TCOE India IEG Interim Evaluation Report of the 3GPP RIT

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# Introduction

This report contains the evaluation results received from TCOE proponents, which are reviewed and harmonized in TCOE meetings and used to summarize the evaluation results for quantitative assessment on TCOE INDIA RIT proposal. All evaluation results were generated by following the IMT‑2020 evaluation methodology as provided in ITU-R M.2412.

# Evaluation Summary

In this interim report, the following KPI has been evaluated.

|  |  |
| --- | --- |
| Test environment | Does the Evaluation Report indicate that the minimum technical performance requirements are met in the test environment? |
| Indoor Hotspot-eMBB | Partially Evaluated. Meets the requirement for the evaluated KPI. |
| Dense Urban-eMBB | Partially Evaluated. Meets the requirement for the evaluated KPI. |
| Rural-eMBB | Partially Evaluated. Meets the requirement for the evaluated KPI. |
| Urban Macro–mMTC | Not evaluated for this report |
| Urban Macro–URLLC | Partially evaluated. Meets the requirement for the evaluated KPI. |

The following KPI have been evaluated for this interim report.

|  |  |  |
| --- | --- | --- |
| Simulation | Analytical | Inspection |
| 1. Average spectral efficiency
2. 5th percentile user spectral efficiency
3. Mobility
4. Reliability
5. User Data Rate
6. Area traffic capacity
 | 1. Peak data rate
2. Peak spectral efficiency
3. User experienced data rate
4. Area traffic capacity
 | 1. Bandwidth
 |

The remaining KPI (connection density, control plane latency, user plane latency, mobility interruption time, energy efficiency) will be evaluated and presented in the final report.

In the next Table, the summary of the evaluated KPI is provided for quick reference. We observe that the RIT fulfills the requirements for the evaluated KPI

# Compliance Table

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Minimum technical performance requirements item (5.2.4.3.x), units, and ReportITU-R M.2410-0 section reference(1)** | **Category** | **Required value** | Value as per TCOE evalaution | **Requirement met?** | **Comments(3)** |
|  | **Usage scenario** | **Test environment** | **Downlink or uplink** |  |  |  |   |
| **5.2.4.3.1**Peak data rate (Gbit/s)*(4.1)* | eMBB | Not applicable | Downlink | 20 | 39.2 | Yes | 16 Component carriers  |
| Uplink | 10 | 20 | Yes |
| **5.2.4.3.2**Peak spectral efficiency (bit/s/Hz)*(4.2)* | eMBB | Not applicable | Downlink | 30 | 48.9 | Yes |  |
| Uplink | 15 | 25 | Yes |
| **5.2.4.3.3**User experienced data rate (Mbit/s)*(4.3)* | eMBB | Dense Urban – eMBB | Uplink | 50 | 50.4 | Yes |   |
| Downlink | 100 |  |  | NOT EVALUATED in this report |
| **5.2.4.3.4**5th percentile user spectral efficiency (bit/s/Hz)*(4.4)*  | eMBB | Indoor Hotspot – eMBB | Downlink | 0.3 | 0.344 | Yes |  |
| Uplink | 0.21 | 0.537 | Yes |  |
| eMBB | Dense Urban – eMBB | Downlink | 0.225 | 0.379 | Yes |  |
| Uplink | 0.15 | 0.213 | Yes |  |
| eMBB | Rural – eMBB  | Downlink | 0.12 | 0.13  | Yes |  |
| Uplink | 0.045 | 0.125 |  |
| **5.2.4.3.5**Average spectral efficiency (bit/s/Hz/ TRxP)*(4.5)*   | eMBB | Indoor Hotspot – eMBB | Downlink | 9  | 11.31 | Yes |  |
| Uplink | 6.75  | 8.64 | Yes |  |
| eMBB  | Dense Urban – eMBB | Downlink | 7.8  | 11.42  | Yes |  |
| Uplink | 5.4  | 6.50 | Yes |  |
| eMBB | Rural – eMBB | Downlink | 3.3  | 4.18 | Yes |  |
| Uplink | 1.6  | 5.71 | Yes |  |
| **5.2.4.3.6**Area traffic capacity (Mbit/s/m2)*(4.6)* | eMBB | Indoor-Hotspot – eMBB | Downlink | 10 | 10.55 | Yes |  |
| **5.2.4.3.7**User plane latency(ms)*(4.7.1)* | eMBB | Not applicable | Downlink  | 4  |  |  | NOT EVALUATED in this report |
| Uplink |  |  |
|  URLLC | Not applicable | Downlink | 1   |  |  | NOT EVALUATED in this report |
| Uplink  |  |  |
| **5.2.4.3.8**Control plane latency (ms)*(4.7.2)* | eMBB | Not applicable | Not applicable  | 20 |  |  | NOT EVALUATED in this report |
| URLLC | Not applicable | Not applicable | 20 |  |  | NOT EVALUATED in this report |
| **5.2.4.3.9**Connection density (devices/km2)*(4.8)* | mMTC | Urban Macro – mMTC | Uplink  | 1 000 000  |   |  | NOT EVALUATED in this report |
|   |  | NOT EVALUATED in this report |
| **5.2.4.3.10**Energy efficiency*(4.9)* | eMBB | Not applicable | Not applicable | Capability to support a high sleep ratio and long sleep duration |  |  |  NOT EVALUATED in this report  |
| **5.2.4.3.11**Reliability*(4.10)*  | URLLC | Urban Macro –URLLC  | Downlink   | 1-10−5 success probability of transmitting a layer 2 PDU (protocol data unit) of size 32 bytes within 1 ms in channel quality of coverage edge99.999% | 99.9998112% | Yes |  |
| Uplink  | 99.9999997% | Yes |  |
| **5.2.4.3.12**Mobility classes*(4.11)* | eMBB | Indoor Hotspot – eMBB | Uplink | Stationary, Pedestrian | Stationary, Pedestrian | Yes | For all evaluation configurations in Indoor Hotspot – eMBB. |
| eMBB | Dense Urban – eMBB | Uplink | Stationary, Pedestrian, Vehicular (up to 30 km/h) | Stationary, Pedestrian,Vehicular (up to 30 km/h) | Yes | For all evaluation configurations in Dense Urban – eMBB |
| eMBB | Rural – eMBB | Uplink | Pedestrian, Vehicular, High speed vehicular | Pedestrian, Vehicular, High speed vehicular | Yes | For all evaluation configurations in Rural - eMBB |
| **5.2.4.3.13**MobilityTraffic channel link data rates (bit/s/Hz)*(4.11)* | eMBB | Indoor Hotspot – eMBB | Uplink | 1.5 (10 km/h) | 1.75  | Yes |  |
| eMBB | Dense Urban – eMBB | Uplink | 1.12 (30 km/h) | 1.89  | Yes |  |
| eMBB  | Rural – eMBB | Uplink  | 0.8 (120 km/h) | 2.31  | Yes |  |
| 0.45 (500 km/h) | 2.07  | Yes |
| **5.2.4.3.14**Mobility interruption time (ms) *(4.12)* | eMBB and URLLC | Not applicable | Not applicable | 0 |  |  | NOT EVALUATED |
| **5.2.4.3.15**Bandwidth and Scalability*(4.13)*  | Not applicable | Not applicable | Not applicable | At least 100 MHz | 800 MHz - 6.4 GHz | Yes |    |
| Up to 1 GHz |  | Yes |
| Support of multiple different bandwidth values | 3 - 13 different component carrier bandwidth values | Yes |
|   | (1) As defined in Report ITU-R M.2410-0.(2) According to the evaluation methodology specified in Report ITU-R M.2412-0.(3) Proponents should report their selected evaluation methodology of the Connection density, the channel model variant used, and evaluation configuration(s) with their exact values (e.g. antenna element number, bandwidth, etc.) per test environment, and could provide other relevant information as well. For details, refer to Report ITU-R M.2412-0, in particular, § 7.1.3 for the evaluation methodologies, § 8.4 for the evaluation configurations per each test environment, and Annex 1 on the channel model variants.(4) Refer to § 7.3.1 of Report ITU-R M.2412-0. |

# Average and 5th percentile spectral efficiency

Average spectral efficiencyis the aggregate throughput of all users (the number of correctly received bits, *i.e.,* the number of bits contained in the SDUs delivered to Layer 3, over a certain period of time) divided by the channel bandwidth of a specific band divided by the number of TRxPs and is measured in bit/s/Hz/TRxP.

