|  |  |
| --- | --- |
| **Radiocommunication Study Groups** |  |
|  |  |
|  | **\*\*\* DRAFT \*\*\*** |
| Received: | **Document 5D/???-E** |
| **14 November 2019** |
| **English only**  **TECHNOLOGY ASPECTS** |
| Director, Radiocommunication Bureau[[1]](#footnote-1)\* | |
| CEG INTERIM Evaluation Report on the Candidate Proposals for IMT-2020 submitted to WP 5D | |

Part I

Administrative aspects of the Independent Evaluation Group

# 1 Name of the Independent Evaluation Group

The evaluation group is known as the Canadian Evaluation Group or CEG.

# 2 Introduction/background of the Independent Evaluation Group

The CEG was founded in 1996 under the auspices of the Canadian National Organization (CNO) and is subject to the CNO process in its method of work. At the time it was established, the objective was to respond to the ITU-R request for evaluations of candidate IMT-2000 Radio Transmission Technology (RTT) submissions as per ITU-R Circular Letter 8/LCCE/47. Of the fifteen technologies that were submitted (ten terrestrial, five satellite), only the terrestrial technologies were evaluated using the method explained in Recommendation ITU-R M.1225. Both time (1 July – 30 September 1998) and resources being limited, the CEG decided to give priority to the most important evaluation criteria/attributes (each criterion had several attributes) as signified by the category G1 in Recommendation ITU-R M.1225. A coordinator was appointed for each criterion and tasked with the duty of developing a summary report for that criterion. The final report of the CEG on the candidate IMT-2000 technologies can be found on the CEG website as indicated in Section 6.1 – a total of five technologies were identified as “IMT-2000.” Detailed specifications of these technologies can be found in Recommendation ITU-R M.1457 – which is being revised even to this day.

Subsequently, the CEG was re-convened in 2007 to evaluate a sixth candidate proposal. The same process was followed as previously with each coordinator evaluating category G1 criteria and as many of the G2, G3 and G4 categories as possible. This proposal was also accepted as an IMT-2000 technology – with the result that M.1457 now contains six Radio Transmission Technologies.

In 2008 the CEG continued its activities under the auspices of the CNO for the evaluation of candidate Radio Interface Technologies (RITs) for IMT-Advanced (cf. ITU-R Circular Letter 5/LCCE/2). For details refer to Document 5D/781 (3 June 2010), available on the CEG website as indicated in Section 6.1.

At the outset, the CEG established an official list of participants and an “unofficial” list of contributors – who were required occasionally to help the participants answer questions or perform complex technical analyses in specific cases. The rules and procedures that governed the CEG work were based on the CNO manual. In a bid to ensure that its work emphasized the **independent** view sought by the ITU in its original call to establish Independent Evaluation Groups (IEGs), the CEG introduced a rule that its members should not participate in other EGs. Conversely, members of other EGs could not participate in the work of the CEG.

# 3 Method of Work

The CEG continues its activities under the auspices of the CNO.

The method of work included:

1) Formal meetings at the CEG Plenary level.

2) Generation of detailed reports (containing analyses, theoretical calculations, etc.) that were then discussed by all participants.

3) Conference calls as required.

4) E-mail exchanges as required.

5) Face-to-face meetings at the coordinators’ level as required.

# 4 Administrative Contact Details

Dr. José Costa, webmaster of the CEG web site (see Section 6.1).

[jose.costa@ericsson.com](mailto:jose.costa@ericsson.com)

# 5 Technical Contact Details

Dr. Venkatesh Sampath, Chairman, Canadian Evaluation Group (CEG).

[ven.sampath@ericsson.com](mailto:ven.sampath@ericsson.com)

# 6 Other pertinent administrative information

**6.1 CEG web site**

The CEG consolidated its former IMT-2000 and IMT-Advanced websites to include also IMT-2020 and future generations of IMT under a single web-site:

[www.IMT-CEG.ca](http://www.IMT-CEG.ca)

**6.2 Candidate proposals submitted to ITU-R and actions taken**

The following table (6.2.1) summarizes the candidate submissions and the actions taken by WP 5D.

Table 6.2.1

Candidate technologies to be evaluated (as determined by the ITU-R).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Proponent** | **3GPP** | **3GPP** | **China** | **Korea** | **ETSI  (TC DECT)** | **Nufront** | **TSDSI** |
| **Original submission in** | Documents [5D/1215](https://www.itu.int/md/R15-WP5D-C-1215/en) and [5D/1216](https://www.itu.int/md/R15-WP5D-C-1216/en) | Documents [5D/1215](https://www.itu.int/md/R15-WP5D-C-1215/en) and [5D/1217](https://www.itu.int/md/R15-WP5D-C-1217/en) | Document [5D/1268](https://www.itu.int/md/R15-WP5D-C-1268/en) | Document [5D/1233](https://www.itu.int/md/R15-WP5D-C-1233/en) | Documents [5D/1230](https://www.itu.int/md/R15-WP5D-C-1230/en) and [5D/1253](https://www.itu.int/md/R15-WP5D-C-1253/en) | Document [5D/1238](https://www.itu.int/md/R15-WP5D-C-1238/en) | Document [5D/1231](https://www.itu.int/md/R15-WP5D-C-1231/en) |
| **WP 5D acknowledgement** | Document [IMT-2020/13](https://www.itu.int/md/R15-IMT.2020-C-0013/en) | Document [IMT-2020/14](https://www.itu.int/md/R15-IMT.2020-C-0014/en) | Document [IMT-2020/15](https://www.itu.int/md/R15-IMT.2020-C-0015/en) | Document [IMT-2020/16](https://www.itu.int/md/R15-IMT.2020-C-0016/en) | Document  [IMT-2020/17](https://www.itu.int/md/R15-IMT.2020-C-0017/en) | Document [IMT-2020/18](https://www.itu.int/md/R15-IMT.2020-C-0018/en) | Document [IMT-2020/19](https://www.itu.int/md/R15-IMT.2020-C-0019/en) |
| **Complete submission?** | Yes | Yes | Yes | Yes | Determination Pending | Determination Pending | Determination Pending |
| **Classification / Technology label** | SRITT:  NR component RIT and  E-UTRA/LTE component RIT | RIT | RIT | RIT | SRIT:  “DECT-2020 NR” component RIT and  “3GPP 5G NR” component RIT | RIT | RIT |
| **WP 5D Observations** | Document [IMT-2020/23](https://www.itu.int/md/R15-IMT.2020-C-0023/en) | Document [IMT-2020/23](https://www.itu.int/md/R15-IMT.2020-C-0023/en) | Document [IMT-2020/24](https://www.itu.int/md/R15-IMT.2020-C-0024/en) | Document [IMT-2020/25](https://www.itu.int/md/R15-IMT.2020-C-0025/en) | Document  [IMT-2020/26](https://www.itu.int/md/R15-IMT.2020-C-0026/en) | Document [IMT-2020/27](https://www.itu.int/md/R15-IMT.2020-C-0027/en) | Document [IMT-2020/28](https://www.itu.int/md/R15-IMT.2020-C-0028/en) |
| **10 Sep 2019 updates** |  |  |  |  | Document [5D/1299](https://www.itu.int/md/R15-WP5D-C-1299/en) | Document [5D/1300](https://www.itu.int/md/R15-WP5D-C-1300/en) | Document [5D/1301](https://www.itu.int/md/R15-WP5D-C-1301/en) |

## 6.3 CEG Members

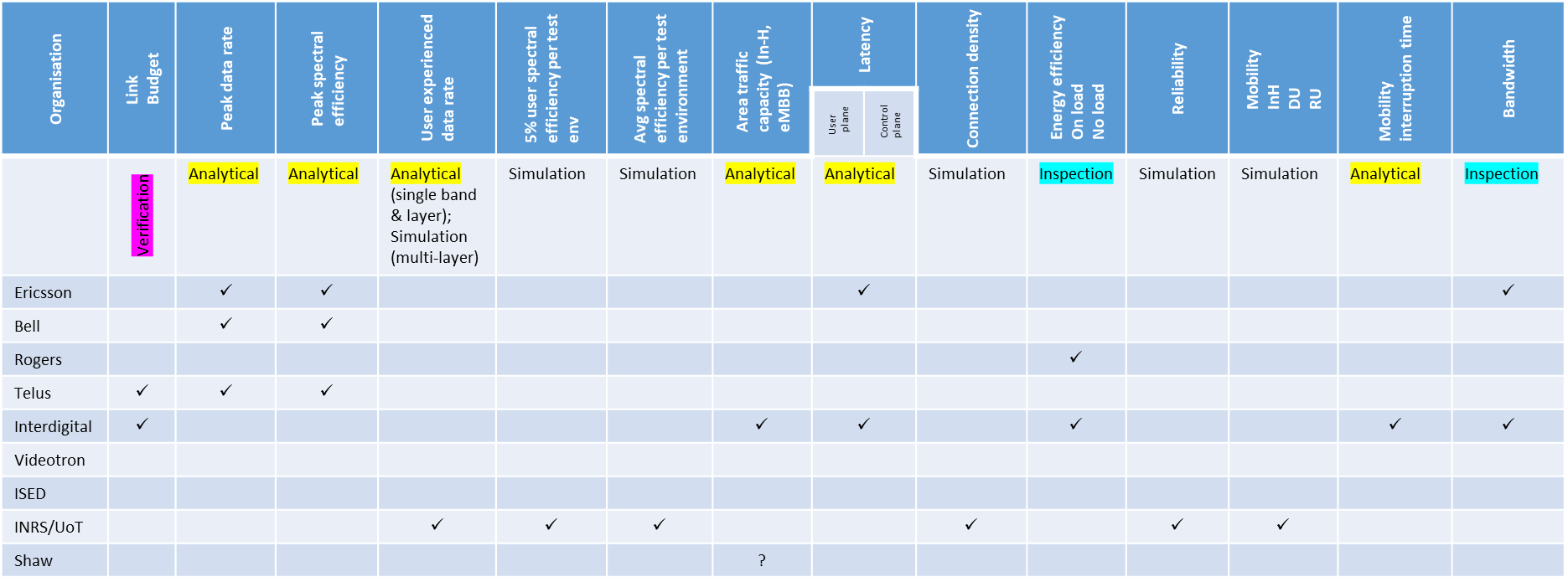
The CEG’s members are shown in Table 6.3.1, as are the responsibilities each accepted.

Table 6.3.1

Matrix of Responsibilities

*[Editor’s Note: To be updated]*

Technical performance requirements (TPRs) to evaluate for IMT-2020



Note 1: For each test environment (5 in all), up to 3 evaluation configurations could be specified, but only 1 for candidate to pass (and 1 for each IEG to evaluate)

Note 2: Simulations conducted by the CEG academic partners – Institut national de recherche scientifique (INRS) and University of Toronto

**Part II**

Technical aspects of the work of the Independent Evaluation Group

# A) What candidate technologies or portions of the candidate technologies this IEG is or might anticipate evaluating?

# 7. Technologies evaluated by the CEG

Notes to Table 7.1:

Note 1 – As illustrated in the table above, the CEG will evaluate both the SRIT and the RIT submitted by 3GPP. It is the CEG’s understanding that such evaluation applies to the candidates from China and Korea, so no separate activity is foreseen on those two submissions.

