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| **Radiocommunication Study Groups** |  |
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| Received: 3 December 2019 | **Document 5D/28-E** |
| **4 December 2019** |
| **English only**  **TECHNOLOGY ASPECTS** |
| Director, Radiocommunication Bureau[[1]](#footnote-1)\* | |
| INTERIM Evaluation Report on the Candidate Proposals for IMT-2020 submitted to WP 5D  Report with Provisional Results[[2]](#footnote-2)\*\* | |
|  | |

Note: This interim evaluation report follows the structure suggested in Document [5D/TEMP/769(Rev1)](https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Documents/5D_TD_769Rev1e_LS_IEGs.docx).

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 Recommendation ITU-ITU-R 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](https://www.itu.int/md/R00-SG05-CIR-0002/en)). For details refer to Document [5D/781](https://www.itu.int/md/R15-WP5D-C-0781/en) (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) |

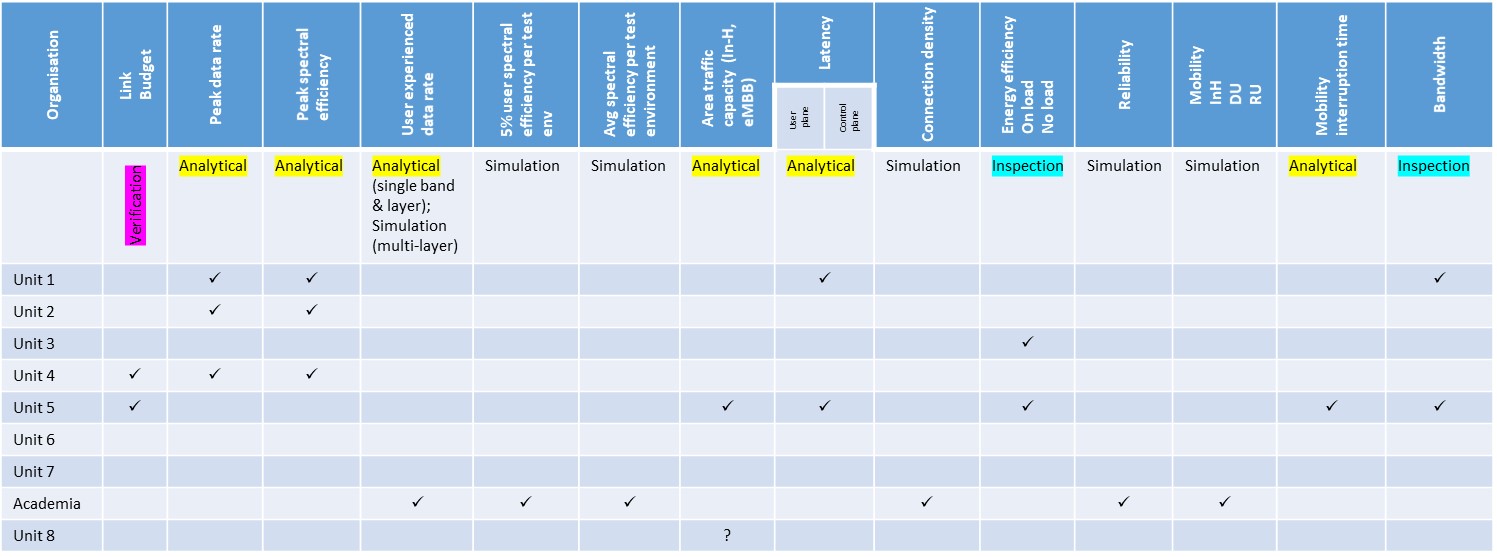
## 6.3 CEG Members

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

Table 6.3.1

Matrix of Responsibilities

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/)) | 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;

# 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.

# 9 Identify areas requiring clarifications

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 (“uploaded” question sent to TSDSI proponent and their response to the [Evaluation Groups Discussion Area](https://extranet.itu.int/itu-r/imt2020-evalgroup/SitePages/Home.aspx?RootFolder=%2Fitu%2Dr%2Fimt2020%2Devalgroup%2FLists%2FComments%2FClarification%20request%20and%20response%20from%20TSDSI%20proponent%20on%20link%2Dbudget%20CEG%2019Oct19&FolderCTID=0x012002008CFD5FDD9B14EE47987B1CC61E92434A&View=%7b55CE2E3D-3BA8-4AC1-B42B-0787393E9FDE%7d)).