The evaluation assumptions are given below.

## Simulation Parameters

**Table 3.1: Evaluation assumptions for DL**

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| Test environment | Indoor Hotspot – eMBB | Dense Urban – eMBB | Rural - eMBB |
| Evaluation configuration | Configuration A/B | Configuration A | Configuration A/B/C  |
| Channel model | InH\_B | UMa\_B | RMa\_B |
| ISD | 20 m (12TRxP) | 200 m | Configuration A/B: 1732 m Configuration C: 6000 m |
| TDD frame structure | DDDSU | DDDSU | DDDSU |
| Carrier Frequency | Configuration A: 4 GHzConfiguration B: 30 GHz | 4 GHz | Configuration A: 700 MHzConfiguration B: 4 GHzConfiguration C: 700 MHz |
| System bandwidth | TDD:Configuration A: 20MHz ;Configuration B: 80MHz  | TDD: 20MHz | TDD: 20MHz |
| FDD:10MHz | FDD:10MHz | FDD:10MHz |
| Subcarrier spacing | FDD: 15 kHzTDD: 15kHz and 30 kHz for configuration A: 60kHz forconfiguration B  | FDD: 15 kHzTDD: 15kHz and 30 kHz | FDD: 15 kHzTDD: 15kHz and 30 kHz |
| Symbols number per slot | 14 | 14 | 14 |
| Number of antenna elements per TRxP | Configuration A/B: 32Tx cross-polarized antennas(M,N,P,Mg,Ng) = (4,4,2,1,1); | For 32Tx: 128Tx cross-polarized antennas(M,N,P,Mg,Ng) = (8,8,2,1,1)For 64Tx: 192Tx cross-polarized antennas(M,N,P,Mg,Ng) = (12,8,2,1,1) | Configuration A/C: 64Tx cross-polarized antennas(M,N,P,Mg,Ng) = (8,4,2,1,1);Configuration B: 128Tx cross-polarized antennas(M,N,P,Mg,Ng) = (8,8,2,1,1) |
| Number of TXRU per TRxP | Configuration A/B: 32TXRU: Vertical 1-to-1 | 32TXRU: Vertical 2-to-864TXRU: Vertical 4-to-12 | Configuration A/C: 8TXRU Vertical 1-to-8; 16TXRU Vertical 2-to-8.Configuration B: 32TXRU Vertical 2-to-8 |
| Number of antenna elements per UE | Configuration A : 4Rx with 0°,90° polarizationConfiguration B : 8Rx with 0°,90° polarization(M,N,P,Mg,Ng; Mp,Np) = (2,4,2,1,2; 1,2) | 4Rx with 0°,90° polarization | Configuration A: 2Rx Configuration B/C: 4Rxwith 0°,90° polarization |
| Transmit power per TRxP | TDD: Configuration A: 24 dBm Configuration B: 23 dBm | TDD: 44 dBm | TDD: 49 dBm |
| FDD: 21 dBm | FDD: 41 dBm | FDD: 46 dBm |
| TRxP number per site | 1 | 3 | 3 |
| Mechanic tilt | 180deg in GCS (pointing to the ground) | 90deg in GCS (pointing to the horizontal direction) | 90deg in GCS (pointing to the horizontal direction) |
| Electronic tilt | Configuration A: 90deg in LCSConfiguration B: According to Zenith angle in "Beam set at TRxP" | 105deg in LCS | Configuration A/B: 100deg in LCS Configuration C: 92deg in LCS  |
| Beam set at TRxP | Configuration B: Azimuth angle φi = [0],Zenith angle θj = [pi/2] | N/A | N/A |
| Beam set at UE | Configuration B: Azimuth angle φi = [-pi/4, pi/4]; Zenith angle θj = [pi/4, 3\*pi/4] | N/A | N/A |
| UT attachment | Based on RSRP (Eq. (8.1-1) in TR 36.873) from port 0 | Based on RSRP (Eq. (8.1-1) in TR 36.873) from port 0 | Based on RSRP (Eq. (8.1-1) in TR 36.873) from port 0 |
| Scheduling | MU-PF | MU-PF | MU-PF |
| ACK/NACK delay | Next available UL slot | Next available UL slot | Next available UL slot |
| MIMO mode | MU-MIMO with rank 2/4 adaptation per user;Configuration A: Maximum MU layer = 12;Configuration B: Maximum MU layer = 6 | MU-MIMO with rank 2/4 adaptation per user;Maximum MU layer = 12 | MU-MIMO with rank 2/4 adaptation per user;Maximum MU layer = 8 for 8Tx and maximum MU layer = 12 for 16Tx and 32Tx; |
| Guard band ratio | TDD: Configuration A: 8.2% for 30kHz SCS and 4.6% for 15kHz SCS (for 20 MHz);Configuration B: 5.5% (for 80 MHz); | TDD: 8.2% for 30kHz SCS and 4.6% for 15kHz SCS (for 20 MHz) | 8.2% for 30kHz SCS and 4.6% for 15kHz SCS (for 20 MHz) |
| FDD: 6.4% (for 10 MHz) | FDD: 6.4% (for 10 MHz) | FDD: 6.4% (for 10 MHz) |
| BS receiver type | MMSE-IRC | MMSE-IRC | MMSE-IRC |
| CSI feedback | 5 slots period based on non-precoded CSI-RS with delay | For 32Tx: 5 slots period based on non-precoded CSI-RS with delayFor 64Tx: 5 slots period based on precoded CSI-RS with delay | 5 slots period based on non-precoded CSI-RS with delay |
| SRS transmission | Non-precoded SRS for 4Tx ports;Period: 5 slots;2 symbols for 30kHz SCS;4 symbols for 15kHz SCS; | Non-precoded SRS for 4Tx ports;Period: 5 slots;2 symbols for 30kHz SCS;4 symbols for 15kHz SCS; | Non-precoded SRS for 2/4 Tx ports for 2/4 Rx;Period: 5 slots;4 symbols per 5 slots for configuration A/B for 15kHz and 30kHz; 2 symbols for 30kHz SCS and 4 symbols for 15kHz SCS for configuration C; |
| Precoder derivation | TDD: SRS based | TDD: SRS based | TDD: SRS based |
| FDD: NR Type II codebook (4 beams, WB+SB quantization, 8 PSK) | FDD: NR Type II codebook (4 beams, WB+SB quantization, 8 PSK) | FDD: NR Type II codebook (4 beams, WB+SB quantization, 8 PSK) |
| Overhead | PDCCH | 2 complete symbols | 2 complete symbols | 2 complete symbols |
| DMRS | Type II, based on MU-layer (dynamic in simulation) | Type II, based on MU-layer (dynamic in simulation) | Type II, based on MU-layer (dynamic in simulation) |
| CSI-RS | FDD: 32 ports per 5 slots | FDD: 32 ports per 5 slots | FDD: 8/16/32 ports for 8Tx/16Tx/32Tx |
| TDD: 32 ports per 5 slots | TDD: For 64Tx, 4 ports per UE per 5 slots; For 32Tx, 32 ports per 5 slots | TDD: 8/16/32 ports for 8Tx/16Tx/32Tx  |
| CSI-RS for IM | ZP CSI-RS with 5 slots period; 4 RE/PRB/5 slots | ZP CSI-RS with 5 slots period; 4 RE/PRB/5 slots | ZP CSI-RS with 5 slots period; 4 RE/PRB/5 slots |
| SSB | 1 SSB per 20 ms | 1 SSB per 20 ms | 1 SSB per 20 ms |
| TRS | 2 consecutive slots per 20 ms, 1 port, maximal 52 PRBs | 2 consecutive slots per 20ms, 1 port, maximal 52 PRBs | 2 consecutive slots per 20 ms, 1 port, maximal 52 PRBs |
| PTRS | Configuration B: 2 ports PT-RS, (L,K) = (1,4) L is time density and K is frequency density | N/A | N/A |
| Channel estimation | Non-ideal | Non-ideal | Non-ideal |
| Waveform | OFDM | OFDM | OFDM |