Note 2 – Further, the CEG intends to evaluate the submissions from TSDSI and ETSI (TC DECT)/DECT FORUM (though in the case of the latter, it will be only the DECT component RIT, as the CEG’s assumption is that the 3GPP evaluation will apply to the 3GPP component). Finally, time permitting, the CEG will also evaluate the candidate submission from Nufront.

Table 7.1

CEG intention to evaluate technologies or parts thereof

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **IMT-2020 SUBMISSION (document number in parentheses)** | | | | | | | |
|  | **3GPP** | | **CHINA** (#15) | **KOREA** (#16) | **TSDSI** (#19) | **ETSI-DECT** (#17) | **Nufront** (#18) |
| **RIT** (#14) | **SRIT** (#13) |
| [Canadian Evaluation Group](https://www.itu.int/oth/R0A06000072/en) ([CEG web site](http://www.imt-ceg.ca/" \t "_blank)) | Will evaluate | Will evaluate | Not evaluate (because WP 5D has determined that the 3GPP evaluation applies to this candidate, too)  See Note 1 | Not evaluate (because WP 5D has determined that the 3GPP evaluation applies to this candidate, too)  See Note 1 | Partial evaluation  See Note 2 | Partial evaluation (only the DECT component RIT)  See Note 2 | Partial evaluation  See Note 2 |
| **Parameters via Inspection** |  |  |  |  |  |  |  |
| Bandwidth |  |  |  |  |  |  |  |
| Energy Efficiency |  |  |  |  |  |  |  |
| Spectrum |  |  |  |  |  |  |  |
| Services |  |  |  |  |  |  |  |
| **Parameters via Analysis** |  |  |  |  |  |  |  |
| Peak data rate |  |  |  |  |  |  |  |
| Peak spectral efficiency |  |  |  |  |  |  |  |
| User experienced data rate |  |  |  |  |  |  |  |
| Area traffic capacity |  |  |  |  |  |  |  |
| Latency (UP and CP) |  |  |  |  |  |  |  |
| Mobility interruption time |  |  |  |  |  |  |  |
| **Parameters via Simulation** |  |  |  |  |  |  |  |
| Average spectral efficiency |  |  |  |  |  |  |  |
| 5% spectral efficiency |  |  |  |  |  |  |  |
| Mobility |  |  |  |  |  |  |  |
| Reliability |  |  |  |  |  |  |  |
| Connection density |  |  |  |  |  |  |  |

# B) Confirmation of utilization of the ITU-R evaluation guidelines in Report ITU R M.2412

# 8. Evaluation Guidelines

The CEG confirms it has utilized the ITU-R evaluation guidelines in Report ITU-R M.2412.

# C) Documentation of any additional evaluation methodologies that are or might be developed by the Independent Evaluation Group to complement the evaluation guidelines;

# 9 Additional evaluations/methodologies

TSDSI – average spectral efficiency and mobility evaluations via simulation (against 30 km/h, since there is no technical performance requirement in Report ITU-R M.2410) TSDSI – link budget calculations for LMLC (include question sent to TSDSI proponent and their response)

# D) Verification as per Report ITU-R M.2411 of the compliance templates and the self-evaluation for each candidate technology as indicated in A)

• *Identify gaps/deficiencies in submitted material and/or self-evaluation;*

*• Identify areas requiring clarifications;*

*• General questions.*

# 10 Compliance templates

## 10.1 Compliance templates for 3GPP SRIT

10.1.1 Technical performance

10.1.2 Services

10.1.3 Spectrum

## 10.2 Compliance templates for 3GPP RIT

10.2.1 Technical performance

10.2.2 Services

10.2.3 Spectrum

## 10.3 Compliance templates for TSDSI

## 10.4 Compliance templates for ETSI/DECT

DECT-2020 NR” component RIT

## 10.5 Compliance templates for Nufront

# E) Assessment as per Reports ITU-R M.2410, ITU-R M.2411 and ITU-R M.2412 for each candidate technology as indicated in A)

• *Detailed analysis/assessment and evaluation by the IEGs of the compliance templates submitted by the proponents per the Report ITU-R M.2411 section 5.2.4;*

*• Provide any additional comments in the templates along with supporting documentation for such comments;*

*• Analysis of the proponent’s self-evaluation by the IEG;*

# 11 Candidate technologies and the portions thereof evaluated

The CEG evaluated the technologies described in Table 6.2.1. A more detailed table with the CEG’s intention to evaluate a candidate technology (or not), with the parameters evaluated, is presented in table 6.3.2.

## 11.1 3GPP SRIT

**Parameters evaluated via Inspection**

11.1.1 Bandwidth

*Source (Embedded file to be deleted later):* 

**11.1.1.1 Conclusion:** CEG concluded that bandwidth and scalability requirements are met by the IMT-2020 3GPP submission.

**11.1.1.2. Verification:**

Based on the 3GPP submission, this discussion we considered the following two component RITs for inspection:

**1. NR bandwidth requirements capabilities.**

**2. LTE bandwidth requirements capabilities.**

**11.1.1.2.1 NR bandwidth requirements capabilities**

The capability of bandwidth and bandwidth scalability for NR:

First, we have the supported bandwidth channels on FR1 (below 6 GHz) and FR2 (above 24 GHz) respectively along with their supported SCS. Then, according to the RRC specification TS 38.331, according to section 6.4, up to 16 component carriers is supported in Rel-15.

According to TS 38.104 the following channel bandwidths and maximum aggregation bandwidths are supported in Rel-15:

Table 11.1.1.2.1.1 NR 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  (410 MHz – 7125 MHz) | 15 | 50 | 16 | 800 |
| 30 | 100 | 16 | 1600 |
| 60 | 100 | 16 | 1600 |
| FR2  (24250 MHz – 52600 MHz) | 60 | 200 | 16 | 3200 |
| 120 | 400 | 16 | 6400 |

And then the following transmission bandwidths configurations are supported for each case:

Table 11.1.1.2.1.2: Transmission bandwidth configuration NRB for FR1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS (kHz) | 5  MHz | 10  MHz | 15  MHz | 20 MHz | 25 MHz | 30  MHz | 40 MHz | 50 MHz | 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 |

Table 5.3.2-2: Transmission bandwidth configuration NRB 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 |

And then in terms of scalability capability we minimum and maximum channel bandwidth and the maximum scalability per component carrier:

Table 11.1.1.2.1.3 Bandwidth scalability capability for NR

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **SCS [kHz]** | **Minimum component carrier bandwidth (MHz)** | **Maximum component carrier bandwidth (MHz)** | **Maximum Number of supported bandwidths 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 |

The bandwidth scalability capability of NR Rel-15 is summarized in Table 2.1.3. 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 NR Rel-15.

**11.1.1.2.2 LTE bandwidth requirements capabilities**

According to Section 5.6 of TS 36.101, the maximum bandwidth of a component carrier is 20 MHz for LTE. Besides, according to Section 6.4 of TS 36.331, carrier aggregation of up to thirty-two component carriers is supported by LTE Rel-15.

Accordingly, LTE Rel-15 reaches the capability of maximum aggregated system bandwidth of 640 MHz. Therefore, the bandwidth requirement of at least 100 MHz is met by LTE Rel-15.

Table 2.2.1: Transmission bandwidth configuration NRB in LTE

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Channel bandwidth BWChannel [MHz] | 1.4 | 3 | 5 | 10 | 15 | 20 |
| Transmission bandwidth configuration NRB | 6 | 15 | 25 | 50 | 75 | 100 |

11.1.2 Energy efficiency

*Source (Embedded file to be deleted later):* 

**11.1.2.1 Conclusion:** CEG concluded that energy efficiency requirements are met by the IMT-2020 3GPP submission.

**11.1.2.2. Verification:**

Based on the 3GPP submission, for this evaluation we considered the following two component RITs for inspection:

**1. NR.**

**2. LTE.**

For both component RITs we will analyze the “no data” scenarios, since the loaded scenario is quantified by spectrum efficiency.

**11.1.2.2.1 NR energy efficiency**

### 11.1.2.2.1.1 NR network side

Based on the definition of the sleep time for the network suggested in Report ITU-R M.2410 requirement, the following sleep mode ratio equations were proposed in the submission documents:





where  indicates the ceiling of *x*,  is the numerology (as defined in TS38.211, e.g., **=0 for 15 kHz SCS, **=1 for 30 kHz SCS, **=3 for 120 kHz SCS, and **=4 for 240 kHz SCS), *L* is the number of SS/PBCH blocks in one SSB set, *P*SSB is the SSB set periodicity, *P*RMSI is the RSMI periodicity, and  is the flag variable (=1 for FR1, and =0 for FR2).

The CEG agrees with the proposed methodology and as a result, the NR network can achieve high sleep ratio in unloaded case.

Table 2.1.1-1 NR network sleep ratio in slot level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **SSB configuration** | | **SSB set periodicity** *P*SSB | | | | | |
| **SCS [kHz]** | **Number of SS/PBCH block per SSB set,** *L* | 5ms | 10ms | 20ms | 40ms | 80ms | 160ms |
| 15kHz | 1 | 80.00% | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% |
| 2 | 80.00% | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% |
| 30kHz | 1 | 95.00% | 97.50% | 98.75% | 99.38% | 99.69% | 99.84% |
| 4 | 80.00% | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% |
| 120kHz | 8 | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% | 99.69% |
| 16 | 80.00% | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% |
| 240kHz | 16 | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% | 99.69% |
| 32 | 80.00% | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% |

Table 2.1.1-2 NR network sleep ratio in symbol level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **SSB configuration** | | **SSB set periodicity** *P*SSB | | | | | |
| **SCS [kHz]** | **Number of SS/PBCH block per SSB set,** *L* | 5ms | 10ms | 20ms | 40ms | 80ms | 160ms |
| 15kHz | 1 | 93.57% | 96.43% | 97.86% | 98.93% | 99.46% | 99.73% |
| 2 | 87.14% | 92.86% | 95.71% | 97.86% | 98.93% | 99.46% |
| 30kHz | 1 | 96.79% | 98.21% | 98.93% | 99.46% | 99.73% | 99.87% |
| 4 | 87.14% | 92.86% | 95.71% | 97.86% | 98.93% | 99.46% |
| 120kHz | 8 | 94.29% | 97.14% | 98.57% | 99.29% | 99.64% | 99.82% |
| 16 | 88.57% | 94.29% | 97.14% | 98.57% | 99.29% | 99.64% |
| 240kHz | 16 | 94.29% | 97.14% | 98.57% | 99.29% | 99.64% | 99.82% |
| 32 | 88.57% | 94.29% | 97.14% | 98.57% | 99.29% | 99.64% |

In terms of milliseconds, the following sleep time can be achieved by NR network on different SSB periodicities:

Based on the above mechanisms, evaluation results of sleep duration are provided in Table 3. It is observed that with SSB set period of 160ms, more than 150ms sleep duration can be obtained by NR network. Therefore, NR network can achieve long sleep duration in unloaded case.