# 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 7.1.

## 11.1 3GPP SRIT

Parameters evaluated via Inspection

### 11.1.1 Bandwidth

11.1.1.1 Conclusion: The CEG concluded that bandwidth and scalability requirements are met by the NR and LTE component RITs in the submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003).

11.1.1.2 Verification: Based on the submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003), the CEG considered the following two component RITs for inspection: NR and LTE.

##### 11.1.1.2.1 NR bandwidth requirement capabilities

The capability of bandwidth and bandwidth scalability for NR:

There are two frequency ranges which are supported – FR1 (410-7125 MHz) and FR2 (24.25‑52.6 GHz). Within each of these ranges, different sub-carrier spacings (SCS) or “numerologies” exist – these are shown in Table 11.1.1.2.1-1. Corresponding to each SCS/numerology, the maximum bandwidth for a single component carrier is also shown in the same table. It is possible to aggregate up to 16 component carriers leading to the maximum bandwidths shown in the last column of the table.

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 – 7 125 MHz) | 15 | 50 | 16 | 800 |
| 30 | 100 | 16 | 1 600 |
| 60 | 100 | 16 | 1600 |
| FR2  (24 250 MHz – 52 600 MHz) | 60 | 200 | 16 | 3 200 |
| 120 | 400 | 16 | 6 400 |

And then the following transmission bandwidth configurations i.e. number of (physical) resource blocks per transmission bandwidth which are supported for each case (see Tables 11.1.1.2.1-2 and 11.1.1.2.1-3).

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 11.1.1.2.1-3

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 |

In terms of scalability, the minimum and maximum channel bandwidths and the maximum scalability per component carrier are illustrated in Table 11.1.1.2.1-4.

Table 11.1.1.2.1-4

Bandwidth scalability of 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 |

It is observed that up to 13 different bandwidths are supported for FR1, and up to 4 for FR2. **Therefore, bandwidth scalability is fulfilled by NR component RIT.**

##### 11.1.1.2.2 LTE component RIT bandwidth requirement capabilities

According to Section 8.1.2 of the self-evaluation report in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003), the maximum bandwidth of a component carrier is 20 MHz for LTE. Besides, according to the same section of this self-evaluation report, carrier aggregation of up to thirty-two component carriers is supported by LTE component RIT.

**Consequently, LTE component RIT can attain a maximum aggregated system bandwidth of 640 MHz, which exceeds the requirement set by the ITU (of at least 100 MHz).**

Table 11.1.1.2.2-1

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

11.1.2.1 Conclusion:The CEG concluded that energy efficiency requirements are met by the NR and LTE component RITs in the submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003).

11.1.2.2 Verification: Based on the submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003), for this evaluation by inspection, the following two component RITs were considered: NR and LTE.

For both component RITs the “no data” scenarios were analyzed, since the “loaded” scenario is quantified by spectrum efficiency. In other words, neither the BS nor the UE are exchanging user-plane data.

##### 11.1.2.2.1 NR component RIT energy efficiency

###### 11.1.2.2.1.1 NR component RIT network side

Based on the definition of sleep time requirement for the network (as shown in Report [ITU-R M.2410](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2410-2017-MSW-E.docx)), the following sleep mode ratio equations were proposed in the submission documents:





where  indicates the ceiling of *x*,  is the numerology (as defined in the self-evaluation Report – Part 4 – Document in [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003), 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 has verified that the NR network can achieve high sleep ratios in the “unloaded” case (see Tables 11.1.2.2.1.1-1 and 11.1.2.2.1.1-2).

