT | |
|  | |

This document describes the initial evaluation results and activities identified for IMT-2020 candidate technology submissions in Documents IMT-2020/3(Rev.2) from TCOE Evaluation Group.

# Background

The Telecom Centres of Excellence (TCOEs) were established in 2007-08 as a Public-Private Partnership (PPP) bringing together Academic Institutions, Telecom Industry (Service providers) and Government with the objective of creating an eco-system for sustainable growth of telecom sector in India. TCOE has signed up as an Independent Evaluation Group (IEG) for the evaluation of the candidate technologies for IMT2020. The evaluation group is made of members from Academia, Research labs and Industry across India.

At the TCOE evaluation group meetings, the contributions for the (S)RIT submissions of 3GPP have been reviewed by its members, and an interim partial evaluation report was prepared for the Dense Urban-eMBB Test Environment. This report is submitted with an intent for discussion in the #31 bis meeting.

**Administrative Contact Details**

Anurag Vibhuti  
TCOE Coordinator.  
[Anurag.cc@tcoe.in](mailto:Anurag.cc@tcoe.in)

**Technical Contact Details**

Radha Krishna Ganti  
[rganti@ee.iitm.ac.in](mailto:rganti@ee.iitm.ac.in?subject=TCOE%20evaluation%20results)

# 3 Evaluation summary

## 3.1 Use of information in Report ITU-R M.2412

*Working Party 5D has defined evaluation guidelines for IMT-2020 candidate technology evaluation in the Report ITU-R M.2412. The latest version of this document is Report ITU-R M.2412-0.*

*Independent Evaluation Groups are requested to indicate in their inputs to Working Party 5D that they applied Report ITU-R M.2412-0 in their evaluation.*

Does Independent Evaluation Group confirm use of Report ITU-R M.2412-0 in their work?

🗹 Yes 🞎 No

## 3.2 Summary the Initial Evaluation Report

Which test environments have been considered in the Initial Evaluation Report? What is outcome of the evaluation?

|  |  |
| --- | --- |
| Test environment | Does the Evaluation Report indicate that the minimum technical performance requirements are met in the test environment? |
| 🞎 Indoor Hotspot-eMBB | 🞎 Yes 🞎 No 🞎 Partial evaluation |
| 🗹 Dense Urban-eMBB | 🞎 Yes 🞎 No 🗹 Partial evaluation |
| 🞎 Rural-eMBB | 🞎 Yes 🞎 No 🞎 Partial evaluation |
| 🞎 Urban Macro–mMTC | 🞎 Yes 🞎 No 🞎 Partial evaluation |
| 🞎 Urban Macro–URLLC | 🞎 Yes 🞎 No 🞎 Partial evaluation |

# Annex A Evaluation Results Contributed by TCOE Evaluation Group Members

## A-1 Introduction

This section contains the evaluation results received from TCOE evaluation group members which are reviewed and harmonized in the TCOE meetings. All the evaluation results were generated by following the IMT‑2020 evaluation methodology. Table A-1-1 shows the different sources of the evaluation results correspond to contributors from the different affiliations.

Table A-1-1

Sources of the evaluation results

|  |  |
| --- | --- |
| Source 1 | Huawei |
| Source 2 | CEWiT |
| Source 3 | IIT Madras |
| Source 4 | Nokia |

## A-2 Results of eMBB Dense Urban Test Environment

Based on the configuration and assumption in Annex B-2, the evaluation results of Dense Urban - eMBB test environment are shown in A-2-1. In order to verify the technical performance of NR RIT, different combinations of 3GPP features, i.e. MIMO schemes, are simulated.

Table A-2-1

Evaluation Result of Dense Urban– eMBB (Configuration A)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| eMBB – Dense Urban | | Configuration A (4GHz) | | | | | | |
| Performance Requirement | Category | Huawei | CEWiT | IITM | Nokia | Result | M.2410 | Note |
| Average spectral efficiency (bps/Hz/TRxP) | Downlink |  | 5.27 | 5.05 |  |  | 7.8 | SU-MIMO |
| 11.45 | 8.613 |  | 9.2 | MU-MIMO |
| Uplink | 8.792 |  |  | 6.8 |  | 5.4 | SU-MIMO |
| 5th percentile user spectral efficiency (bps/Hz) | Downlink |  | 0.125 | 0.12 |  |  | 0.225 | SU-MIMO |
| 0.376 | 0.359 |  | 0.33 | MU-MIMO |
| Uplink | 0.375 |  |  | 0.28 |  | 0.15 | SU-MIMO |