**Therefore, NR meets network side energy efficiency requirement.**

Table 2.1.1-3 NR network sleep duration (ms) in slot level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **SSB configuration** | | **SSB set periodicity** *P*SSB | | | | | |
| **SCS [kHz]** | **Number of SS/PBCH block per SSB set,** *L* | 5ms | 10ms | 20ms | 40ms | 80ms | 160ms |
| 15kHz | 1 | 4.00 | 9.00 | 19.00 | 39.00 | 79.00 | 159.00 |
| 2 | 4.00 | 9.00 | 19.00 | 39.00 | 79.00 | 159.00 |
| 30kHz | 1 | 4.50 | 9.50 | 19.50 | 39.50 | 79.50 | 159.50 |
| 4 | 4.00 | 9.00 | 19.00 | 39.00 | 79.00 | 159.00 |
| 120kHz | 8 | 4.50 | 9.72 | 18.92 | 39.03 | 78.97 | 158.99 |
| 16 | 4.00 | 9.88 | 18.77 | 39.05 | 78.96 | 158.99 |
| 240kHz | 16 | 4.50 | 9.86 | 18.90 | 39.04 | 78.97 | 158.99 |
| 32 | 4.00 | 9.94 | 18.76 | 39.06 | 78.96 | 158.99 |

### 11.1.2.2.1.2 NR UE side

The sleep ratio and sleep duration for NR UEs under unloaded case are evaluated.

For NR, DRX is supported for UEs in idle, inactive and connected states.

The DRX cycle for idle state / inactive state UE consists of an “On Duration” during which the UE should perform SSB monitoring, paging monitoring and RRM measurement, and an “Off Duration” during which the UE can skip reception of downlink channels to save energy.

During the On Duration of a DRX cycle, the UE is assumed to perform the following tasks:

- Synchronization on one SSB burst (short paging cycle)

- Paging monitoring- this can consist on multiple slots. The Paging Frame is no longer than a one SSB bursts.

- RRM measurement which is based on SS/PBCH and it is assumed to be 3.5ms.

The transition time for switching ON/OFF UE internal components is assumed to be 10ms

**Based on these assumptions, the UE can be in sleep mode more than 90% in for any DRX cycle in idle/inactive state:**

Table 2.1.2-1 NR device sleep ratio in slot level (for idle / inactive mode)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Paging cycle *N*PC\_RF \*10 (ms) | SCS(kHz) | SSB L | SSB reception time(ms) | SSB cycle (ms) | Number of SSB burst set | RRM measurement time per DRX (ms) | Transition time(ms) | Sleep ratio |
| RRC-Idle/Inactive | 320 | 240 | 32 | 1 | -- | 1 | 3.5 | 10 | 95.5% |
| 2560 | 15 | 2 | 1 | -- | 1 | 3 | 10 | 99.5% |
| 2560 | 15 | 2 | 1 | 160 | 2 | 3 | 10 | 93.2% |

**For RRC-Connected Mode, with no data transmissions, we get more than 84% sleep mode, assuming the ON Duration” and the other similar parameters:**

Table 2.1.2-2 NR device sleep ratio in slot level (for connected mode)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | DRX cycle *T*SC\_ms \* *M*SC (ms) | Number of SSB burst set | DRX-onDurationTimer(ms) | RRM measurement time per DRX (ms) | Transition time(ms) | Sleep ratio |
| RRC-Connected | 320 | 1 | 2 | 3.5 | 10 | 95.2% |
| 320 | 1 | 10 | 3 | 10 | 92.8% |
| 2560 | 1 | 100 | 3 | 10 | 95.6% |
| 10240 | 1 | 1600 | 3 | 10 | 84.2% |

**11.1.2.2.2 LTE energy efficiency**

### 11.1.2.2.2.1 LTE network side

For LTE, the FeMBMS/Unicast-mixed cell and MBMS-dedicated cell are employed in LTE network evaluation.

For FeMBMS/Unicast-mixed cell,

* Sub-frame 0 and 5 are always used as non-MBSFN sub-frame for synchronization and SI acquisition.
* Sub-frame 4 and 9 are assumed to be configured as MBSFN sub-frames.
* MBSFN sub-frames are assumed not to contain unicast control region.

For FeMBMS/Unicast-mixed cell, 8 sub-frames are configured to be MBSFN sub-frames, and in the remaining 2 sub-frames, only PDCCH/SSS/PSSS and PBCH are transmitted.

Therefore, the sleep ratio of FeMBMS/Unicast-mixed cell is 1-2/10=80% for sub-frame level.

For MBMS-dedicated cell, one-non-MBSFN sub-frame is transmitted every 40ms, thus the sleep ratio in subframe level is 1-1/40=97.5%. Similarly, in symbol level the sleep ratio can be further improved to 1-(1+6)/14/40 = 98.75%.

In conclusion, in milliseconds, the following results were found:

Table 2.2.1-1 LTE network sleep duration (ms) in subframe level

|  |  |
| --- | --- |
| **Cell type** | Sleep duration (ms) |
| FeMBMS/Unicast-mixed cell | 4.00 |
| MBMS-dedicated cell | 39.00 |

**Therefore, the LTE component RIT meets network side energy efficiency requirement.**

### 11.1.2.2.2.2 LTE UE side

For LTE, DRX is supported for UE in both idle and connected modes.

When DRX is used, the UE wakes up and receives PSS/SSS for synchronization, listens to PDCCH only on specific paging occasion defined in-terms of paging frame and subframe within period of *N*PC\_RF radio frames defined by the DRX cycle (paging cycle) of the cell and performs RRM measurement. The UE can remain in sleep mode for remaining duration within DRX cycle.

With similar assumption with NR case, using the LTE specific DRX cycles, the following results were found for idle mode:

Table 2.2.2-1 LTE device sleep ratio in subframe level (for idle mode)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Paging cycle *N*PC\_RF \*10 (ms) | Synchronization reception time per cycle(ms) | Synchronization cycle(ms) | Number of  synchronization | RRM measurement time per DRX (ms) | Transition time (ms) | DL/UL subframe ratio | Sleep ratio |
| RRC-Idle | 320 | 2 | 10\* | 1 | 6 | 10 | 1 | 93.1% |
| 320 | 2 | 10\* | 2 | 6 | 10 | 1 | 90.0% |
| 2560 | 2 | 10\* | 1 | 6 | 10 | 1 | 99.1% |
| 2560 | 2 | 10\* | 2 | 6 | 10 | 1 | 98.8% |

For the RRC-Connected state we have(without data transmission):

Table 2.2-2 LTE device sleep ratio in subframe level (for connected mode)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | DRX cycle *T*CYCLE\_SF (ms) | Synchronization reception time(ms) | Synchronization cycle(ms) | Number of synchronization | PDCCH reception time(ms) | RRM measurement time per DRX (ms) | DL/UL subframe ratio | Sleep ratio |
| RRC-Connected | 320 | 2 | -- | 1 | 10 | 6 | 1 | 91.9% |
| 320 | 2 | 10 | 2 | 10 | 6 | 0.5 | 85.6% |
| 2560 | 2 | -- | 1 | 100 | 6 | 1 | 95.5% |
| 2560 | 2 | 10 | 2 | 100 | 6 | 0.5 | 91.2% |
| 10240 | 2 | -- | 1 | 1600 | 6 | 1 | 84.2% |

**In both idle and connected states, the LTE device can achieve a very high percentage of sleep mode at the sub-frame level.**

**Parameters evaluated via Analysis**

11.1.3 Peak data rate

11.1.4 Peak spectral efficiency

11.1.5 User experienced data rate (single band, single layer)

11.1.6 Area traffic capacity (InH, eMBB)

*Source (Embedded file to be deleted later):* 

**11.1.6.1 Conclusion:** CEG concluded that traffic area requirement is met by the IMT-2020 3GPP submission.

**11.1.6.2. Verification:**

The requirement is defined for the purpose of evaluation in the Indoor Hotspot (InH) eMBB test environment, where the target value for the area traffic capacity on the downlink is 10 Mbits/s/m2.

The Indoor Hotspot-eMBB test environment consists of one floor of a building. The height of the ceiling is 3 m. The floor has a surface of 120 m × 50 m and 12 BSs/sites which are placed in 20 meters spacing as shown in Fig. 1, with a LOS probability as defined by channel model in Annex 1, Table A1-9 of [3]. In FIG. 1, internal walls are not explicitly shown but are modeled via the stochastic LOS probability model.

The type of site deployed (e.g. one TRxP per site or 3 TRxPs per site) is not defined and should be reported by the proponent.

Fig. 1

Indoor Hotspot sites layout



If we take 12 TRxP in the above scenario, then we can compute as follows:

= 12 / (120m X 50m) = 0.002 TRxP/m2

For FDD with DL with 32x4 MU-MIMO Type II Codebook, and SCS = 15KHz the average spectrum efficiency has been derived as:

Channel Model A: = 13.24 for 40MHz carrier bandwidth.

Channel Model B: = 13.54 for 40MHz carrier bandwidth.

For this FDD configuration, using a 400MHz aggregation bandwidth we will have:

**Channel Model A:**

= 0.002 X 400MHz X 13.24 = 10.59 Mbits/s/Hz

**Channel Model B:**

= 0.002 X 400MHz X 13.54 = 10.83 Mbits/s/Hz

**Observation 1: For FDD configuration the minimum requirement for area traffic capacity can be met with a minimum aggregated channel bandwidth of 400MHz.**

For TDD with DL with 32x4 MU-MIMO Type II Codebook reciprocity based, 4T SRS, SCS = 15KHz and DDDSU frame structure, the average spectrum efficiency has been derived as:

Channel Model A: = 14.65 for 40MHz carrier bandwidth.

Channel Model B: = 14.64 for 40MHz carrier bandwidth.

So, for the above TDD configuration with 360MHz aggregated bandwidth we will find:

**Channel Model A:**

= 0.002 X 360 MHz X 14.65 = 10.54 Mbits/s/Hz

**Channel Model B:**

= 0.002 X 360 MHz X 14.64 = 10.54 Mbits/s/Hz

**Observation 2: For TDD configuration the minimum requirement for area traffic capacity can be met with a minimum aggregated channel bandwidth of 360MHz.**

11.1.7 Latency (user-plane and control-plane)

11.1.8 Mobility interruption time

*Source (Embedded file to be deleted later):* 

The Mobility interruption time requirement for IMT-2020 is 0 ms as specified by Report ITU-R M.2410 document. The CEG concluded the 3GPP submission is compliant with the ITU-R requirement.

**Analysis details**

The Mobility Interruption time requirement is defined by Report ITU-R M.2410 as follows:

*“Mobility interruption time is the shortest time duration supported by the system during which a user terminal cannot exchange user plane packets with any base station during transitions.*

*The mobility interruption time includes the time required to execute any radio access network procedure, radio resource control signalling protocol, or other message exchanges between the mobile station and the radio access network, as applicable to the candidate RIT/SRIT.*

*This requirement is defined for the purpose of evaluation in the eMBB and URLLC usage scenarios.*

*The minimum requirement for mobility interruption time is 0 ms.”*

As for the evaluation part, the following analysis method is mentioned in Report ITU-R M.2412 that we reproduce here for convenience:

*“The procedure of exchanging user plane packets with base stations during transitions shall be described based on the proposed technology including the functions and the timing involved.”*

The following scenarios are considered based on the 3GPP submission (Rel-15):

**1. NR mobility scenarios:**

1.1 Beam mobility.

1.2 CA (Carrier Aggregation) mobility.

**2. LTE mobility scenarios:**

2.1 Pcell (primary Cell) mobility.

2.2 DC (Dual Connectivity) mobility.

**1. NR mobility scenarios**

**1.1 NR Beam mobility**

One of the new features for NR is the specification of beam management. While moving into a cell, the transmit-receive beam of a user terminal may need to be changed.