**Table 3.2: Evaluation assumptions for UL**

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| Test environment | Indoor Hotspot – eMBB | Dense Urban – eMBB | Rural - eMBB |
| Evaluation configuration | Configuration A/B | Configuration A | Configuration A/B/C |
| Channel model | InH\_B | UMa\_B | RMa\_B |
| Subcarrier spacing | FDD: 15 kHzTDD: 15kHz and 30 kHz for configuration A: 60kHz forconfiguration B  | FDD: 15 kHzTDD: 15kHz and 30 kHz | FDD: 15 kHzTDD: 15kHz and 30kHz |
| TDD frame structure | DDDSU | DDDSU | DDDSU |
| Symbols number per slot | 14 | 14 | 14 |
| Number of antenna elements per TRxP | Configuration A: 32Rx cross-polarized antenna (M,N,P,Mg,Ng) = (4,4,2,1,1);Configuration B: 64Rx cross-polarized antenna for 16TXRU, (M,N,P,Mg,Ng) = (4,8,2,1,1);32Rx cross-polarized antenna for 32TXRU, (M,N,P,Mg,Ng) = (4,4,2,1,1); | For 32Rx: 128Rx cross-polarized antenna(M,N,P,Mg,Ng) = (8,8,2,1,1)For 64Rx: 192Rx cross-polarized antenna(M,N,P,Mg,Ng) = (12,8,2,1,1) | Configuration A/C: 64Rx cross-polarized antenna(M,N,P,Mg,Ng) = (8,4,2,1,1);Configuration B: 128Rx cross-polarized antenna(M,N,P,Mg,Ng) = (8,8,2,1,1) |
| Number of TXRU per TRxP | Configuration A/B: 32TXRU Vertical 1-to-1;Configuration B: 16TXRU Vertical 2-to-4, Horizontal 4-to-8 | 32TXRU: Vertical 2-to-864TXRU: Vertical 4-to-12 | Configuration A/C: 8TXRU Vertical 1-to-8Configuration B: 32TXRU Vertical 2-to-8 |
| Number of antenna elements per UE | Configuration A : 2Tx/4Tx with 0°,90° polarizationConfiguration B : 8Tx with 0°,90° polarization(M,N,P,Mg,Ng; Mp,Np) = (2,4,2,1,2; 1,2) | 2Tx/4Tx with 0°,90° polarization | Configuration A: 1Tx for FDD, 2Tx with 0°,90° polarization ;Configuration B: 1Tx/4Tx with 0°,90° polarizationConfiguration C: 2Tx/4Tx with 0°,90° polarization |
| UE power class | 23 dBm | 23 dBm | 23 dBm |
| Mechanic tilt | 180deg in GCS (pointing to the ground) | 90deg in GCS (pointing to the horizontal direction) | 90deg in GCS (pointing to the horizontal direction) |
| Electronic tilt | Configuration A: 90deg in LCSConfiguration B: According to Zenith angle in "Beam set at TRxP" | 105deg in LCS | Configuration A/B: 100deg in LCS Configuration C: 92deg in LCS |
| Beam set at TRxP | Configuration B: For 32Rx, Azimuth angle φi = [0],Zenith angle θj = [pi/2];For 16Rx, Azimuth angle φi = [-pi/4,pi/4], Zenith angle θj = [pi/2]; | N/A | N/A |
| Beam set at UE | Configuration B: Azimuth angle φi = [-pi/4, pi/4]; Zenith angle θj = [pi/4, 3\*pi/4] | N/A | N/A |
| UT attachment | Based on RSRP (Eq. (8.1-1) in TR36.873) from port 0 | Based on RSRP (Eq. (8.1-1) in TR36.873) from port 0 | Based on RSRP (Eq. (8.1-1) in TR36.873) from port 0 |
| Scheduling | SU-PF | SU-PF | SU-PF |
| MIMO mode | Configuration A: SU-MIMO with rank 2 adaptation; Configuration B: SU-MIMO with rank 4 adaptation;  | SU-MIMO with rank 2 adaptation | SIMO for 1Tx;SU-MIMO with rank 2 adaptation for 2Tx/4Tx |
| 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 | Non-precoded SRS based, with delay | Non-precoded SRS based, with delay |
| Power control | $α=0.9， P\_{0}=-86$ dBm | $α=0.6， P\_{0}=-60$ dBm | Configuration A: $α=0.8， P\_{0}=-76$ dBm;Configuration B: $α=0.6， P\_{0}=-60$ dBm;Configuration C: $α=0.6， P\_{0}=-60$ dBm |
| Power backoff model | Continuous RB allocation: follow TS 38.101 in Section 6.2.2;Non-continuous RB allocation: additional 2 dB reduction | Continuous RB allocation: follow TS 38.101 in Section 6.2.2;Non-continuous RB allocation: additional 2 dB reduction | Continuous RB allocation: follow TS 38.101 in Section 6.2.2;Non-continuous RB allocation: additional 2 dB reduction |
| Overhead | PUCCH | 2 RBs and 14 OFDM symbols for FDD and TDD 30kHz SCS;4 RBs and 14 OFDM symbols for TDD 15kHz and 60kHz SCS; | 2 RBs and 14 OFDM symbols for FDD and TDD 30kHz SCS;4 RBs and 14 OFDM symbols for TDD 15kHz SCS; | 2 RBs and 14 OFDM symbols for FDD and TDD 30kHz SCS;4 RBs and 14 OFDM symbols for TDD 15kHz SCS; |
| DMRS | Type II, 2 symbols (including one additional DMRS symbol), multiplexing with PUSCH | Type II, 2 symbols (including one additional DMRS symbol), multiplexing with PUSCH | Type II, 2 symbols (including one additional DMRS symbol), multiplexing with PUSCH |
| SRS | 2 symbols per 5 slots, | 2 symbols per 5 slots, | 2 symbols per 5 slots, |
| PTRS | Configuration B: 2 ports PT-RS, (L,K) = (1,4) L is time density and K is frequency density | N/A | N/A |
| Channel estimation | Non-ideal | Non-ideal | Non-ideal |
| Waveform | OFDM | OFDM | OFDM |