## B-2 Evaluation Assumptions and Configuration

1. Dense Urban-eMBB

Table B-2-1

Assumptions and Configuration of Dense Urban-eMBB (Downlink Case)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Configuration A - Downlink | | | | |
|  | ITU-R M.2412 | Huawei | Nokia | CEWiT / IITM |
| Baseline configuration | | | | |
| Carrier frequency for evaluation | 1 layer (Macro) with 4 GHz | 4 GHz | 4 GHz | 1 layer (Macro) with 4 GHz |
| BS antenna height | 25 m | 25 m | 25 m | 25 m |
| Total transmit power per TRxP | 44 dBm for 20 MHz bandwidth 41 dBm for 10 MHz bandwidth | 41 dBm for 10 MHz bandwidth | 41 dBm for 10 MHz bandwidth | 41 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm | 23 dBm | 23 dBm |
| Percentage of high loss and low loss building type | 20% high loss, 80% low loss | 20% high loss, 80% low loss | 20% high loss, 80% low loss | 20% high loss, 80% low loss |
| Inter-site distance | 200 m | 200 m | 200 m | 200 m |
| Number of antenna elements per TRxP | Up to 256 Tx/Rx | 128Tx cross-polarized antenna (M,N,P,Mg,Ng) = (8,8,2,1,1) | 256Tx/Rx,  (M,N,P,Mg,Ng) = (16,8,2,1,1) | 128Tx/Rx,  (M,N,P,Mg,Ng) = (8,8,2,1,1) |
| Number of UE antenna elements | Up to 8 Tx/Rx | 4Rx (M,N,P,Mg,Ng) = (1,2,2,1,1) with 0°,90° polarization | 4Tx/Rx,  (M,N,P,Mg,Ng) = (1,2,2,1,1), | 4Tx/Rx,  (M,N,P,Mg,Ng) = (1,2,2,1,1), |
| Device deployment | 80% indoor,  20% outdoor (in-car) Randomly and uniformly distributed over the area under Macro layer | Aligned with reference | Aligned with reference | Aligned with reference |
| UE mobility model | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction. | Aligned with reference | Aligned with reference | Aligned with reference |
| UE speeds of interest | Indoor users: 3 km/h Outdoor users (in-car): 30 km/h | Aligned with reference | Aligned with reference | Aligned with reference |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB | 5 dB | 5 dB |
| UE noise figure | 7 dB | 7 dB | 7 dB | 7 dB |
| BS antenna element gain | 8 dBi | 8 dBi | 8 dBi | 8 dBi |
| UE antenna element gain | 0 dBi | 0 dBi | 0 dBi | 0 dBi |
| Thermal noise level | ‒174 dBm/Hz | ‒174 dBm/Hz | ‒174 dBm/Hz | ‒174 dBm/Hz |
| Traffic model | Full buffer | Full buffer | Full buffer | Full buffer |
| Simulation bandwidth | 20 MHz for TDD, 10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD |
| UE density | 10 UEs per TRxP Randomly and uniformly distributed over the area under Macro layer | Aligned with reference | Aligned with reference | Aligned with reference |
| UE antenna height | Outdoor UEs: 1.5 m Indoor UTs: 3(nfl – 1) + 1.5; nfl ~ uniform(1,Nfl) where Nfl ~ uniform(4,8) | Aligned with reference | Aligned with reference | Aligned with reference |
| Channel Model | Macro layer: UMa\_A, UMa\_B Micro layer: UMi\_A, UMi\_B | UMa\_A, UMa\_B | UMa\_A | UMa\_B |
| Additional parameters | | | | |  |  |  | Additional parameters |
| Subcarrier spacing |  | 15 kHz | 15 kHz | 15 kHz |
| Symbols number per slot |  | 14 | 14 | 14 |
| Number of TXRU per TRxP |  | 32TXRU, Vertical 2-to-8 (Mp,Np,P,Mg,Ng) = (2,8,2,1,1) | 32TXRU,  (Mp,Np,P,Mg,Ng) = (2,8,2,1,1) | 32TXRU,  (Mp,Np,P,Mg,Ng) = (2,8,2,1,1) |
| TRxP number per site |  | 3 | 3 | 3 |
| 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) = (1,2,2,1,1) | 4TXRU,  (Mp,Np,P,Mg,Ng) = (1,2,2,1,1) |
| Mechanic tilt |  | 90deg in GCS (pointing to the horizontal direction) | 90deg in GCS (pointing to the horizontal direction) | 90deg in GCS (pointing to the horizontal direction) |
| Electronic tilt |  | 105deg in LCS | 100deg in LCS | 105deg in LCS |
| UT attachment |  | Based on RSRP (Eq. (8.1-1) in TR 36.873) 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 |
| Scheduling |  | PF | PF with frequency selective scheduling | PF |
| ACK/NACK delay |  | Next available UL slot | N / A | Next available UL slot |
| MIMO mode |  | MU-MIMO with rank adaptation | MU-MIMO with maximum rank 1,  maximum number of paired users is 12 | MU-MIMO/SU-MIMO adaptation assuming ideal channel along with rank adaptation |
| Guard band ratio |  | FDD: 6.4% (for 10 MHz) | FDD: 6.4% (for 10 MHz) | FDD: 6.4% (for 10 MHz) |
| BS receiver type |  | MMSE-IRC | MMSE with channel estimation error and interference modeling | MMSE-IRC |
| CSI feedback |  | PMI, CQI: every 5 slot; RI: every 5 slot; Subband based | PMI, CQI: every 5 slot; RI: every 5 slot; Subband based | PMI, CQI: every 5 slot; RI: every 5 slot; Subband based |
| Precoder derivation |  | FDD: NR Type II codebook based | FDD: NR Type II codebook based | FDD: NR Type II codebook based |
| Channel estimation |  | Non-ideal | Non-ideal | Non-ideal |
| Waveform |  | OFDM | OFDM | OFDM |
| Wrapping around method |  | Geographical distance-based wrapping | Geographical distance-based wrapping | Geographical distance-based wrapping |
| Polarized antenna model |  | Model-2 (TR36.873) | Model-2 (TR36.873) | Model-2 (TR36.873) |
| Modulation |  | Up to 256QAM | Up to 256 QAM | Up to 256 QAM |
| Overhead Assumption | | | | |  |  |  | Overhead Assumption |
| PDCCH |  | 2 OFDM symbols per slot | 2 OFDM symbols per slot | 2 OFDM symbols per slot |
| DMRS |  | Type II, up to 12 ports, dynamic | 2 OFDM symbols | Type II, based on MU-layer (dynamic in simulation upto 6 ports) |
| CSI-RS |  | CM : 5 slots period; 32 ports for 32Tx;  IM : ZP CSI-RS with 5 slots period; 4 RE/PRB/5 slots | N / A | 32 ports with periodicity of 5ms (for CM); |
| SSB |  | 1 SSB per 20 ms | 1 SSB per 20 ms | 1 SSB per 20 ms |
| TRS |  | 2 consecutive slots per 20ms, 1 port, 52PRB  12 RE/PRB/20ms | N / A | 20ms period; maximal bandwidth with 52 PRB; burst length with 2 slots 12 RE/PRB/20ms |