Table 11.1.2.2.1.1-1

NR component RIT network sleep ratio at slot level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SSB configuration | | SSB set periodicity *P*SSB | | | | | |
| SCS [kHz] | Number of SS/PBCH block per SSB set, *L* | 5 msec | 10 msec | 20 msec | 40 msec | 80 msec | 160 msec |
| 15 kHz | 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% |
| 30 kHz | 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% |
| 120 kHz | 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% |
| 240 kHz | 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 11.1.2.2.1.1-2

NR component RIT network sleep ratio at symbol level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SSB configuration | | SSB set periodicity *P*SSB | | | | | |
| SCS [kHz] | Number of SS/PBCH block per SSB set, *L* | 5 msec | 10 msec | 20 msec | 40 msec | 80 msec | 160 msec |
| 15 kHz | 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% |
| 30 kHz | 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% |
| 120 kHz | 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% |
| 240 kHz | 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 times can be achieved by NR component RIT network for different SSB periodicities:

Based on the above mechanisms, evaluation results of sleep duration are provided in Table 11.1.2.2.1.1.3. It is observed that with SSB set period of 160msec, more than 150 msec sleep duration can be obtained by NR component RIT network. Therefore, the NR component RIT network can achieve long sleep durations in the unloaded case.

The CEG concludes that NR component RIT meets the network side energy efficiency requirement.

Table 11.1.2.2.1.1-3

NR component RIT network sleep duration (msec) at slot level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SSB configuration | | SSB set periodicity *P*SSB | | | | | |
| SCS [kHz] | Number of SS/PBCH block per SSB set, *L* | 5 msec | 10 msec | 20 msec | 40 msec | 80 msec | 160 msec |
| 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 component RIT UE side

The sleep ratio and sleep duration for NR component RIT UE corresponding to the “unloaded” case are evaluated.

For NR, DRX is supported by the UE in the idle, inactive and connected states.

The DRX cycle for an idle/inactive UE consists of an “On Duration” state during which the UE performs SSB monitoring, paging monitoring and RRM measurement, and an “Off Duration” state during which it 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 of multiple slots. The Paging Frame is no longer than a single SSB burst.

– RRM measurement which is based on SS/PBCH and is assumed to be 3.5 msec.

The transition time for switching ‘ON’ or ‘OFF’ the internal components of the UE is assumed to be 10 msec.

Based on these assumptions, the NR UE can be in sleep mode more than 90% of the time for any DRX cycle in the idle/inactive state (see Tables 11.1.2.2.1.2-1 and 11.1.2.2.1.2-2).

Table 11.1.2.2.1.2-1

NR component RIT UE sleep ratio at slot level (for idle/inactive mode)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Paging cycle *N*PC\_RF \*10 (msec) | SCS (kHz) | SSB L | SSB reception time (msec) | SSB cycle (msec) | Number of SSB burst set | RRM measurement time per DRX (msec) | Transition time (msec) | 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, the sleep mode is more than 84%, assuming an “ON Duration” and other similar parameters.

Table 11.1.2.2.1.2-2

NR component RIT UE sleep ratio at slot level (for connected mode)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | DRX cycle *T*SC\_msec \* *M*SC (msec) | Number of SSB burst set | DRX-onDurationTimer (msec) | RRM measurement time per DRX (msec) | Transition time (msec) | 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 component RIT energy efficiency

###### 11.1.2.2.2.1 LTE component RIT network side

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

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 or 1-1/5, which is 80% at the sub-frame level.

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

In conclusion, in milliseconds, the CEG found the following results (see Table 11.1.2.2.2.1-1):

Table 11.1.2.2.2.1-1

LTE component RIT network sleep duration (msec) at subframe level

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

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

###### 11.1.2.2.2.2 LTE component RIT UE side

For LTE, DRX is supported by the 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 occasions, defined in terms of paging-frame and sub-frame within a period of *N*PC\_RF radio frames, which in turn, is defined by the DRX cycle (paging cycle) of the cell and performs RRM measurement. The UE can remain in sleep mode for the remainder of the DRX cycle.

With assumptions similar to the NR case and using the LTE-specific DRX cycles, the CEG found the following results for idle mode (see Tables 11.1.2.2.2.2-1 and 11.1.2.2.2.2-2):

Table 11.1.2.2.2.2-1

LTE component RIT UE sleep ratio at subframe level (for idle mode)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Paging cycle *N*PC\_RF \*10 (msec) | Synchronization reception time per cycle (msec) | Synchronization cycle (msec) | Number of synchronization | RRM measurement time per DRX (msec) | Transition time (msec) | 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 (without data transmission).