The UE can be configured to perform beam measurements and reporting based on a set of specific RS resources. The device can report physical layer measurements for the strongest beam and for the rest of the reported beams in the report just the difference with the best beam.

NR supports beam indication. This implies in informing the UE that certain PDSCH and/or PDCCH transmissions uses the same transmission beam as a configured reference signal (RS). That means that a certain PDSCH and/or PDCCH is transmitted using the same spatial filter as the configured RS. So, beam indication is based on the configuration and downlink signaling of so-called Transmission Configuration Indication (TCI) states.

A UE can be configured by RRC with up to 64 TCI states, and by means of MAC signaling, the network can indicate a specific TCI state.

In some situations, the PDSCH beam indication can be performed using 2 different procedures due to the flexible offset scheduling timing. If this is larger than N symbols, DCI scheduling (on PDCCH) can indicate the TCI state. If it is smaller than N, the UE may assume quasi-collocated transmissions with the PDCCH.

***Observation 1:*** ***The above described mechanism is sufficiently flexible and allows gNB to schedule DL data on multiple beams on different slots.***

A similar procedure is available for UL direction, whereas PUSCH is sent using an SRS resource indicator (SRI) configured by gNB. Thus, and gNB-side beam is selected for UL data reception accordingly.

***Observation 2: gNB may select different beams at different slots depending on the UE mobility. Therefore, UL data packet transmission is kept during beam pair switching at different slots.***

***Beam Mobility analysis conclusion: the UE can always exchange user plane packets with gNB during the mobility transitions. Therefore, 0ms mobility interruption time can be achieved by NR for this scenario.***

**1.1 NR** **Carrier Aggregation**

When moving within the same PCell with CA enabled, the set of configured SCells of the UE may change. The SCell addition procedure and SCell release procedures can occur.

During these procedures, the UE can always exchange user plane packets with the gNB during transitions, because the data transmission between the UE and the PCell is kept. Therefore, 0ms mobility interruption time is achieved by NR for this case.

***NR CA mobility analysis conclusion:*** ***0 ms mobility interruption time can be achieved by NR for CA mobility.***

11.1.9 Link Budget Analysis

*Source (Embedded file to be deleted later):* 

Link budget calculation is an important network planning tool that efficiently provides a first order approximation of cell coverage for a given level of service (and vice versa) and enables comparing the performance of different frequency bands during the network planning phase. One of the main development targets of the 3GPP based NR technology was to match or exceed the link budget of IMT-Advanced technologies. As part of the Canadian Evaluation Group (CEG) study, the calculations provided by 3GPP have been verified to determine whether the IMT-2020 targets would be met by the NR technology.

Inspection of the link budget template tables provided by 3GPP clearly shows that they are well prepared, cover the considered deployment scenarios and are appropriate for link budget evaluation. Further, it has been verified that all setup parameters for the deployment scenarios under consideration are within the ranges suggested by the ITU-R WP 5D in the M.2411 and M.2412 documents.

Focus of the verification efforts was centred on deriving the shadow fading margins, penetration margins and data rate to signal to interference (SINR) mapping as these values have been used in the tables without providing sufficient details. For both considered channel models (Channel Model A and B), the theoretical derivation and numerical calculations, confirm that the shadowing margins, coverage areas and receiver sensitivity points all either match or are sufficiently close in value to what has been provided by 3GPP. Furthermore, in the instances where a small difference was observed the 3GPP was found to have utilized more conservative values.

Shadow fading margin (SFM) derivation methodology

For each of the deployment scenarios under consideration the cell area coverage for a single omnidirectional site has been considered to substantially reduce the complexity of the problem.

Starting with the following cell area coverage probability integral

= (1)

where the probability of coverage at a distance *r* from the site with the pathloss can be expressed as:

(2)

after substituting and resolving the integral, the cell coverage probability becomes:

(3)

where:

***Q-function*** is the tail distribution function of the standard normal distribution.

In all eMBB and URLLC deployment scenarios, the cell coverage probability of 90% and 95% have been considered for data and control channels, respectively.

For the mMTC deployment scenarios, 99% cell area coverage was considered for both data and control channels.

Using the above cell coverage area coverage probability functional points along with the pathloss equations for Channel Model A and B, the SFM was derived as a function of the pathloss exponent and shadow fading margin.

Shadow Fading Standard Deviation considerations:

The eMBB and URLLC deployment scenarios were considered to be the most challenging cases, particularly the NLOS, NLOS-Outdoor-Indoor and NLOS In-Car scenarios, with = 5, and the outdoor σ having a different value.

Since there is only a single σ value that can be inserted into the calculation equation, scenarios with two independent standard deviations combined them using the following rule:

*σ* = (4)

For NLOS cases of eMBB and URLLC:

*a =*

*b =*

and for NLOS-O-I cases:

*a =*

*b =*

For Channel Model A, where an explicit value is not defined, the is derived and approximated using a generic uniform distribution of a variable into an interval (a, b), U (a, b), with the following characteristics:

The median u is defined as follows

*u = (a + b)/2* (5)

while the standard deviation σ is derived as follows:

= (6)

The pathloss exponent it is determined by the applicable pathloss equations found in the M.2412 document along with the rest of the used shadow fading margin σ for each specific scenario.

The summary of the results for SFM values are presented in the following tables for each Channel Model. They all fall well within the values from 3GPP self-evaluation template.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **SFM eMBB - Channel Model A** | | | | | | | | | |
| Scenario | **InH (4GHz)** | | **DU (4GHz)** | | | | **Rural(700MHz)** | | | |
| Results  origin | **3GPP** | **CEG** | **3GPP** | | **CEG** | | **3GPP** | | **CEG** | |
| Control Channel  SFM  (95%) | 2.80 | 2.84 | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 8.07 | 6.95 | 8.12 | 6.97 | 10.45 | 8.45 | 10.01 | 8.24 |
| Data Channel  SFM (90%) | O.91 | 0.94 | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 4.85 | 4.03 | 4.89 | 4.04 | 6.61 | 5.13 | 6.24 | 4.86 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **SFM eMBB - Channel Model B** | | | | | | | | | |
| Scenario | **InH (4GHz)** | | **DU (4GHz)** | | | | **Rural(700MHz)** | | | |
| Results  origin | **3GPP** | **CEG** | **3GPP** | | **CEG** | | **3GPP** | | **CEG** | |
| Control Channel  SFM  (95%) | 8.50 | 8.49 | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 8.07 | 9.04 | 8.12 | 9.59 | 10.45 | 10 | 10.01 | 9.66 |
| Data Channel  SFM  (90%) | 5.20 | 5.20 | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 4.85 | 5.60 | 4.89 | 5.99 | 6.61 | 6.30 | 6.24 | 5.92 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **SFM URLLC - Channel Model B** | | | |
| Scenario | **UMa (700MHz)** | | | |
| Results  origin | **3GPP** | | **CEG** | |
| Control Channel  SFM  (95%) | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 8.11 | 8.30 | 8.12 | 7.59 |
| Data Channel  SFM  (90%) | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 4.89 | 5.10 | 4.89 | 4.50 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **SFM URLLC - Channel Model A** | | | |
| Scenario | **UMa (700MHz)** | | | |
| Results  origin | **3GPP** | | **CEG** | |
| Control Channel  SFM  (95%) | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 8.11 | 7 | 8.12 | 7.28 |
| Data Channel  SFM  (90%) | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 4.89 | 4.08 | 4.89 | 4.15 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **SFM mMTC - Channel Model A** | | | | | | | | | | | |
| Scenario | **UMa NB-IoT (700MHz)** | | | | | | **UMa eMTC (700MHz)** | | | | | |
| Results  origin | **3GPP** | | | **CEG** | | | **3GPP** | | | **CEG** | | |
| Control Channel  SFM  (99%) | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I |
| 6.30 | 10.26 | 12.22 | 6.24 | 10.26 | 12.32 | 6.30 | 10.26 | 12.22 | 6.24 | 10.26 | 12.32 |
| Data Channel  SFM  (99%) | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I |
| 6.30 | 10.26 | 12.22 | 6.24 | 10.26 | 12.32 | 6.30 | 10.26 | 12.22 | 6.24 | 10.26 | 12.32 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **SFM mMTC - Channel Model B** | | | | | | | | | | | |
| Scenario | **UMa NB-IoT (700MHz)** | | | | | | **UMa eMTC (700MHz)** | | | | | |
| Results  origin | **3GPP** | | | **CEG** | | | **3GPP** | | | **CEG** | | |
| Control Channel  SFM (99%) | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I |
| 6.3 | 10.26 | 17 | 6.24 | 10.26 | 16.18 | 6.3 | 10.26 | 17 | 6.24 | 10.26 | 16.18 |
| Data Channel  SFM (99%) | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I |
| 6.3 | 10.26 | 17 | 6.24 | 10.26 | 16.18 | 6.3 | 10.26 | 17 | 6.24 | 10.26 | 16.18 |

Penetration Margin derivation

The penetration margin calculations were performed using the instructions and information from M.2412 for both Channel Model A and B. On the other hand, the car penetration part utilized a conducted study on LTE mobiles mounted on various car models that verified the values agreed on for NLOS eMBB scenarios.

Also, for mMTC scenarios the high loss equations for building penetration loss were used due to the 99% cell area coverage requirement which is considered to be the most conservative case.

The tables below detail and compare the derived penetration loss values for all scenarios with 3GPP derived values. All derived values are within a 1dB range or less.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Penetration Margin eMBB - Channel Model A** | | | | | | | | | |
| Scenario | **InH (4GHz)** | | **DU (4GHz)** | | | | **Rural(700MHz)** | | | |
| Results  origin | **3GPP** | **CEG** | **3GPP** | | **CEG** | | **3GPP** | | **CEG** | |
| Penetration  Margin | 0 | 0 | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 9 | 26.25 | 9 | 26.25 | 9 | 12.5 | 9 | 12.5 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Penetration Margin eMBB - Channel Model B** | | | | | | | | | |
| Scenario | **InH (4GHz)** | | **DU (4GHz)** | | | | **Rural(700MHz)** | | | |
| Results  origin | **3GPP** | **CEG** | **3GPP** | | **CEG** | | **3GPP** | | **CEG** | |
| Penetration  Margin | 0 | 0 | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 9 | 17.98 | 9 | 17.98 | 9 | 11.90 | 9 | 11.96 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Penetration Margin**  **URLLC - Channel Model A** | | | |
| Scenario | **UMa (700MHz)** | | | |
| Results  origin | **3GPP** | | **CEG** | |
| Penetration  Margin | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 9 | 26.25 | 9 | 26.25 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Penetration Margin**  **URLLC - Channel Model B** | | | |
| Scenario | **UMa (700MHz)** | | | |
| Results  origin | **3GPP** | | **CEG** | |
| Penetration  Margin | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 9 | 14.41 | 9 | 14.46 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Penetration Margin mMTC - Channel Model A** | | | | | | | | | | | |
| Scenario | **UMa NB-IoT (700MHz)** | | | | | | **UMa eMTC (700MHz)** | | | | | |
| Results  origin | **3GPP** | | | **CEG** | | | **3GPP** | | | **CEG** | | |
| Penetration  Margin | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I |
| 0 | 0 | 26.25 | 0 | 0 | 26.25 | 0 | 0 | 26.25 | 0 | 0 | 26.25 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Penetration Margin mMTC - Channel Model B** | | | | | | | | | | | |
| Scenario | **UMa NB-IoT (700MHz)** | | | | | | **UMa eMTC (700MHz)** | | | | | |
| Results  origin | **3GPP** | | | **CEG** | | | **3GPP** | | | **CEG** | | |
| Penetration  Margin | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I |
| 0 | 0 | 21.92 | 0 | 0 | 22.01 | 0 | 0 | 21.92 | 0 | 0 | 22.01 |

SNR verification

SNR verification was done using link level simulations. The methodology used was based on maintaining the same spectrum efficiency from 3GPP self-evaluation templates and computing the equivalent channel overhead for each specified bandwidth. The number of antennas and all other RF characteristics was maintained to provide a correct verification of the proposed results.