Table B-2-4

Assumptions and Configuration of Dense Urban-eMBB (Uplink Case)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Configuration A - Uplink | | | | |
|  | ITU-R M.2412 | Huawei | Nokia | CEWiT / IITM |
| Baseline configuration | | | | |
| Carrier frequency for evaluation | 1 layer (Macro) with 4 GHz | Aligned with reference | Aligned with reference | Aligned with reference |
| BS antenna height | 25 m | 25 m | 25 m | 25 m |
| Total transmit power per TRxP | 44 dBm for 20 MHz bandwidth 41 dBm for 10 MHz bandwidth | 41 dBm for 10 MHz bandwidth | 41 dBm for 10 MHz bandwidth | 41 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm | 23 dBm | 23 dBm |
| Percentage of high loss and low loss building type | 20% high loss, 80% low loss | 20% high loss, 80% low loss | 20% high loss, 80% low loss | 20% high loss, 80% low loss |
| Inter-site distance | 200 m | 200 m | 200 m | 200 m |
| Number of antenna elements per TRxP | Up to 256 Tx/Rx | 128Rx cross-polarized antenna (M,N,P,Mg,Ng) = (8,8,2,1,1) | 256Tx/Rx,  (M,N,P,Mg,Ng) = (16,8,2,1,1) | 128Tx/Rx,  (M,N,P,Mg,Ng) = (8,8,2,1,1) |
| Number of UE antenna elements | Up to 8 Tx/Rx | 4Tx (M,N,P,Mg,Ng) = (1,2,2,1,1) with 0°,90° polarization | 4Tx/Rx,  (M,N,P,Mg,Ng) = (1,2,2,1,1), | 4Tx/Rx,  (M,N,P,Mg,Ng) = (1,2,2,1,1), |
| Device deployment | 80% indoor,  20% outdoor (in-car) Randomly and uniformly distributed over the area under Macro layer | Aligned with reference | Aligned with reference | Aligned with reference |
| UE mobility model | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction. | Aligned with reference | Aligned with reference | Aligned with reference |
| UE speeds of interest | Indoor users: 3 km/h Outdoor users (in-car): 30 km/h | Aligned with reference | Aligned with reference | Aligned with reference |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB | 5 dB | 5 dB |
| UE noise figure | 7 dB | 7 dB | 7 dB | 7 dB |
| BS antenna element gain | 8 dBi | 8 dBi | 8 dBi | 8 dBi |
| UE antenna element gain | 0 dBi | 0 dBi | 0 dBi | 0 dBi |
| Thermal noise level | ‒174 dBm/Hz | ‒174 dBm/Hz | ‒174 dBm/Hz | ‒174 dBm/Hz |
| Traffic model | Full buffer | Full buffer | Full buffer | Full buffer |
| Simulation bandwidth | 20 MHz for TDD,  10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD |
| UE density | 10 UEs per TRxP Randomly and uniformly distributed over the area under Macro layer | Aligned with reference | Aligned with reference | Aligned with reference |
| UE antenna height | Outdoor UEs: 1.5 m Indoor UTs: 3(nfl – 1) + 1.5; nfl ~ uniform(1,Nfl) where Nfl ~ uniform(4,8) | Aligned with reference | Aligned with reference | Aligned with reference |
| Channdel Model | UMa\_A, UMa\_B | UMa\_A, UMa\_B | UMa\_A | UMa\_B |
| Additional parameters | | | | |  |  |  | Additional parameters |
| Subcarrier spacing |  | 15 kHz | 15 kHz | 15 kHz |
| Symbols number per slot |  | 14 | 14 | 14 |
| Number of TXRU per TRxP |  | 16TXRU (Mp,Np,P,Mg,Ng) = (1,8,2,1,1) Vertical 1-to-8 | 4TXRU,  (Mp,Np,P,Mg,Ng) = (2,1,2,1,1) | 4TXRU,  (Mp,Np,P,Mg,Ng) = (2,1,2,1,1) |