## Results

**Table 3.3: FDD DL spectral efficiency evaluation for different system bandwidth in FR1
(Channel model B)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Test env.** | **Evaluation config.** | **Average spectral efficiency (bit/s/Hz/TRxP)** | **5th percentile spectral efficiency(bit/s/Hz)** |
| **BW=10** **MHz** | **BW=20** **MHz** | **BW=50** **MHz** | **Req.** | **BW=10** **MHz** | **BW=20 MHz** | **BW=50 MHz** | **Req.** |
| Indoor Hotspot  | Config. A 32T4R | 11.307 | 12.826 | 13.862 | 9 | 0.344 | 0.39 | 0.422 | 0.3 |
| Dense Urban  | Config. A 32T4R | 11.417 | 12.904 | 13.921 | 7.8 | 0.379 | 0.428 | 0.462 | 0.225 |
| Rural  | Config. A8T2R | 6.537 | 7.32 | 7.858 | 3.3 | 0.13 | 0.146 | 0.156 | 0.12 |
| Config. A16T2R | 7.456 | - | - | 0.156 | - | - |
| Config. B32T4R | 13.533 | 15.299 | 16.506 | 0.345 | 0.39 | 0.421 |
| Config. C8T4R | 7.607 | 8.521 | 9.151 | 0.183 | 0.205 | 0.22 |
| Config. C16T4R | 8.137 | - | - | 0.201 | - | - |

**Table 3.4: TDD DL spectral efficiency evaluation for different system bandwidth in FR1 (Channel model B)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Test env.** | **Evaluation config.** | **Average spectral efficiency (bit/s/Hz/TRxP)** | **5th percentile spectral efficiency(bit/s/Hz)** |
| **BW=20** **MHz** | **BW=40** **MHz** | **BW=100 MHz** | **Req.** | **BW=20** **MHz** | **BW=40 MHz** | **BW=100 MHz** | **Req.** |
| Indoor Hotspot  | Config. A (30KHz SCS);32T4R | 12.78 | 14.953 | 16.439 | 9 | 0.385 | 0.45 | 0.495 | 0.3 |
| Config. A (15KHz SCS); 32T4R | 12.53 | - | - | 0.394 | - | - |
| Dense Urban  | Config. A (30KHz SCS);32T4R | 12.581 | 14.646 | 16.061 | 7.8 | 0.385 | 0.448 | 0.491 | 0.225 |
| Config. A (30KHz SCS);64T4R | 15.542 | 18.184 | 19.991 | 0.475 | 0.556 | 0.611 |
| Config. A (15KHz SCS);32T4R | 12.506 | - | - | 0.395 | - | - |
| Config. A (15KHz SCS);64T4R | 15.172 | - | - | 0.483 | - | - |
| Rural  | Config. A(30KHz SCS);8T2R | 7.604 | 8.742 | 9.526 | 3.3 | 0.185 | 0.213 | 0.232 | 0.12 |
| Config. A(30KHz SCS);16T2R | 9.049 | - | - | 0.215 | - | - |
| Config. A(15KHz SCS);8T2R | 7.433 | - | - | 0.156 | - | - |
| Config. A(15KHz SCS);16T2R | 8.783 | - | - | 0.18 | - | - |
| Config. B(30KHz SCS);32T4R | 14.946 | 17.405 | 19.09 | 0.37 | 0.431 | 0.473 |
| Config. B(15KHz SCS);32T4R | 14.901 | - | - | 0.359 | - | - |
| Config. C(30KHz SCS);8T4R | 7.641 | 8.787 | 9.576 | 0.178 | 0.205 | 0.223 |
| Config. C(30KHz SCS);16T4R | 8.429 | - | - | 0.19 | - | - |
| Config. C(15KHz SCS);8T4R | 7.869 | - | - | 0.192 | - | - |
| Config. C(15KHz SCS);16T4R | 8.653 | - | - | 0.211 | - | - |

**Table 3.5: FDD UL spectral efficiency evaluation in FR1 (Channel model B)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Test env.** | **Evaluation config.** | **Average spectral efficiency (bit/s/Hz/TRxP)** | **5th percentile spectral efficiency(bit/s/Hz)** |
| **BW=10** **MHz** | **BW=20 MHz** | **BW=40** **MHz** | **Req.** | **BW=10 MHz** | **BW=20** **MHz** | **BW=40 MHz** | **Req.** |
| Indoor Hotspot  | Config. A 2T32R | 8.643 | 8.809  | 9.148  | 6.75 | 0.537 | 0.547  | 0.568  | 0.21 |
| Config. A 4T32R | 9.198 | - | - | 0.572 | - | - |
| Dense Urban  | Config. A 2T16R | 6.499 | 6.624  | 6.879  | 5.4 | 0.213 | 0.217  | 0.225  | 0.15 |
| Config. A 2T32R | 7.874 | 8.025  | 8.334  | 0.315 | 0.321  | 0.333  |
| Config. A 4T32R | 8.568 | - | - | 0.365 | - | - |
| Rural  | Config. A1T8R | 4.184 | 4.264  | 4.428  | 1.6 | 0.125 | 0.127  | 0.132  | 0.045 |
| Config. A2T8R | 6.204 | - | - | 0.133 | - | - |
| Config. B1T32R | 4.161 | 4.241  | 4.404  | 0.142 | 0.145  | 0.150  |
| Config. B4T32R | 7.364 | - | - | 0.209 | - | - |
| Config. C 2T8R | 3.999 | 4.076  | 4.233  | 0.073 | 0.074  | 0.077  |
| Config. C4T8R | 4.675 | - | - | 0.091 | - | - |

**Table 3.6: TDD UL spectral efficiency evaluation in FR1 (Channel model B)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Test env.** | **Evaluation Config.** | **Average spectral efficiency (bit/s/Hz/TRxP)** | **5th percentile spectral efficiency(bit/s/Hz)** |
| **BW=20** **MHz** | **BW=40** **MHz** | **BW=100 MHz** | **Req.** | **BW=20** **MHz** | **BW=40** **MHz** | **BW=100 MHz** | **Req.** |
| Indoor Hotspot  | Config. A (30KHz SCS);2T32R | 7.604 | 7.902  | 8.460  | 6.75 | 0.423 | 0.440  | 0.471  | 0.21 |
| Config. A (30KHz SCS);4T32R | 8.277 | - | - | 0.469 | - | - |
| Config. A (15KHz SCS);2T32R | 7.631 | - | - | 0.428 | - | - |
| Config. A (15KHz SCS);4T32R | 8.363 | - | - | 0.476 | - | - |
| Dense Urban | Config. A (30KHz SCS);2T32R | 6.629 | 6.889  | 7.375  | 5.4 | 0.271 | 0.282  | 0.302  | 0.15 |
| Config. A (30KHz SCS);2T64R | 7.601 | 7.899  | 8.457  | 0.353 | 0.367  | 0.393  |
| Config. A (30KHz SCS);4T32R | 7.329 | - | - | 0.336 | - | - |
| Config. A (15KHz SCS);2T32R | 6.813 | - | - | 0.259 | - | - |
| Config. A (15KHz SCS);2T64R | 7.861 | - | - | 0.31 | - | - |
| Config. A (15KHz SCS);4T32R | 7.554 | - | - | 0.303 | - | - |
| Rural  | Config. A(30KHz SCS);2T8R | 5.171 | 5.374  | 5.753  | 1.6 | 0.107 | 0.111  | 0.119  | 0.045 |
| Config. A(15KHz SCS);2T8R | 5.483 | - | - | 0.094 | - | - |
| Config. B(30KHz SCS);1T32R | 3.384 | 3.517  | 3.765  | 0.103 | 0.107  | 0.115  |
| Config. B(30KHz SCS);4T32R | 6.257 | - | - | 0.141 | - | - |
| Config. B(15KHz SCS);1T32R | 3.643 | - | - | 0.104 | - | - |
| Config. B(15KHz SCS);4T32R | 6.349 | - | - | 0.157 | - | - |
| Config. C(30KHz SCS);2T8R | 3.593 | 3.734  | 3.997  | 0.059 | 0.061  | 0.066  |
| Config. C(30KHz SCS);4T8R | 4.153 | - | - | 0.071 | - | - |
| Config. C(15KHz SCS);2T8R | 3.751 | - | - | 0.045 | - | - |
| Config. C(15KHz SCS);4T8R | 4.293 | - | - | 0.056 | - | - |

# Mobility

Mobility is the maximum mobile station speed at which a defined QoS can be achieved (in km/h). The QoS is defined as normalized traffic channel link data rate. Channel model B is used for all the Mobility evaluations.