Table 11.1.2.2.2.2-2

LTE component RIT UE sleep ratio at subframe level (for connected mode)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | DRX cycle *T*CYCLE\_SF (msec) | Synchronization reception time (msec) | Synchronization cycle (msec) | Number of synchronization | PDCCH reception time (msec) | RRM measurement time per DRX (msec) | 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% |

**The CEG concludes that in both idle and connected states, the LTE component RIT** **UE can achieve a very high percentage of sleep ratio at the sub-frame level.**

Parameters evaluated via Analysis

### 11.1.3 Peak data rate

11.1.3.1 Conclusion:The CEG concluded that peak data rate requirements are met by the submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003).

11.1.3.2 Verification: Both component RITs, NR and LTE, are considered in the analysis of this technical requirement:

Spectral efficiency is an essential parameter for evaluation of radio access technologies. It provides insights into expected data rates for a given amount of spectrum, and at the same time it is used to compare different radio access technologies (e.g., IMT-2000 vs. IMT-Advanced vs. IMT-2020 comparison). Early mobile technologies had a very low peak spectral efficiency (e.g. early GSM systems were providing speeds of the order of 10 kbps, or spectral efficiency of < 1 bit/s/Hz), while later technologies such as IMT-2020 have very high target spectral efficiency and data rates, as summarized below:

Table 11.1.3 -1

Target peak spectral efficiency and peak data rates (as per Report [ITU-R M.2410](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2410-2017-MSW-E.docx))

|  |  |  |
| --- | --- | --- |
|  | Peak Spectral Efficiency (bit/s/Hz) | Peak Data Rate (Gbit/s) |
| Downlink | 30 | 20 |
| Uplink | 15 | 10 |

Evidently, by comparing the peak spectral efficiency and peak data rate targets, required bandwidth can be calculated by dividing the two columns in the table above, which results in 667 MHz of the minimal bandwidth needed both for the DL and UL.

In Annex 1, the calculations of the peak spectral efficiencies for the two different frequency ranges FR1 (410 MHz – 7 125 MHz) and FR2 (24 250 MHz – 52 600 MHz) are shown in detail; a brief explanation of the detailed calculations is presented in the following two paragraphs.

#### 11.1.3.3 NR calculations

Depending on parameters such as channel bandwidth and spacing of subcarriers, it has been shown that the DL spectral efficiency ranges between 37.66 bits/s/Hz and 46.74 bits/s/Hz in the FR1 portion of the spectrum, which is well above the target spectral efficiency of 30 bits/s/Hz. Similarly, the UL spectral efficiency varies between 20.14 bits/s/Hz and 25 bits/s/Hz, also well above the target of 15 bits/s/Hz. In any of the calculated scenarios, there is enough room for higher overheads that may be needed (compared to overheads used in theoretical calculation). In addition to spectral efficiency, peak data rates per single carrier have been calculated and it has been shown that up to 4.67 Gbits/s can be achieved using a single 100 MHz carrier. Therefore, by combining 5 carriers (500 MHz), it is possible to achieve target of 20 Gbits/s.

For the FR2 range, spectral efficiencies are also above the ITU-R targets, even though there is less room for overhead increase when 64QAM is considered (as opposed to 256 QAM). In terms of peak data rates, even with 64QAM, a peak data rate of 10.85 Gbits/s is achievable with a single 400 MHz carrier. Therefore, only 2 carriers are needed to achieve the ITU-R target of 20 Gbits/s.

A more realistic use case is to combine FR1 and FR2 frequencies via carrier aggregation, but since the proponent’s specifications allow up to 16 carriers to be aggregated, target peak data rates of 20 Gbits/s on the DL and 10 Gbits/s on the UL should be easily achieved.