| TRxP number per site |  | 3 | 3 | 3 |
| Number of TXRU per UE |  | 2TXRU (Mp,Np,P,Mg,Ng) = (1,1,2,1,1) (1-to-1 mapping) | 4TXRU,  (Mp,Np,P,Mg,Ng) = (1,2,2,1,1) | 4TXRU,  (Mp,Np,P,Mg,Ng) = (1,2,2,1,1) |
| Mechanic tilt |  | 90deg in GCS  (pointing to the horizontal direction) | 90deg in GCS  (pointing to the horizontal direction) | 90deg in GCS  (pointing to the horizontal direction) |
| Electronic tilt |  | 105deg in LCS | 100deg in LCS | 105deg in LCS |
| UT attachment |  | Based on RSRP (Eq. (8.1-1) in TR 36.873) 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 |
| Scheduling |  | PF | PF with wideband scheduling | SU-PF |
| ACK/NACK delay |  | Next available UL slot | Next available UL slot | Next available UL slot |
| MIMO mode |  | SU-MIMO with rank adaptation | MU-MIMO with maximum UE rank of 2, maximum number of paired users is 6 | SU-MIMO with rank adaptation |
| BS receiver type |  | MMSE-IRC | MMSE-IRC | MMSE-IRC |
| UE precoder scheme |  | Codebook based | Codebook based | Codebook based |
| UL CSI derivation |  | Non-precoded SRS based, with delay | Codebook-based transmission,  CSI feedback period is 10ms, CSI feedback delay is 5 ms | Non-precoded SRS based, with delay |
| Power control |  | α= 0.9, P0 =-86 dBm | N / A | α= 0.8, P0 =-76 dBm |
| RB allocation for Power backoff model |  | Continuous: follow TS 38.101; Non-continuous: additional 2 dB reduction | N/A | N/A |
| Channel estimation |  | Non-ideal | Ideal | Ideal |
| Waveform |  | OFDM | OFDM | OFDM |
| CSI feedback |  | N/A | N/A | N/A |
| Wrapping around method |  | Geographical distance-based wrapping | Geographical distance-based wrapping | Geographical distance-based wrapping |
| Polarized antenna model |  | Model-2 (TR36.873) | Model-2 (TR36.873) | Model-2 (TR36.873) |
| Modulation |  | Up to 256QAM | Up to 256 QAM | Up to 256 QAM |
| Overhead Assumption | | | | |  |  |  | Overhead Assumption |
| PUCCH |  | 2 PRBs and 14 OS for the slots without SRS transmission;  2 PRBs and 12 OS for the slots with SRS |  | 1 slot with (3 PRB, 14 OS) and 9 slots with (1 PRB, 2 OS) |
| DMRS |  | Type II, 2 symbols, multiplexed with PUSCH | 2 complete symbols | Type II, 2 complete symbols |
| SRS |  | 2 symbols per 5 slots, |  | 2 OFDM symbols per 5 slots |

## B-4 Different MIMO modes

Two MIMO modes, MU-MIMO and SU-MIMO, are considered for the evaluation of NR DL spectral efficiency. The rank that a UE can use on a single resource element is eventually bounded by the number of receiver antenna ports and to a maximum of 2 for Type II feedback. If multiple UEs can be paired on the same resource element, the overall ranks gathered from these paired UEs will reveal better resource utilization and typically result in higher spectral efficiency. Pairing of UEs is done either based on the Type II feedback or assuming ideal channel information. The layers assigned to the UEs is dynamically changed based on the UE pairings in the current TTI.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_