## Simulation assumption of System level simulation (SLS) part for mobility

The simulation assumption of system level part for mobility evaluation is listed in Table 4.1.1.

**Table 4.1.1: Simulation assumptions of SLS**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Indoor Hotspot – eMBB | Dense urban - eMBB | Rural - eMBB |
| Evaluation configuration | Configuration A, Configuration B | Configuration A  | Configuration A, Configuration B |
| Carrier frequency for evaluation | 4 GHz | 4 GHz | Configuration A :700 MHzConfiguration B : 4 GHz |
| Multiple access | OFDMA | OFDMA | OFDMA |
| Duplexing  | FDD, TDD | FDD, TDD | FDD, TDD |
| Transmission scheme | UL SIMO | UL SIMO | UL SIMO |
| BS antenna height | 3m | 25 m | 35 m |
| Total transmit power per TRxP | 21 dBm for 10 MHz bandwidth | 41 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 | - | 20% high loss, 80% low loss (applies to Channel model B) | 100% low loss (applies to Channel model B) |
| Inter-site distance | 20 m | 200 m | 1732 m |
| Number of antenna elements per TRxP | 32 Tx/Rx, (M,N,P,Mg,Ng) = (4,4,2,1,1), (dH,dV) = (0.5, 0.5)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 | 32 Tx/Rx, (M,N,P,Mg,Ng) = (8,2,2,1,1), (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) | 8TXRU, (Mp,Np,P,Mg,Ng) = (1,4,2,1,1) | 4TXRU, (Mp,Np,P,Mg,Ng) = (1,2,2,1,1) |
| Number of UE antenna elements | 1Tx/Rx, (M,N,P,Mg,Ng) = (1,1,1,1,1) | 1Tx/Rx, (M,N,P,Mg,Ng) = (1,1,1,1,1) | 1Tx/Rx, (M,N,P,Mg,Ng) = (1,1,1,1,1) |
| Device deployment | 100% indoorRandomly and uniformly distributed over the area | 80% indoor, 20% outdoor (in car)Randomly and uniformly distributed over the area under Macro layer | 50% indoor, 50% outdoor (in car)Randomly and uniformly distributed over the area |
| UE speeds of interest | 10 km/h | 30 km/h; | 120 km/h;500km/h; |
| Traffic model | Full buffer | Full buffer | Full buffer |
| Simulation bandwidth | For FDD: 10 MHzFor TDD: 20 MHz | For FDD: 10 MHzFor TDD: 20 MHz | For FDD: 10 MHzFor TDD: 20 MHz |
| UE density | 10 UEs per TRxP | 10 UEs per TRxP | 10 UEs per TRxP |
| UE antenna height | 1.5 m | Outdoor UEs: 1.5 mIndoor UTs: 3(nfl – 1) + 1.5;nfl ~ uniform(1,Nfl) whereNfl ~ uniform(4,8) | 1.5 m |
| Channel model variant | Channel model B | Channel model B | Channel model B |
| TRxP number per site | 1 or 3 | 3 | 3 |
| Mechanic tilt | For 1 TRxP per site:180° in GCS (pointing to the ground)For 3 TRxPs per site: 110° | 90° in GCS (pointing to horizontal direction) | 90° in GCS (pointing to horizontal direction) |
| Electronic tilt | 90° in LCS | 105° in LCS | 100° in LCS |
| Handover margin (dB) | 1 | 1 | 1 |
| TRxP boresight | For 1 TRxP per site::-For 3 TRxP per site: 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 | No wrapping around | Geographical distance based wrapping | Geographical distance based wrapping |
| Minimum distance of TRxP and UE | d2D\_min=0m | d2D\_min=10m | d2D\_min=10m |
| Polarized antenna model | Model-2 in TR36.873 | Model-2 in TR36.873 | Model-2 in TR36.873 |
| Power control parameters | **= 0.6, P0 = -60 dBm | **= 0.9, P0 = -86 dBm | For 700 MHz :**= 0.8, P0 = -76 dBmFor 4 GHz :**= 0.6, P0 = -60 dBm |
| Numerology | For FDD: One slot with 15 kHz SCSFor TDD: One slot with 30 kHz SCS | For FDD: One slot with 15 kHz SCSFor TDD: One slot with 30 kHz SCS | For 700 MHz:* 120 km/h: one slot with 15 kHz SCS
* 500 km/h: one slot with 30 kHz SCS

For 4 GHz:* 120 km/h: one slot with 30 kHz SCS
* 500 km/h: one slot with 60 kHz SCS
 |
| Scheduling | PF | PF | PF |
| Receiver | MMSE-IRC | MMSE-IRC | MMSE-IRC |
| Pre-processing SINR calculation | Aligned with Section 2.1.1 in R1-1805643 | Aligned with Section 2.1.1 in R1-1805643 | Aligned with Section 2.1.1 in R1-1805643 |

## Simulation assumption of Link level simulation (LLS) part for mobility

The simulation assumption of link level part for mobility evaluation is listed in Table 4.2.1.

**Table 4.2.1: Simulation assumptions of LLS**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Indoor Hotspot – eMBB | Dense urban - eMBB | Rural – eMBB  |
| Carrier frequency for evaluation | 4 GHz | 4 GHz | Configuration A :700 MHz; Configuration B : 4 GHz |
| RIT | NR | NR | NR |
| Waveform | CP-OFDM | CP-OFDM | CP-OFDM |
| Duplexing  | FDD, TDD | FDD, TDD | FDD, TDD |
| TDD frame structure | DDDSU | DDDSU | DDDSU |
| Evaluated service profiles | Full buffer best effort | Full buffer best effort | Full buffer best effort |
| Simulation bandwidth | 10 MHz | 10 MHz | 10 MHz |
| Number of users in simulation | 1 | 1 | 1 |
| Link-level Channel model | NLOS: CDL-iLOS: CDL-iv | NLOS: CDL-iiiLOS: CDL-v | NLOS: CDL-iiiLOS: CDL-v |
| UE speed | 10 km/h | 30 km/h | 120 km/h, 500 km/h |
| Subcarrier spacing | For FDD: 15 kHzFor TDD: 30 kHz | For FDD: 15 kHzFor TDD: 30 kHz | For 700 MHz:* 120 km/h: 15 kHz
* 500 km/h: 30 kHz