#### 11.1.3.4 LTE calculations

Using the transport block sizes specified in the self-evaluation section of Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003), a peak spectral efficiency of around 50 bits/s/Hz is calculated for LTE and a peak data rate of 1 Gbits/s per single 20 MHz channel. Given that LTE allows up to 32 component carriers in carrier aggregation, the peak DL data rate can be as high as 32 Gbits/s assuming 20 MHz channels.

**In conclusion, the peak data rate values computed in Annex 1 and explained in this section, for both NR and LTE component RITs, fulfil the ITU targets for these technical performance requirements.**

### 11.1.4 Peak spectral efficiency

11.1.4.1 Conclusion:The CEG concluded that peak spectral efficiency requirements are met by the submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003).

11.1.4.2 Verification: Both component RITs, NR and LTE, are considered in the analysis of this technical requirement, which is carried out in section 11.1.3 above, with full details in Annex 1.

**In conclusion, the peak spectral efficiency values computed in Annex 1 and explained in Section 11.1.3, for both NR and LTE component RITs, fulfil the ITU targets for these technical performance requirements.**

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

### 11.1.6 Area traffic capacity (InH, eMBB)

11.1.6.1 Conclusion: The CEG concluded that the SRIT area traffic capacity requirement is met by the submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003).

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 Mbit/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 area of 120 m × 50 m and 12 BSs/site. The BSs are placed at 20 m spacing as shown in Fig. 1, with a LOS probability as defined by channel model in Annex 1, Table A1-9 of Report [ITU-R M.2412](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2412-2017-MSW-E.docx). In the figure, internal walls are not explicitly shown but are modelled via the stochastic LOS probability model.

The type of site deployed (e.g. 1 TRxP per site or 3 TRxPs per site) is not defined and should be reported by the proponent.

Figure 1

Indoor Hotspot sites layout



If 12 TRxPs are assumed in the above scenario, then can be computed as follows:

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

For FDD with DL, 32 x 4 MU-MIMO Type II Codebook and SCS = 15 KHz, the average spectrum efficiency can be derived as:

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

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

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

Channel Model A

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

Channel Model B

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

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

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

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

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

So, for an aggregated bandwidth of 360 MHz:

Channel Model A

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

Channel Model B

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

Observation 2: For a TDD configuration, the SRIT 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

11.1.8.1 Conclusion: The CEG concluded that the SRIT submission in Document [IMT‑2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003) is compliant with the ITU requirement of 0msec as specified by Report [ITU‑R M.2410](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2410-2017-MSW-E.docx).

11.1.8.2 Verification: Details of the analysis. The following scenarios were considered based on the submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003).

NR mobility scenarios:

– Beam mobility

– CA (Carrier Aggregation) mobility

LTE mobility scenarios:

– PCell (Primary Cell) mobility

– DC (Dual Connectivity) mobility

##### 11.1.8.2.1 NR component RIT Beam mobility

One of the new features of NR is the specification of beam management. While moving into a “new” 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 remaining beams, just their differences from 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 RS. This 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 signalling 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 signalling, the network can indicate a specific TCI state.

In some situations, the PDSCH beam indication can be performed using two 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-co-located transmissions with the PDCCH.

Observation 1: The above described mechanism is sufficiently flexible and allows the g-Node B (gNB) to schedule DL data on multiple beams on different slots.

A similar procedure is available for the UL, where PUSCH is sent using an SRS resource indicator (SRI) configured by the gNB. Thus, the 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 the gNB during mobility transitions. Therefore, 0msec mobility interruption time can be achieved by NR component RIT for this scenario*.***

##### 11.1.8.2.2 NR component RIT Carrier Aggregation mobility

When moving within the same PCell and CA enabled, the set of configured Secondary Cells (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, 0msec mobility interruption time is achieved by NR in this case.

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

### 11.1.9 Link Budget Analysis

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. As part of the CEG study, the calculations provided by the proponent in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003) have been verified to determine whether the IMT-2020 targets would be met by their technology submission.

Inspection of the link-budget tables provided by the Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003) proponent 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 in Reports [ITU-R M.2411](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2411-2017-PDF-E.pdf) and [ITU-R M.2412](https://www.itu.int/pub/R-REP-M.2412-2017).