The simulations verified that all suggested SNR values in the 3GPP link budget templates were within 1-2 dB margin from the simulated values, which is below the receiver implementation loss of 2 dB. For this reason, and acknowledging the simulators implementation margins, it is concluded that the proposed SNR values are correct.

**Parameters evaluated via Simulation**

11.1.10 5% user spectral efficiency (per test environment)

11.1.11 Average spectral efficiency (per test environment)

11.1.12 Connection density

11.1.13 Reliability

11.1.14 Mobility (InH, DU, RU)

## 11.2 3GPP RIT

**Parameters evaluated via Inspection**

11.2.1 Bandwidth

*See Section 11.1.1 (move the relevant parts here)*

11.2.1.1Conclusion**:** CEG concluded that bandwidth and scalability requirements are met by the IMT-2020 3GPP submission.

**11.2.1.2 Verification:**

**11.2.1.2.1 NR bandwidth requirements capabilities**

The capability of bandwidth and bandwidth scalability for NR:

First, we have the supported bandwidth channels on FR1 (below 6 GHz) and FR2 (above 24 GHz) respectively along with their supported SCS. Then, according to the RRC specification TS 38.331, according to section 6.4, up to 16 component carriers is supported in Rel-15.

According to TS 38.104 the following channel bandwidths and maximum aggregation bandwidths are supported in Rel-15:

Table 11.1.1.2.1.1 NR 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  (410 MHz – 7125 MHz) | 15 | 50 | 16 | 800 |
| 30 | 100 | 16 | 1600 |
| 60 | 100 | 16 | 1600 |
| FR2  (24250 MHz – 52600 MHz) | 60 | 200 | 16 | 3200 |
| 120 | 400 | 16 | 6400 |

And then the following transmission bandwidths configurations are supported for each case:

Table 11.1.1.2.1.2: Transmission bandwidth configuration NRB for FR1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS (kHz) | 5  MHz | 10  MHz | 15  MHz | 20 MHz | 25 MHz | 30  MHz | 40 MHz | 50 MHz | 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 |

Table 5.3.2-2: Transmission bandwidth configuration NRB 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 |

And then in terms of scalability capability we minimum and maximum channel bandwidth and the maximum scalability per component carrier:

Table 11.1.1.2.1.3 Bandwidth scalability capability for NR

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **SCS [kHz]** | **Minimum component carrier bandwidth (MHz)** | **Maximum component carrier bandwidth (MHz)** | **Maximum Number of supported bandwidths 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 |

The bandwidth scalability capability of NR Rel-15 is summarized in Table 2.1.3. 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 NR Rel-15.

11.2.2 Energy efficiency

*See Section 11.1.2 (move the relevant parts here)*

**11.2.2.1 Conclusion:** CEG concluded that energy efficiency requirements are met by the IMT-2020 3GPP submission.

**11.1.2.2.1Verification:**

### 11.2.2.2.1.1 NR network side

Based on the definition of the sleep time for the network suggested in Report ITU-R M.2410 requirement, the following sleep mode ratio equations were proposed in the submission documents:

where indicates the ceiling of *x*,  is the numerology (as defined in TS38.211, e.g., **=0 for 15 kHz SCS, **=1 for 30 kHz SCS, **=3 for 120 kHz SCS, and **=4 for 240 kHz SCS), *L* is the number of SS/PBCH blocks in one SSB set, *P*SSB is the SSB set periodicity, *P*RMSI is the RSMI periodicity, and  is the flag variable (=1 for FR1, and =0 for FR2).

The CEG agrees with the proposed methodology and as a result, the NR network can achieve high sleep ratio in unloaded case.

Table 2.1.1-1 NR network sleep ratio in slot level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **SSB configuration** | | **SSB set periodicity** *P*SSB | | | | | |
| **SCS [kHz]** | **Number of SS/PBCH block per SSB set,** *L* | 5ms | 10ms | 20ms | 40ms | 80ms | 160ms |
| 15kHz | 1 | 80.00% | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% |
| 2 | 80.00% | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% |
| 30kHz | 1 | 95.00% | 97.50% | 98.75% | 99.38% | 99.69% | 99.84% |
| 4 | 80.00% | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% |
| 120kHz | 8 | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% | 99.69% |
| 16 | 80.00% | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% |
| 240kHz | 16 | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% | 99.69% |
| 32 | 80.00% | 90.00% | 95.00% | 97.50% | 98.75% | 99.38% |

Table 2.1.1-2 NR network sleep ratio in symbol level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **SSB configuration** | | **SSB set periodicity** *P*SSB | | | | | |
| **SCS [kHz]** | **Number of SS/PBCH block per SSB set,** *L* | 5ms | 10ms | 20ms | 40ms | 80ms | 160ms |
| 15kHz | 1 | 93.57% | 96.43% | 97.86% | 98.93% | 99.46% | 99.73% |
| 2 | 87.14% | 92.86% | 95.71% | 97.86% | 98.93% | 99.46% |
| 30kHz | 1 | 96.79% | 98.21% | 98.93% | 99.46% | 99.73% | 99.87% |
| 4 | 87.14% | 92.86% | 95.71% | 97.86% | 98.93% | 99.46% |
| 120kHz | 8 | 94.29% | 97.14% | 98.57% | 99.29% | 99.64% | 99.82% |
| 16 | 88.57% | 94.29% | 97.14% | 98.57% | 99.29% | 99.64% |
| 240kHz | 16 | 94.29% | 97.14% | 98.57% | 99.29% | 99.64% | 99.82% |
| 32 | 88.57% | 94.29% | 97.14% | 98.57% | 99.29% | 99.64% |

In terms of milliseconds, the following sleep time can be achieved by NR network on different SSB periodicities:

Based on the above mechanisms, evaluation results of sleep duration are provided in Table 3. It is observed that with SSB set period of 160ms, more than 150ms sleep duration can be obtained by NR network. Therefore, NR network can achieve long sleep duration in unloaded case.

**Therefore, NR meets network side energy efficiency requirement.**

Table 2.1.1-3 NR network sleep duration (ms) in slot level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **SSB configuration** | | **SSB set periodicity** *P*SSB | | | | | |
| **SCS [kHz]** | **Number of SS/PBCH block per SSB set,** *L* | 5ms | 10ms | 20ms | 40ms | 80ms | 160ms |
| 15kHz | 1 | 4.00 | 9.00 | 19.00 | 39.00 | 79.00 | 159.00 |
| 2 | 4.00 | 9.00 | 19.00 | 39.00 | 79.00 | 159.00 |
| 30kHz | 1 | 4.50 | 9.50 | 19.50 | 39.50 | 79.50 | 159.50 |
| 4 | 4.00 | 9.00 | 19.00 | 39.00 | 79.00 | 159.00 |
| 120kHz | 8 | 4.50 | 9.72 | 18.92 | 39.03 | 78.97 | 158.99 |
| 16 | 4.00 | 9.88 | 18.77 | 39.05 | 78.96 | 158.99 |
| 240kHz | 16 | 4.50 | 9.86 | 18.90 | 39.04 | 78.97 | 158.99 |
| 32 | 4.00 | 9.94 | 18.76 | 39.06 | 78.96 | 158.99 |

### 11.2.2.2.1.2 NR UE side

The sleep ratio and sleep duration for NR UEs under unloaded case are evaluated.

For NR, DRX is supported for UEs in idle, inactive and connected states.

The DRX cycle for idle state / inactive state UE consists of an “On Duration” during which the UE should perform SSB monitoring, paging monitoring and RRM measurement, and an “Off Duration” during which the UE can skip reception of downlink channels to save energy.

During the On Duration of a DRX cycle, the UE is assumed to perform the following tasks:

- Synchronization on one SSB burst (short paging cycle)

- Paging monitoring- this can consist on multiple slots. The Paging Frame is no longer than a one SSB bursts.

- RRM measurement which is based on SS/PBCH and it is assumed to be 3.5ms.

The transition time for switching ON/OFF UE internal components is assumed to be 10ms

**Based on these assumptions, the UE can be in sleep mode more than 90% in for any DRX cycle in idle/inactive state:**

Table 2.1.2-1 NR device sleep ratio in slot level (for idle / inactive mode)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Paging cycle *N*PC\_RF \*10 (ms) | SCS(kHz) | SSB L | SSB reception time(ms) | SSB cycle (ms) | Number of SSB burst set | RRM measurement time per DRX (ms) | Transition time(ms) | Sleep ratio |
| RRC-Idle/Inactive | 320 | 240 | 32 | 1 | -- | 1 | 3.5 | 10 | 95.5% |
| 2560 | 15 | 2 | 1 | -- | 1 | 3 | 10 | 99.5% |
| 2560 | 15 | 2 | 1 | 160 | 2 | 3 | 10 | 93.2% |

**For RRC-Connected Mode, with no data transmissions, we get more than 84% sleep mode, assuming the ON Duration” and the other similar parameters:**

Table 2.1.2-2 NR device sleep ratio in slot level (for connected mode)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | DRX cycle *T*SC\_ms \* *M*SC (ms) | Number of SSB burst set | DRX-onDurationTimer(ms) | RRM measurement time per DRX (ms) | Transition time(ms) | Sleep ratio |
| RRC-Connected | 320 | 1 | 2 | 3.5 | 10 | 95.2% |
| 320 | 1 | 10 | 3 | 10 | 92.8% |
| 2560 | 1 | 100 | 3 | 10 | 95.6% |
| 10240 | 1 | 1600 | 3 | 10 | 84.2% |

**Parameters evaluated via Analysis**

11.2.3 Peak data rate

11.2.4 Peak spectral efficiency

11.2.5 User experienced data rate (single band, single layer)

11.2.6 Area traffic capacity (InH, eMBB)

*See Section 11.1.6 (move the relevant parts here)*

**11.2.6.1 Conclusion:** CEG concluded that traffic area requirement is met by the IMT-2020 3GPP submission.

**11.2.6.2 Verification:**

The requirement is defined for the purpose of evaluation in the Indoor Hotspot (InH) eMBB test environment, where the target value for the area traffic capacity on the downlink is 10 Mbits/s/m2.