For 4 GHz:* 120 km/h: 30 kHz
* 500 km/h: 60 kHz
 |
| Symbols number per slot | 14 | 14 | 14 |
| Antenna configuration at TRxP | 8R, (4,4,2,1,1; 1,4) | 8R, (8,4,2,1,1; 1,4) | 4R, (8,2,2,1,1; 1,2) |
| Antenna configuration at UE | 1T, (1,1,1,1,1; 1,1) | 1T, (1,1,1,1,1; 1,1) | 1T, (1,1,1,1,1; 1,1) |
| TXRU pattern at TRxP | Option 1: 0dBi Omni-directional | Option 1: 0dBi Omni-directional | Option 1: 0dBi Omni-directional |
| TXRU pattern at UE | Option 1: 0dBi Omni-directional | Option 1: 0dBi Omni-directional | Option 1: 0dBi Omni-directional |
| Transmission mode | SIMO | SIMO | SIMO |
| Transmission rank | Rank 1 | Rank 1 | Rank 1 |
| UL precoder | - | - | - |
| TRxP receiver type | MMSE-IRC | MMSE-IRC | MMSE-IRC |
| Channel estimation | LMMSE | LMMSE | LMMSE |
| Number of subcarriers per PRB | 12 | 12 | 12 |
| Data allocation | 14 symbol slots, with 12 RB allocated | 14 symbol slots, with 12 RB allocated | 14 symbol slots, with 12 RB allocated |
| Channel coding scheme | LDPC | LDPC | LDPC |
| Link adaptation | Yes | Yes | Yes |
| HARQ | Max 4 HARQ transmissions | Max 4 HARQ transmissions | Max 4 HARQ transmissions |
| DMRS configuration | 2 symbol DMRS (front loaded and one additional) with configuration type 2, no FDM with data and full power utilization in DMRS symbols | 2 symbol DMRS (front loaded and one additional) with configuration type 2, no FDM with data and full power utilization in DMRS symbols | - For 4GHz 500km/h: 4 symbol DMRS (front loaded and 3 additional) with configuration type 2, no FDM with data and full power utilization in DMRS symbols- Others: 2 symbol DMRS (front loaded and one additional) with configuration type 2, no FDM with data and full power utilization in DMRS symbols |
| Other overhead | - SRS: 2 symbols per 5 slots. For TDD, the 2 symbols are the 2 uplink symbols in S sub-frame- PUCCH :2 RB in 10MHz bandwidth  | - SRS: 2 symbols per 5 slots. For TDD, the 2 symbols are the 2 uplink symbols in S sub-frame- PUCCH :2 RB in 10MHz bandwidth | - SRS: 2 symbols per 5 slots. For TDD, the 2 symbols are the 2 uplink symbols in S sub-frame- PUCCH :2 RB in 10MHz bandwidth |

Based on the above figures, the 50%-tile point of the CDF for different test environments are listed in Table 4.2.2.

**Table 4.2.2: The 50%-tile point of SINR CDF for different test environments**

|  |  |  |  |
| --- | --- | --- | --- |
| Test environment | Evaluation configuration | UE mobility | 50%-tile point of SINR CDF (dB) |
| Channel model B |
| Rural – eMBB | Config. A (700 MHz) | 120 km/h | 10.14 |
| 500 km/h | 9.65 |
| Rural - eMBB | Config. B (4 GHz) | 120 km/h | 4.50 |
| 500 km/h | 2.72 |
| Dense Urban – eMBB | Config. A (4 GHz) | 30 km/h | 5.32 |
| Indoor Hotspot – eMBB (12 TRxP) | Config. A (4 GHz) | 10 km/h | 3.95 |
| Indoor Hotspot – eMBB (36 TRxP) | Config. A (4 GHz) | 10 km/h | -0.07 |

## Results

**Table 4.2.3: The uplink link level evaluation results for different test environments for NR**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Test environment | ITU requirement (bit/s/Hz) | Evaluation configuration | Channel Model | 50%-tile point of SINR CDF (dB) | Uplink SE (bit/s/Hz) |
| FDD | TDD |
| NLOS | LOS | NLOS | LOS |
| Indoor Hotspot –eMBB (12 TRxP) | 1.5 | Config. A(4 GHz) | Channel model B | 3.95 | 1.75  | 2.07  | 1.60  | 1.95  |
| Dense Urban – eMBB | 1.12 | Config. A(4 GHz) | Channel model B | 5.32 | 1.89  | 2.19  | 1.79  | 2.06  |
| Rural –eMBB (120 km/h) | 0.8 | Config. A(700 MHz) | Channel model B | 10.14 | 2.31  | 2.90  | 2.09  | 2.63  |
| Config. B(4 GHz) | Channel model B | 4.50 | 1.28  | 1.68  | 1.16  | 1.52  |
| Rural –eMBB (500 km/h) | 0.45 | Config. A(700 MHz) | Channel model B | 9.65 | 2.07  | 2.64  | 1.87  | 2.39  |
| Config. B(4 GHz) | Channel model B | 2.72 | 0.91  | 1.33  | 0.83  | 1.22  |

# Reliability

Reliability is the success probability of transmitting a layer 2/3 packet within a required maximum time, which is the time it takes to deliver a small data packet from the radio protocol layer 2/3 SDU ingress point to the radio protocol layer 2/3 SDU egress point of the radio interface at a certain channel quality. Reliability is evaluated under Urban Macro – URLLC test environment.

## Simulation assumption of SLS part for Urban Macro - URLLC test environment

The simulation assumption for system level part of Urban Macro – URLLC test environment is listed in Table 5.1.1.

**Table 5.1.1: Simulation assumptions for SLS**

|  |  |
| --- | --- |
|  | Urban Macro - URLLC |
| Evaluation configuration | Configuration A, Configuration B |
| Carrier frequency for evaluation | Configuration A : 4 GHz 60KHz SCSConfiguration B :700 MHz 30KHz SCS |
| Multiple access (DL/UL) | OFDMA |
| Duplexing | FDD |
| Transmission scheme | DL: SU-MIMO with rank 1UL: SIMO |
| BS antenna height | 25 m |
| Total transmit power per TRxP | 46 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm |
| Percentage of high loss and low loss building type | 100% low loss (applies to Channel model B) |
| Inter-site distance | 500m |
| Number of antenna elements per TRxP | Configuration A DL: 64 Tx/Rx, (M,N,P,Mg,Ng) = (8,4,2,1,1), (dH,dV) = (0.5, 0.8)λ+45°, -45° polarizationConfiguration B DL: 16 Tx/Rx, (M,N,P,Mg,Ng) = (8,1,2,1,1), (dH,dV) = (0.5, 0.8)λ+45°, -45° polarizationConfiguration A UL: 128 Tx/Rx, (M,N,P,Mg,Ng) = (8,8,2,1,1), (dH,dV) = (0.5, 0.8)λ+45°, -45° polarizationConfiguration B UL: 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 | Configuration A DL: 8TXRU, (Mp,Np,P,Mg,Ng) = (1,4,2,1,1)Configuration B DL: 2TXRU, (Mp,Np,P,Mg,Ng) = (1,1,2,1,1)Configuration A UL: 16TXRU, (Mp,Np,P,Mg,Ng) = (1,8,2,1,1)Configuration B UL: 8TXRU, (Mp,Np,P,Mg,Ng) = (1,4,2,1,1) |
| Number of UE antenna elements | 1Tx, 2Rx, (M,N,P,Mg,Ng) = (1,1,2,1,1) |
| Number of TXRU per UE | 1TXU, 2RXU  |
| Device deployment | 80% outdoor ,20% indoorRandomly and uniformly distributed over the area |
| UE speeds of interest | 3 km/h for indoor and 30 km/h for outdoor |
| Traffic model | Full buffer |
| Simulation bandwidth | 10 MHz |
| UE density | 10 UEs per TRxP |
| UE antenna height | 1.5 m |
| Channel model variant | Channel model B |
| TRxP number per site | 3 |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) |
| Electronic tilt | Configuration A : 99° in LCSConfiguration B : 100° in LCS |
| Handover margin (dB) | 1 |
| TRxP boresight | 30 / 150 / 270 degrees |
| UT attachment | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 |
| Wrapping around method | Geographical distance based wrapping |
| Minimum distance of TRxP and UE | d2D\_min=10m |
| Polarized antenna model | Model-2 in TR36.873 |
| Power control parameters | Configuration A :**= 0.8, P0 = -86 dBmConfiguration B :**= 0.9, P0 = -86 dBm |
| Scheduling | PF |
| Receiver | MMSE-IRC |
| Pre-processing SINR calculation | Aligned with Section 2.1.1 in R1-1805643 |

## Simulation assumption of LLS part for Urban Macro - URLLC test environment

The simulation assumption for link level part of Urban Macro – URLLC test environment is listed in Table 5.2.1.