The Indoor Hotspot-eMBB test environment consists of one floor of a building. The height of the ceiling is 3 m. The floor has a surface of 120 m × 50 m and 12 BSs/sites which are placed in 20 meters spacing as shown in Fig. 1, with a LOS probability as defined by channel model in Annex 1, Table A1-9 of [3]. In FIG. 1, internal walls are not explicitly shown but are modeled via the stochastic LOS probability model.

The type of site deployed (e.g. one TRxP per site or 3 TRxPs per site) is not defined and should be reported by the proponent.

Fig. 1

Indoor Hotspot sites layout

If we take 12 TRxP in the above scenario, then we can compute as follows:

= 12 / (120m X 50m) = 0.002 TRxP/m2

For FDD with DL with 32x4 MU-MIMO Type II Codebook, and SCS = 15KHz the average spectrum efficiency has been derived as:

Channel Model A: = 13.24 for 40MHz carrier bandwidth.

Channel Model B: = 13.54 for 40MHz carrier bandwidth.

For this FDD configuration, using a 400MHz aggregation bandwidth we will have:

**Channel Model A:**

= 0.002 X 400MHz X 13.24 = 10.59 Mbits/s/Hz

**Channel Model B:**

= 0.002 X 400MHz X 13.54 = 10.83 Mbits/s/Hz

**Observation 1: For FDD configuration the minimum requirement for area traffic capacity can be met with a minimum aggregated channel bandwidth of 400MHz.**

For TDD with DL with 32x4 MU-MIMO Type II Codebook reciprocity based, 4T SRS, SCS = 15KHz and DDDSU frame structure, the average spectrum efficiency has been derived as:

Channel Model A: = 14.65 for 40MHz carrier bandwidth.

Channel Model B: = 14.64 for 40MHz carrier bandwidth.

So, for the above TDD configuration with 360MHz aggregated bandwidth we will find:

**Channel Model A:**

= 0.002 X 360 MHz X 14.65 = 10.54 Mbits/s/Hz

**Channel Model B:**

= 0.002 X 360 MHz X 14.64 = 10.54 Mbits/s/Hz

**Observation 2: For TDD configuration the minimum requirement for area traffic capacity can be met with a minimum aggregated channel bandwidth of 360MHz.**

11.2.7 Latency (user-plane and control-plane)

11.2.8 Mobility interruption time

*See Section 11.1.8 (move the relevant parts here)*

**11.2.8.1 Conclusion:** CEG concluded that mobility interruption time requirement is met by the IMT-2020 3GPP submission.

**11.2.8.2 Verification:**

**11.2.8.2.1 NR mobility scenarios**

**11.2.8.2.1.1.1 NR Beam mobility**

One of the new features for NR is the specification of beam management. While moving into a cell, the transmit-receive beam of a user terminal may need to be changed.

The UE can be configured to perform beam measurements and reporting based on a set of specific RS resources. The device can report physical layer measurements for the strongest beam and for the rest of the reported beams in the report just the difference with the best beam.

NR supports beam indication. This implies in informing the UE that certain PDSCH and/or PDCCH transmissions uses the same transmission beam as a configured reference signal (RS). That means that a certain PDSCH and/or PDCCH is transmitted using the same spatial filter as the configured RS. So, beam indication is based on the configuration and downlink signaling of so-called Transmission Configuration Indication (TCI) states.

A UE can be configured by RRC with up to 64 TCI states, and by means of MAC signaling, the network can indicate a specific TCI state.

In some situations, the PDSCH beam indication can be performed using 2 different procedures due to the flexible offset scheduling timing. If this is larger than N symbols, DCI scheduling (on PDCCH) can indicate the TCI state. If it is smaller than N, the UE may assume quasi-collocated transmissions with the PDCCH.

***Observation 1:*** ***The above described mechanism is sufficiently flexible and allows gNB to schedule DL data on multiple beams on different slots.***

A similar procedure is available for UL direction, whereas PUSCH is sent using an SRS resource indicator (SRI) configured by gNB. Thus, and gNB-side beam is selected for UL data reception accordingly.

***Observation 2: gNB may select different beams at different slots depending on the UE mobility. Therefore, UL data packet transmission is kept during beam pair switching at different slots.***

***Beam Mobility analysis conclusion: the UE can always exchange user plane packets with gNB during the mobility transitions. Therefore, 0ms mobility interruption time can be achieved by NR for this scenario.***

**11.2.8.2.1.1.2 NR** **Carrier Aggregation**

When moving within the same PCell with CA enabled, the set of configured SCells of the UE may change. The SCell addition procedure and SCell release procedures can occur.

During these procedures, the UE can always exchange user plane packets with the gNB during transitions, because the data transmission between the UE and the PCell is kept. Therefore, 0ms mobility interruption time is achieved by NR for this case.

***NR CA mobility analysis conclusion:*** ***0 ms mobility interruption time can be achieved by NR for CA mobility.***

11.2.9 Link Budget Analysis

*See Section 11.1.9 (move the relevant parts here)*

Link budget calculation is an important network planning tool that efficiently provides a first order approximation of cell coverage for a given level of service (and vice versa) and enables comparing the performance of different frequency bands during the network planning phase. One of the main development targets of the 3GPP based NR technology was to match or exceed the link budget of IMT-Advanced technologies. As part of the Canadian Evaluation Group (CEG) study, the calculations provided by 3GPP have been verified to determine whether the IMT-2020 targets would be met by the NR technology.

Inspection of the link budget template tables provided by 3GPP clearly shows that they are well prepared, cover the considered deployment scenarios and are appropriate for link budget evaluation. Further, it has been verified that all setup parameters for the deployment scenarios under consideration are within the ranges suggested by the ITU-R WP 5D in the M.2411 and M.2412 documents.

Focus of the verification efforts was centred on deriving the shadow fading margins, penetration margins and data rate to signal to interference (SINR) mapping as these values have been used in the tables without providing sufficient details. For both considered channel models (Channel Model A and B), the theoretical derivation and numerical calculations, confirm that the shadowing margins, coverage areas and receiver sensitivity points all either match or are sufficiently close in value to what has been provided by 3GPP. Furthermore, in the instances where a small difference was observed the 3GPP was found to have utilized more conservative values.

Shadow fading margin (SFM) derivation methodology

For each of the deployment scenarios under consideration the cell area coverage for a single omnidirectional site has been considered to substantially reduce the complexity of the problem.

Starting with the following cell area coverage probability integral

= (1)

where the probability of coverage at a distance *r* from the site with the pathloss can be expressed as:

(2)

after substituting and resolving the integral, the cell coverage probability becomes:

(3)

where:

***Q-function*** is the tail distribution function of the standard normal distribution.

In all eMBB and URLLC deployment scenarios, the cell coverage probability of 90% and 95% have been considered for data and control channels, respectively.

For the mMTC deployment scenarios, 99% cell area coverage was considered for both data and control channels.

Using the above cell coverage area coverage probability functional points along with the pathloss equations for Channel Model A and B, the SFM was derived as a function of the pathloss exponent and shadow fading margin.

Shadow Fading Standard Deviation considerations:

The eMBB and URLLC deployment scenarios were considered to be the most challenging cases, particularly the NLOS, NLOS-Outdoor-Indoor and NLOS In-Car scenarios, with = 5, and the outdoor σ having a different value.

Since there is only a single σ value that can be inserted into the calculation equation, scenarios with two independent standard deviations combined them using the following rule:

*σ* = (4)

For NLOS cases of eMBB and URLLC:

*a =*

*b =*

and for NLOS-O-I cases:

*a =*

*b =*

For Channel Model A, where an explicit value is not defined, the is derived and approximated using a generic uniform distribution of a variable into an interval (a, b), U (a, b), with the following characteristics:

The median u is defined as follows

*u = (a + b)/2* (5)

while the standard deviation σ is derived as follows:

= (6)

The pathloss exponent it is determined by the applicable pathloss equations found in the M.2412 document along with the rest of the used shadow fading margin σ for each specific scenario.

The summary of the results for SFM values are presented in the following tables for each Channel Model. They all fall well within the values from 3GPP self-evaluation template.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **SFM eMBB - Channel Model A** | | | | | | | | | |
| Scenario | **InH (4GHz)** | | **DU (4GHz)** | | | | **Rural(700MHz)** | | | |
| Results  origin | **3GPP** | **CEG** | **3GPP** | | **CEG** | | **3GPP** | | **CEG** | |
| Control Channel  SFM  (95%) | 2.80 | 2.84 | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 8.07 | 6.95 | 8.12 | 6.97 | 10.45 | 8.45 | 10.01 | 8.24 |
| Data Channel  SFM (90%) | O.91 | 0.94 | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 4.85 | 4.03 | 4.89 | 4.04 | 6.61 | 5.13 | 6.24 | 4.86 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **SFM eMBB - Channel Model B** | | | | | | | | | |
| Scenario | **InH (4GHz)** | | **DU (4GHz)** | | | | **Rural(700MHz)** | | | |
| Results  origin | **3GPP** | **CEG** | **3GPP** | | **CEG** | | **3GPP** | | **CEG** | |
| Control Channel  SFM  (95%) | 8.50 | 8.49 | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 8.07 | 9.04 | 8.12 | 9.59 | 10.45 | 10 | 10.01 | 9.66 |
| Data Channel  SFM  (90%) | 5.20 | 5.20 | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 4.85 | 5.60 | 4.89 | 5.99 | 6.61 | 6.30 | 6.24 | 5.92 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **SFM URLLC - Channel Model B** | | | |
| Scenario | **UMa (700MHz)** | | | |
| Results  origin | **3GPP** | | **CEG** | |
| Control Channel  SFM  (95%) | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 8.11 | 8.30 | 8.12 | 7.59 |
| Data Channel  SFM  (90%) | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 4.89 | 5.10 | 4.89 | 4.50 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **SFM URLLC - Channel Model A** | | | |
| Scenario | **UMa (700MHz)** | | | |
| Results  origin | **3GPP** | | **CEG** | |
| Control Channel  SFM  (95%) | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 8.11 | 7 | 8.12 | 7.28 |
| Data Channel  SFM  (90%) | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 4.89 | 4.08 | 4.89 | 4.15 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **SFM mMTC - Channel Model A** | | | | | | | | | | | |
| Scenario | **UMa NB-IoT (700MHz)** | | | | | | **UMa eMTC (700MHz)** | | | | | |
| Results  origin | **3GPP** | | | **CEG** | | | **3GPP** | | | **CEG** | | |
| Control Channel  SFM  (99%) | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I |
| 6.30 | 10.26 | 12.22 | 6.24 | 10.26 | 12.32 | 6.30 | 10.26 | 12.22 | 6.24 | 10.26 | 12.32 |
| Data Channel  SFM  (99%) | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I |
| 6.30 | 10.26 | 12.22 | 6.24 | 10.26 | 12.32 | 6.30 | 10.26 | 12.22 | 6.24 | 10.26 | 12.32 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **SFM mMTC - Channel Model B** | | | | | | | | | | | |
| Scenario | **UMa NB-IoT (700MHz)** | | | | | | **UMa eMTC (700MHz)** | | | | | |
| Results  origin | **3GPP** | | | **CEG** | | | **3GPP** | | | **CEG** | | |
| Control Channel  SFM (99%) | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I |
| 6.3 | 10.26 | 17 | 6.24 | 10.26 | 16.18 | 6.3 | 10.26 | 17 | 6.24 | 10.26 | 16.18 |
| Data Channel  SFM (99%) | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I |
| 6.3 | 10.26 | 17 | 6.24 | 10.26 | 16.18 | 6.3 | 10.26 | 17 | 6.24 | 10.26 | 16.18 |

Penetration Margin derivation

The penetration margin calculations were performed using the instructions and information from M.2412 for both Channel Model A and B. On the other hand, the car penetration part utilized a conducted study on LTE mobiles mounted on various car models that verified the values agreed on for NLOS eMBB scenarios.