**Table 5.2.1:** **Simulation assumptions for LLS**

|  |  |
| --- | --- |
|  | Urban Macro - URLLC |
| Evaluation configuration | Configuration A,Configuration B |
| Carrier frequency | Configuration A :4GHzConfiguration B :700MHz |
| Waveform | DL/UL: CP-OFDM |
| System Bandwidth | 10MHz |
| Channel model | TDL-iii (NLOS) |
| Scaled delay spread | 363ns(NLOS) |
| UE Speed | 3km/h |
| Sub-carrier spacing | Configuration A :60 kHzConfiguration B :30 kHz |
| Number of symbols per slot | 14 |
| Antenna configuration at TRxP | Configuration A: 16TRXU (8 Tx port and 16 Rx port)Configuration B: 8TRXU (2 Tx port and 8 Rx port) |
| Antenna configuration at UE | 1 Tx port, 2Rx port |
| TXRU pattern at TRxP | 0dBi Omni-directional |
| TXRU pattern at UE | 0dBi Omni-directional |
| Data Transmission mode | DL SU-MIMO with rank 1UL: SIMO |
| Channel estimation | Realistic |
| PDCCH transmission scheme | Polar code. 64bit payload includes CRC.  |
| Data coding | LDPC, BG2 |
| Packet size  | 256bit |
| DMRS configuration | Type 1, 2 symbol DMRS |

## Results

**Table 5.3.1 DL reliability evaluation result**

|  |  |  |  |
| --- | --- | --- | --- |
| Test environment | Evaluation configuration | Transmission scheme |  5%-tile point of SINR CDF (dB) |
| Channel model B |
| Urban Macro – URLLC | Config. A (4 GHz) | One PDCCH + 2 PDSCH | 99.99990561% |
| Urban Macro – URLLC | Config. B (700 MHz) | One shot | 99.9998112% |

**Table 5.3.2: UL reliability evaluation result**

|  |  |  |  |
| --- | --- | --- | --- |
| Test environment | Evaluation configuration | Transmission scheme |  5%-tile point of SINR CDF (dB) |
| Channel model B |
| Urban Macro – URLLC | Config. A (4 GHz) | One shot | 99.9999924% |
| Urban Macro – URLLC | Config. B (700 MHz) | One shot | 99.9999997% |

# User Experienced Data Rate

User experienced data rate is the 5% point of the cumulative distribution function (CDF) of the user throughput. User throughput (during active time) is defined as the number of correctly received bits, i.e. the number of bits contained in the service data units (SDUs) delivered to Layer 3, over a certain period of time.

The user experienced data rate, Ruser is given by:

 Ruser = W(Effective Bandwidth) × SEuser (5th Percentile)

**Table 6.1: UL user throughput with different simulation bandwidths**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Evaluated features | Evaluation configuration | Carrier frequency for *fi* (*i*=1 or 2) | Simulation bandwidth *SBWi* on *fi* | Simulated user throughput *SRk* |
| NR FDD  | Configuration A | *f*1=4 GHz | 10 MHz | 5%-tile: 3.15 Mbps |
| NR FDD | Configuration A | *f*1=4 GHz | 160 MHz | 50.4 Mbps |

# Area Traffic Capacity

As defined in Report ITU-R M.2410, area traffic capacity is the total traffic throughput served per geographic area (in Mbit/s/m2). The throughput is the number of correctly received bits, i.e. the number of bits contained in the SDUs delivered to Layer 3, over a certain period of time.

The area traffic capacity of the RIT is evaluated using analytical way based on the downlink average spectral efficiency evaluation for Indoor Hotspot – eMBB test environment. Let W denote the channel bandwidth and $ρ$ the TRxP density (TRxP/m2). The area traffic capacity Carea is related to average spectral efficiency SEavg through equation Carea = ρ × W × SEavg.

**Table 7.1: Downlink area traffic capacity (Mbit/s/m2) in Indoor Hotspot-eMBB at 4GHz
(12 TRxP, Channel model B)**

|  |  |  |
| --- | --- | --- |
| System bandwidth (MHz) | Average spectral efficiency SE*avg* [bps/Hz/TRxP] | 12TRxP (TRxP density $ρ$=0.002TRxP/m2) |
| FDD 50 MHz bandwidth per CC with 15 kHz SCS | TDD100 MHz bandwidth per CC with 30 kHz SCS | FDD | TDD(DDDSU) |
| *W =*300 | 11.968 | 13.675 | 7.18 | 6.33 |
| *W* = 350 | 8.38 | 7.38 |
| *W* = 400 | 9.57 | 8.34 |
| *W* = 450 | 10.77 | 9.49 |
| *W* = 500 | 11.97 | 10.55 |

# Peak Spectral Efficiency

Peak spectral efficiency is the maximum data rate under ideal conditions divided by channel bandwidth (in bit/s/Hz), where the maximum data rate is the received data bits assuming error-free conditions assignable to a single mobile station, when all assignable radio resources for the corresponding link direction are utilized (i.e. excluding radio resources that are used for physical layer synchronization, reference signals or pilots, guard bands and guard times).

The generic formula for peak spectral efficiency for FDD and TDD for a specific component carrier (say *j-th CC (component carrier)*) is given by

 $SE\_{p\_{j}}=\frac{v\_{Layers}^{\left(j\right)}Q\_{m}^{\left(j\right)}f^{\left(j\right)}R\_{max}\frac{N\_{PRB}^{BW\left(j\right),μ}12}{T\_{s}^{μ}}\left(1-OH^{\left(j\right)}\right)}{BW^{\left(j\right)}}$ (1.1)

Wherein,

* Rmax = 948/1024
* For the j-th CC,
	+  is the maximum number of layers
	+  is the maximum modulation order
	+ is the scaling factor
		- * The scaling factor can at least take the values 1 and 0.75.
			* is signalled per band and per band per band combination as per UE capability signaling
	+  is the numerology (as defined in TS38.211)
	+  is the average OFDM symbol duration in a subframe for numerology , i.e. . Note that normal cyclic prefix is assumed.
	+  is the maximum RB allocation in bandwidth  with numerology , as given in TS38.104 section 5.3.2, where  is the UE supported maximum bandwidth in the given band or band combination.
	+ is the overhead calculated as the average ratio of the number of REs occupied by L1/L2 control, Synchronization Signal, PBCH, reference signals and guard period (for TDD), etc. with respect to the total number of REs in effective bandwidth time product as given by α(j).BW(j).(14\*Tsu)

− α(j) is the normalized scalar considering the downlink/uplink ratio; for FDD α(j)=1 for DL and UL; and for TDD and other duplexing α(j) for DL and UL is calculated based on the DL/UL configuration.

− For guard period (GP), 50% of GP symbols are considered as downlink overhead, and 50% of GP symbols are considered as uplink overhead.

## DL Peak Spectral Efficiency

For evaluating downlink Peak Spectral Efficiency, we consider an FDD case with 50MHz bandwidth, and 15kHz subcarrier spacing, in FR1 region. In an ideal case, we can have a maximum of 8layers, using 256QAM.

For the reference signal overheads, we assume the following :

|  |  |  |
| --- | --- | --- |
|  | Applied duplexing | FR1 |
| OH | FDD | * PDCCH: CORESET of 24 PRBs (4 CCE) in every slot
	+ - 12 RE/PRB/slot
* TRS burst of 2 slots with periodicity of 20ms and occupies 52 PRBs
	+ - 12 RE/PRB/20 ms
* DMRS: Type 2, 16 RE/PRB/slot for 8 layers
* CSI-RS: 8 CSI-RS ports with periodicity of 20ms
	+ - 8 RE/PRB/20 ms
* 1 SS/PBCH blocks (SSB) per 20ms; one SSB occupies 960REs = 4 OFDM symbols × 20 PRB × 12 REs/PRB

NOTE1: if the channel bandwidth is less than the bandwidth of SSB, then SSB is not transmitted and the overhead of SS/PBCH block is zero.NOTE2: If the channel bandwidth is less than TRS bandwidth, the TRS bandwidth is assumed to be equal to the channel bandwidth. |

Using these values, we get the downlink peak spectral efficiency to be 54.35\*(1-0.1) = 48.9 bits/sec/Hz which is higher than the ITU requirement of 30 bits/sec/Hz

## UL Peak Spectral Efficiency

For evaluating uplink Peak Spectral Efficiency, we consider an FDD case with 50MHz bandwidth, and 15kHz subcarrier spacing, in FR1 region. In an ideal case, we can have a maximum of 4 layers, using 256QAM.

For the reference signal overheads, we assume the following :

|  |  |  |
| --- | --- | --- |
|  | Applied duplexing |  FR1 |
| OH1  | FDD, TDD (DDDSU) | * PUCCH: short PUCCH with 1 PRB and 1 symbol in every UL slot; 12 RE/slot
* DMRS: Type I, one complete symbol; 12 RE/PRB/slot
* SRS: 1 symbol with periodicity of 10ms for FDD; 1 symbol with periodicity of 20ms for TDD
 |

Using these values, we get the uplink peak spectral efficiency to be 27.18\*(1-0.08) = 25.0 bits/sec/Hz which is higher than the ITU requirement of 15 bits/sec/Hz

# Peak data rate

As defined in Report ITU-R M.2410, peak data rate is the maximum achievable data rate under ideal conditions (in bit/s), which is the received data bits assuming error-free conditions assignable to a single mobile station, when all assignable radio resources for the corresponding link direction are utilized (i.e. excluding radio resources that are used for physical layer synchronization, reference signals or pilots, guard bands and guard times).

## DL Peak Data rate

**Table 4.2.4.1.1 DL peak data rate**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Duplexing** | **SCS [kHz]** | **Per CC BW (MHz)** | **Peak data rate per CC (Gbit/s)** | **Aggregated peak data rate over 16 CCs (Gbit/s)** | **Required DL bandwidth (MHz) 1** | **Req. (Gbit/s)** |
| FDD | FR1 | 15 | 50 | 2.45 | 39.2 | 420 | 20 |
| NOTE 1: The value only indicates the required bandwidth to meet the DL peak data rate. It is not necessarily supported as the Transmission bandwidth. |

## UL Peak Data rate

UL peak data rate is evaluated based on the evaluation results of peak spectral efficiency provided in Section 1. Table 2.2.1 provides the evaluation results for the specific component carrier (CC) bandwidth. It is observed that the RIT fulfils the UL peak data rate requirement.

**Table 2.2.1 UL peak data rate**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Duplexing** | **SCS [kHz]** | **Per CC BW (MHz)** | **Peak data rate per CC (Gbit/s)** | **Aggregated peak data rate over 16 CCs (Gbit/s)** | **Required UL bandwidth to meet the requirement (MHz)1** | **Req. (Gbit/s)** |
| FDD | FR1 | 15 | 50 | 1.25 | 20 | 400 | 10 |
| NOTE 1: The value only indicates the required bandwidth to meet the DL peak data rate. It is not necessarily supported as the Transmission bandwidth. |

# Bandwidth and scalability

As defined in Report ITU-R M.2410, bandwidth is the maximum aggregated system bandwidth. The bandwidth may be supported by single or multiple radio frequency (RF) carriers. Scalable bandwidth is the ability of the candidate RIT/SRIT to operate with different bandwidths.

According to Section 5.3.2 of TS.38.104, the maximum bandwidth related to specific sub-carrier spacing (SCS) and frequency range (FR) for a component carrier is provided in Table 6.1. Besides, according to Section 6.4 of TS.38.331, carrier aggregation of up to sixteen component carriers is supported. Accordingly, the capability of maximum aggregated system bandwidth is presented in Table 6.1. It is observed that the maximum aggregated bandwidth for FR 1 is 800 MHz to 1600 MHz; while for FR 2, the maximum aggregated bandwidth is 3200 MHz to 6400 MHz. Therefore, the bandwidth requirement of at least 100 MHz is met by the RIT under all frequency ranges for all sub-carrier spacing values.

RIT capability on bandwidth

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **SCS [kHz]**  | **Maximum bandwidth for one component carrier (MHz)** | **Maximum number of component carriers for carrier aggregation** | **Maximum aggregated bandwidth (MHz)** |
| FR1 | 15 | 50 |  16 | 800 |
| 30 | 100 | 16 | 1600 |
| 60 | 100 | 16 | 1600 |
| FR2  | 60 | 200 | 16 | 3200 |
| 120 | 400 | 16 | 6400 |

According to Section 5.3.2 of TS38.104, different bandwidths are supported for a component carrier at given SCS as listed in Table 6.2. Accordingly, the bandwidth scalability capability of the RIT is summarized in Table 6.3. It is observed that up to 13 different bandwidths are supported for FR 1, and up to 4 different bandwidths are supported for FR 2. Therefore bandwidth scalability capability is fulfilled by the RIT.

Transmission bandwidth configuration NRB

(a) For FR1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SCS (kHz)** | **5MHz** | **10MHz** | **15MHz** | **20 MHz** | **25 MHz** | **30 MHz** | **40 MHz** | **50MHz** | **60 MHz** | **70****MHz** | **80 MHz** | **90 MHz** | **100 MHz** |
| **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** |
| 15 | 25 | 52 | 79 | 106 | 133 | 160 | 216 | 270 | N/A | N.A | N/A | N/A | N/A |
| 30 | 11 | 24 | 38 | 51 | 65 | 78 | 106 | 133 | 162 | 189 | 217 | 245 | 273 |
| 60 | N/A | 11 | 18 | 24 | 31 | 38 | 51 | 65 | 79 | 93 | 107 | 121 | 135 |

 (b) For FR2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SCS [kHz]** | **50 MHz** | **100 MHz** | **200 MHz** | **400 MHz** |
| **NRB** | **NRB** | **NRB** | **NRB** |
| 60 | 66 | 132 | 264 | N.A |
| 120 | 32 | 66 | 132 | 264 |
|  |  |  |  |  |

Bandwidth scalability capability

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **SCS [kHz]**  | **Minimum component carrier bandwidth (MHz)** | **Maximum component carrier bandwidth (MHz)** | **Maximum Number of supported bandwidth for a component carrier** |
| FR1 | 15 | 5 | 50 | 8 |
| 30 | 5 | 100 | 13 |
| 60 | 10 | 100 | 12 |
| FR2 | 60 | 50 | 200 | 3 |
| 120 | 50 | 400 | 4 |
|  |  |  |  |  |