Also, for mMTC scenarios the high loss equations for building penetration loss were used due to the 99% cell area coverage requirement which is considered to be the most conservative case.

The tables below detail and compare the derived penetration loss values for all scenarios with 3GPP derived values. All derived values are within a 1dB range or less.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Penetration Margin eMBB - Channel Model A** | | | | | | | | | |
| Scenario | **InH (4GHz)** | | **DU (4GHz)** | | | | **Rural(700MHz)** | | | |
| Results  origin | **3GPP** | **CEG** | **3GPP** | | **CEG** | | **3GPP** | | **CEG** | |
| Penetration  Margin | 0 | 0 | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 9 | 26.25 | 9 | 26.25 | 9 | 12.5 | 9 | 12.5 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Penetration Margin eMBB - Channel Model B** | | | | | | | | | |
| Scenario | **InH (4GHz)** | | **DU (4GHz)** | | | | **Rural(700MHz)** | | | |
| Results  origin | **3GPP** | **CEG** | **3GPP** | | **CEG** | | **3GPP** | | **CEG** | |
| Penetration  Margin | 0 | 0 | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 9 | 17.98 | 9 | 17.98 | 9 | 11.90 | 9 | 11.96 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Penetration Margin**  **URLLC - Channel Model A** | | | |
| Scenario | **UMa (700MHz)** | | | |
| Results  origin | **3GPP** | | **CEG** | |
| Penetration  Margin | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 9 | 26.25 | 9 | 26.25 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Penetration Margin**  **URLLC - Channel Model B** | | | |
| Scenario | **UMa (700MHz)** | | | |
| Results  origin | **3GPP** | | **CEG** | |
| Penetration  Margin | NLOS | NLOS O-I | NLOS | NLOS O-I |
| 9 | 14.41 | 9 | 14.46 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Penetration Margin mMTC - Channel Model A** | | | | | | | | | | | |
| Scenario | **UMa NB-IoT (700MHz)** | | | | | | **UMa eMTC (700MHz)** | | | | | |
| Results  origin | **3GPP** | | | **CEG** | | | **3GPP** | | | **CEG** | | |
| Penetration  Margin | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I |
| 0 | 0 | 26.25 | 0 | 0 | 26.25 | 0 | 0 | 26.25 | 0 | 0 | 26.25 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Penetration Margin mMTC - Channel Model B** | | | | | | | | | | | |
| Scenario | **UMa NB-IoT (700MHz)** | | | | | | **UMa eMTC (700MHz)** | | | | | |
| Results  origin | **3GPP** | | | **CEG** | | | **3GPP** | | | **CEG** | | |
| Penetration  Margin | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I | LOS | NLOS | NLOS O-I |
| 0 | 0 | 21.92 | 0 | 0 | 22.01 | 0 | 0 | 21.92 | 0 | 0 | 22.01 |

SNR verification

SNR verification was done using link level simulations. The methodology used was based on maintaining the same spectrum efficiency from 3GPP self-evaluation templates and computing the equivalent channel overhead for each specified bandwidth. The number of antennas and all other RF characteristics was maintained to provide a correct verification of the proposed results.

The simulations verified that all suggested SNR values in the 3GPP link budget templates were within 1-2 dB margin from the simulated values, which is below the receiver implementation loss of 2 dB. For this reason, and acknowledging the simulators implementation margins, it is concluded that the proposed SNR values are correct.

**Parameters evaluated via Simulation**

11.2.10 5% user spectral efficiency (per test environment)

Table 11.2.10.1. Evaluation Result of Indoor Hotspot – eMBB (Configuration A) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Indoor hotspot** | | **Channel Model B - Configuration A (4GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| 5% USE  [bps/Hz] | **DL** | 0.300 | 0.310-0.590 | 0.331 | … | 0.330 | 0.360 |
| **UL** | 0.210 | 0.270-0.630 | … | … | 0.590 | 0.411 |

Table 11.2.10.2. Evaluation Result of Indoor Hotspot – eMBB (Configuration A) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Indoor hotspot** | | **Channel Model B - Configuration A (4GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| 5% USE  [bps/Hz] | **DL** | 0.300 | 0.310-0.590 | 0.416 | … | 0.392 | 0.504 |
| **UL** | 0.210 | 0.270-0.630 | … | … | 0.390 | 0.565 |

Table 11.2.10.3. Evaluation Result of Indoor Hotspot – eMBB (Configuration B) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Indoor hotspot** | | **Channel Model B - Configuration B (30GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **SUMSUNG** |
| 5% USE  [bps/Hz] | **DL** | 0.300 | 0.310-1.180 | … | … | 0.408 | 0.313 |
| **UL** | 0.210 | 0.300-0.430 | … | … | 0.414 | 0.394 |

Table 11.2.10.4. Evaluation Result of Indoor Hotspot – eMBB (Configuration B) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Indoor hotspot** | | **Channel Model B - Configuration B (30GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| 5% USE  [bps/Hz] | **DL** | 0.300 | 0.310-1.180 | 0.610 | … | 0.308 | 0.997 |
| **UL** | 0.210 | 0.300-0.430 | … | … | 0.405 | 0.374 |

Table 11.2.10.5. Evaluation Result of Dense Urban – eMBB (Configuration A) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Dense Urban** | | **Channel Model B - Configuration A (4GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| 5% USE  [bps/Hz] | **DL** | 0.225 | 0.230-0.810 | 0.248 | 0.380 | 0.400 | 0.421 |
| **UL** | 0.150 | 0.160-0.600 | 0.273 | 0.228 | 0.505 | 0.347 |

Table 11.2.10.6. Evaluation Result of Dense Urban – eMBB (Configuration A) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Dense Urban** | | **Channel Model B - Configuration A (4GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| 5% USE  [bps/Hz] | **DL** | 0.225 | 0.230-0.810 | 0.328 | 0.430 | **X** | **X** |
| **UL** | 0.150 | 0.160-0.600 | 0.274 | 0.213 | **X** | **X** |

Table 11.2.10.7. Evaluation Result of Dense Urban – eMBB (Configuration B) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Dense Urban** | | **Channel Model B - Configuration B (30GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| 5% USE  [bps/Hz] | **DL** | 0.225 | … | 0.490 | 0.350 | **X** | **X** |
| **UL** | 0.150 | … | 0.244 | 0.264 | **X** | **X** |

Table 11.2.10.8. Evaluation Result of Dense Urban – eMBB (Configuration B) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Dense Urban** | | **Channel Model B - Configuration B (30GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| 5% USE  [bps/Hz] | **DL** | 0.225 | … | 0.494 | 0.370 | **X** | **X** |
| **UL** | 0.150 | … | 0.245 | 0.291 | **X** | **X** |

Table 11.2.10.9. Evaluation Result of Rural Urban – eMBB (Configuration A) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration A (700MHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| 5% USE  [bps/Hz] | **DL** | 0.120 | 0.130-0.570 | 0.174 | 0.162 | 0.128 | 0.155 |
| **UL** | 0.045 | 0.090-0.630 | 0.617 | 0.248 | 0.231 | 0.113 |

Table 11.2.10.10. Evaluation Result of Rural Urban – eMBB (Configuration A) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration A (700MHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| 5% USE  [bps/Hz] | **DL** | 0.120 | 0.130-0.570 | 0.171 | 0.159 | **X** | **X** |
| **UL** | 0.045 | 0.090-0.630 | 0.334 | 0.193 | **X** | **X** |

Table 11.2.10.11. Evaluation Result of Rural Urban – eMBB (Configuration B) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration B (4GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| 5% USE  [bps/Hz] | **DL** | 0.120 | 0.120-2.110 | 0.278 | 0.187 | 0.452 | 0.321 |
| **UL** | 0.045 | 0.020-0.340 | 0.145 | 0.189 | 0.190 | 0.126 |

Table 11.2.10.12. Evaluation Result of Rural Urban – eMBB (Configuration B) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration B (4GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| 5% USE  [bps/Hz] | **DL** | 0.120 | 0.120-2.110 | 0.349 | 0.370 | **X** | **X** |
| **UL** | 0.045 | 0.020-0.340 | 0.195 | 0.132 | **X** | **X** |

11.2.11 Average spectral efficiency (per test environment)

Table 11.2.11.1. Evaluation Result of Indoor Hotspot – eMBB (Configuration A) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Indoor hotspot** | | **Channel Model B - Configuration A (4GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| ASE [bps/Hz/TRxP] | **DL** | 9.000 | 8.770-16.880 | 10.750 | … | 11.120 | 10.544 |
| **UL** | 6.750 | 6.950-15.170 | … | … | 8.820 | 8.588 |

Table 11.2.11.2. Evaluation Result of Indoor Hotspot – eMBB (Configuration A) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Indoor hotspot** | | **Channel Model B - Configuration A (4GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| ASE [bps/Hz/TRxP] | **DL** | 9.000 | 8.770-16.880 | 11.095 | … | 13.021 | 13.456 |
| **UL** | 6.750 | 6.950-15.170 | … | … | 7.003 | 9.256 |

Table 11.2.11.3. Evaluation Result of Indoor Hotspot – eMBB (Configuration B) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Indoor hotspot** | | **Channel Model B - Configuration B (30GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **SAMSUNG** |
|  |  |
| ASE [bps/Hz/TRxP] | **DL** | 9.000 | 8.500-19.910 | … | … | 12.690 | 8.495 |
| **UL** | 6.750 | 6.900-11.440 | … | … | 10.386 | 7.657 |

Table 11.2.11.4. Evaluation Result of Indoor Hotspot – eMBB (Configuration B) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Indoor hotspot** | | **Channel Model B - Configuration B (30GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
|  |  |
| ASE [bps/Hz/TRxP] | **DL** | 9.000 | 8.500-19.910 | 17.811 | … | 11.599 | 16.745 |
| **UL** | 6.750 | 6.900-11.440 | … | … | 7.037 | 7.440 |

Table 11.2.11.5. Evaluation Result of Dense Urban – eMBB (Configuration A) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Dense Urban** | | **Channel Model B - Configuration A (4GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| ASE [bps/Hz/TRxP] | **DL** | 7.800 | 7.870-22.330 | 11.200 | 11.270 | 11.390 | 11. 867 |
| **UL** | 5.400 | 5.510-22.480 | 6.087 | 6.512 | 8.790 | 8.702 |

Table 11.2.11.6. Evaluation Result of Dense Urban – eMBB (Configuration A) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Dense Urban** | | **Channel Model B - Configuration A (4GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| ASE [bps/Hz/TRxP] | **DL** | 7.800 | 7.870-22.330 | 14.371 | 13.371 | **X** | **X** |
| **UL** | 5.400 | 5.510-22.480 | 6.099 | 6.462 | **X** | **X** |

Table 11.2.11.7. Evaluation Result of Dense Urban – eMBB (Configuration B) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Dense Urban** | | **Channel Model B - Configuration B (30GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| ASE [bps/Hz/TRxP] | **DL** | 7.800 | … | 13.752 | 11.360 | **X** | **X** |
| **UL** | 5.400 | … | 6.087 | 6.397 | **X** | **X** |

Table 11.2.11.8. Evaluation Result of Dense Urban – eMBB (Configuration B) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Dense Urban** | | **Channel Model B - Configuration B (30GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| ASE [bps/Hz/TRxP] | **DL** | 7.800 | … | 13.521 | 13.144 | **X** | **X** |
| **UL** | 5.400 | … | 5.994 | 7.752 | **X** | **X** |

Table 11.2.11.9. Evaluation Result of Rural Urban – eMBB (Configuration A) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration A (700MHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| ASE [bps/Hz/TRxP] | **DL** | 3.300 | 5.040-17.370 | 11.600 | 6.152 | 5.640 | 5.774 |
| **UL** | 1.600 | 3.750-15.550 | 4.349 | 6.951 | 4.637 | 6.243 |

Table 11.2.11.10. Evaluation Result of Rural Urban – eMBB (Configuration A) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration A (700MHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| ASE [bps/Hz/TRxP] | **DL** | 3.300 | 5.040-17.370 | 9.609 | 7.490 | **X** | **X** |
| **UL** | 1.600 | 3.750-15.550 | 3.626 | 5.872 | **X** | **X** |

Table 11.2.11.11. Evaluation Result of Rural Urban – eMBB (Configuration B) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration B (4GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| ASE [bps/Hz/TRxP] | **DL** | 3.300 | 5.960-21.110 | 13.891 | 6.480 | 11.640 | 11.063 |
| **UL** | 1.600 | 2.700-21.300 | 4.102 | 7.125 | 3.988 | 6.231 |

Table 11.2.11.12. Evaluation Result of Rural Urban – eMBB (Configuration B) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration B (4GHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **MEDIATEK** | **TPCEG** |
| ASE [bps/Hz/TRxP] | **DL** | 3.300 | 5.960-21.110 | 10.384 | 13.144 | **X** | **X** |
| **UL** | 1.600 | 2.700-21.300 | 2.907 | 3.361 | **X** | **X** |

Table 11.2.11.13. Evaluation Result of Rural Urban – eMBB (Configuration C – LMLC) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration C (700MHz)** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **Ericsson** |
|  |  |
| ASE [bps/Hz/TRxP] | **DL** | 3.300 | 3.900 – 19.290 | 10.521 | **X** | 8.137 | 5.563 |
| **UL** | 1.600 | 2.700 – 10.590 | 3.500 | **X** | 4.104 | 4.754 |

11.2.12 Connection density

Table 11.2.12.1. Evaluation Result of Urban Macro-mMTC (Configuration A) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **mMTC – Urban Macro** | | **Channel Model B - Configuration A (700MHz) – NR RIT** | | | | | |
| **Metric** | **Link** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **Ericsson** |
| Connection density  [device/km^2] | **UL** | 3.300 | 1,267,000 - 1,503,000 | 1.458,509 | 1,518,832 | 1,465,000 | 1,575,368 |

11.2.13 Reliability

11.2.14 Mobility (InH, DU, RU)

Table 11.2.14.1. Evaluation Result of Indoor Hotspot – eMBB (Configuration A, 10km/h) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Indoor Hotspot** | | **Channel Model B - Configuration A (4GHz) – NR RIT** | | | | | |
| **Metric** | **LoS/NLoS** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| Normalized traffic channel link data rate (bit/s/Hz) | **LoS** | 1.500 | 1.590 – 3.850 | … | … | 2.050 | 1.840 |
| **NLoS** | 1.500 | 1.590 – 3.850 | … | … | 1.750 | 2.130 |

Table 11.2.14.2. Evaluation Result of Indoor Hotspot – eMBB (Configuration A, 10km/h) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Indoor Hotspot** | | **Channel Model B - Configuration A (4GHz) – NR RIT** | | | | | |
| **Metric** | **LoS/NLoS** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| Normalized traffic channel link data rate (bit/s/Hz) | **LoS** | 1.500 | 1.590 – 3.850 | … | … | 1.940 | 2.070 |
| **NLoS** | 1.500 | 1.590 – 3.850 | … | … | 1.590 | 1.780 |

Table 11.2.14.3. Evaluation Result of Indoor Hotspot – eMBB (Configuration B, 10km/h) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Indoor Hotspot** | | **Channel Model B - Configuration B (30GHz) – NR RIT** | | | | | |
| **Metric** | **LoS/NLoS** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **SAMSUNG** | **CATT** |
|  |
| Normalized traffic channel link data rate (bit/s/Hz) | **LoS** | 1.500 | 2.140 – 4.760 | … | … | 3.010 | **X** |
| **NLoS** | 1.500 | 2.140 – 4.760 | … | … | 4.760 | **X** |

Table 11.2.14.4. Evaluation Result of Indoor Hotspot – eMBB (Configuration B, 10km/h) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Indoor Hotspot** | | **Channel Model B - Configuration B (30GHz) – NR RIT** | | | | | |
| **Metric** | **LoS/NLoS** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Sharp** | **CATT** |
|  |
| Normalized traffic channel link data rate (bit/s/Hz) | **LoS** | 1.500 | 2.140 – 4.760 | … | … | 2.150 | **X** |
| **NLoS** | 1.500 | 2.140 – 4.760 | … | … | 2.140 | **X** |

Table 11.2.14.5. Evaluation Result of Dense Urban – eMBB (Configuration A, 30km/h) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Dense Urban** | | **Channel Model B - Configuration A (4GHz) – NR RIT** | | | | | |
| **Metric** | **LoS/NLoS** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| Normalized traffic channel link data rate (bit/s/Hz) | **LoS** | 1.120 | 1.280 - 4.580 | 2.260 | 2.210 | 2.190 | 2.350 |
| **NLoS** | 1.120 | 1.280 - 4.580 | 1.907 | 1.950 | 1.890 | 2.060 |

Table 11.2.14.6. Evaluation Result of Dense Urban – eMBB (Configuration A, 30km/h) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Dense Urban** | | **Channel Model B - Configuration A (4GHz) – NR RIT** | | | | | |
| **Metric** | **LoS/NLoS** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| Normalized traffic channel link data rate (bit/s/Hz) | **LoS** | 1.120 | 1.280 - 4.580 | 2.2104 | 2.060 | 1.620 | **X** |
| **NLoS** | 1.120 | 1.280 - 4.580 | 2.1461 | 1.790 | 1.830 | **X** |

Table 11.2.14.7. Evaluation Result of Dense Urban – eMBB (Configuration B, 30km/h) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Dense Urban** | | **Channel Model B - Configuration B (30GHz) – NR RIT** | | | | | |
| **Metric** | **LoS/NLoS** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| Normalized traffic channel link data rate (bit/s/Hz) | **LoS** | 1.120 | 1.280 - 4.580 | 2.242 | … | **X** | **X** |
| **NLoS** | 1.120 | 1.230 – 3.220 | 1.890 | 1.180 | **X** | 1.240 |

Table 11.2.14.8. Evaluation Result of Dense Urban – eMBB (Configuration B, 30km/h) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Dense Urban** | | **Channel Model B - Configuration B (30GHz) – NR RIT** | | | | | |
| **Metric** | **LoS/NLoS** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| Normalized traffic channel link data rate (bit/s/Hz) | **LoS** | 1.120 | 1.230 – 3.220 | 1.751 | … | **X** | **X** |
| **NLoS** | 1.120 | 1.230 – 3.220 | 1.662 | … | **X** | **X** |

Table 11.2.14.9. Evaluation Result of Rural Urban – eMBB (Configuration A, 120km/h) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration A (700MHz) – NR RIT** | | | | | |
| **Metric** | **LoS/NLoS** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| Normalized traffic channel link data rate (bit/s/Hz) | **LoS** | 0.800 | 0.850 – 2.910 | 2.660 | 2.570 | 2.900 | **X** |
| **NLoS** | 0.800 | 0.850 – 2.910 | 2.545 | 2.130 | 2.320 | **X** |

Table 11.2.14.10. Evaluation Result of Rural Urban – eMBB (Configuration A, 120km/h) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration A (700MHz) – NR RIT** | | | | | |
| **Metric** | **LoS/NLoS** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| Normalized traffic channel link data rate (bit/s/Hz) | **LoS** | 0.800 | 0.850 – 2.910 | 2.308 | 2.180 | 2.630 | **X** |
| **NLoS** | 0.800 | 0.850 – 2.910 | 2.191 | 1.920 | 2.100 | **X** |

Table 11.2.14.11. Evaluation Result of Rural Urban – eMBB (Configuration B, 120km/h) - FDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration B (4GHz) – NR RIT** | | | | | |
| **Metric** | **LoS/NLoS** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| Normalized traffic channel link data rate (bit/s/Hz) | **LoS** | 0.800 | 1.020 – 2.750 | 2.537 | 2.620 | 2.900 | **X** |
| **NLoS** | 0.800 | 1.020 – 2.750 | 2.376 | 2.150 | 2.310 | **X** |

Table 11.2.14.12. Evaluation Result of Rural Urban – eMBB (Configuration B, 120km/h) - TDD

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **eMBB – Rural** | | **Channel Model B - Configuration B (4GHz) – NR RIT** | | | | | |
| **Metric** | **LoS/NLoS** | **M.2410** | **Min-Max** | **INRS** | **UofT** | **Huawei** | **CATT** |
| Normalized traffic channel link data rate (bit/s/Hz) | **LoS** | 0.800 | 1.020 – 2.750 | 2.451 | 2.140 | 2.630 | **X** |
| **NLoS** | 0.800 | 1.020 – 2.750 | 1.935 | 1.940 | 2.090 | **X** |

## 11.3 TSDSI RIT

## 11.4 Nufront RIT

## 11.5 ETSI/DECT Forum SRIT

# F) Questions and feedback to WP 5D and/or the proponents or other IEGs;

# 12. Questions and feedback

# G) In the interim report, kindly provide the proposed next steps towards the final report to be sent to WP 5D for the February 2020 meeting.

# 13. Next steps towards the final report

Part III

Conclusion

# 14 Overall conclusion

## 14.1 3GPP SRIT

## 14.2 3GPP RIT

## 14.3 TSDSI RIT

## 14.4 Nufront RIT

## 14.5 ETSI/DECT Forum SRIT

## Annex

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1. \* Submitted on behalf of the Canadian Evaluation Group (CEG) [↑](#footnote-ref-1)