Focus of the verification efforts was centred on deriving the shadow fading margins, penetration margins and data-rate to signal-to-interference ratio (SINR) mapping as these values have been used in the tables without providing sufficient details. For both considered channel models (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 the Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003) proponent. Furthermore, in the instances where a small difference was observed, the proponent 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 the ***Q-function*** is the tail distribution function of the standard normal distribution and:

In all eMBB and URLLC deployment scenarios, cell coverage probabilities of 90% and 95% were 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 probability functional points along with the pathloss equations for channel models A and B, the SFM was derived as a function of the pathloss exponent.

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 the NLOS cases of eMBB and URLLC:

*a =*

*b =*

and for the 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 is determined by the applicable pathloss equations found in Report [ITU‑R M.2412](https://www.itu.int/pub/R-REP-M.2412-2017) along with the rest of the shadow fading margins σ used for each specific scenario.

The summary of the results for SFM values is presented in the following tables for each channel model. They all fall well within the values of the self-evaluation template in Document [IMT‑2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003). Note that for the sake of brevity, the proponent is referred to as “3GPP” in the following tables.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | SFM eMBB – Channel Model A | | | | | | | | | |
| Scenario | InH (4 GHz) | | DU (4 GHz) | | | | Rural (700 MHz) | | | |
| Results from: | **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 (4 GHz) | | DU (4 GHz) | | | | Rural (700 MHz) | | | |
| Results from: | **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 A | | | | | Scenario | UMa (700 MHz) | | | | | Results from: | **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 URLLC - Channel Model B | | | | | Scenario | UMa (700 MHz) | | | | | Results from: | **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 mMTC – Channel Model A | | | | | | | | | | | |
| Scenario | UMa NB-IoT (700 MHz) | | | | | | UMa eMTC (700 MHz) | | | | | |
| Results from: | **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 (700 MHz) | | | | | | UMa eMTC (700 MHz) | | | | | |
| Results from: | **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 Report [ITU-R M.2412](https://www.itu.int/pub/R-REP-M.2412-2017) for both channel models A and B. Note that the car penetration portion utilized a study conducted on LTE mobiles mounted on various car models that verified the agreed values for NLOS eMBB scenarios.

Also, for mMTC scenarios, the high-loss equations for building penetration 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 against the values in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003). All differences are within a 1 dB range. Again note that the proponent is referred to as “3GPP” for the sake of brevity in the following tables.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Penetration margin eMBB – Channel Model A | | | | | | | | | |
| Scenario | InH (4 GHz) | | DU (4 GHz) | | | | Rural (700 MHz) | | | |
| Results from: | **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 (4 GHz) | | DU (4 GHz) | | | | Rural (700 MHz) | | | |
| Results from: | **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 (700 MHz) | | | | | Results from: | **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 (700 MHz) | | | | | Results from: | **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 (700 MHz) | | | | | | UMa eMTC (700 MHz) | | | | | |
| Results from: | **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 (700 MHz) | | | | | | UMa eMTC (700 MHz) | | | | | |
| Results from: | **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 the proponent’s self-evaluation templates and computing the equivalent channel overhead for each specified bandwidth. The number of antennas and all other RF characteristics were maintained to provide a correct verification of the proposed results.

The simulations verified that all suggested SNR values in the proponent’s 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, 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

11.2.1.1Conclusion: The CEG concluded that bandwidth and scalability requirements are met by the NR RIT submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003).

11.2.1.2 Verification: Based on the submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003), the CEG evaluated the bandwidth capabilities of the NR RIT.

##### **11.2.1.2.1** NR RIT bandwidth requirements capabilities

The capability of bandwidth and bandwidth scalability for NR RIT:

There are two frequency ranges which are supported – FR1 (410-7125 MHz) and FR2 (24.25‑52.6 GHz), along with their associated SCS or numerologies. Up to 16 component carriers can be aggregated.

According to the self-evaluation report in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003), the following channel bandwidths and maximum aggregation bandwidths are supported (see Table 11.2.1.2.1):

Table 11.2.1.2-1

NR 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  (410 MHz – 7 125 MHz) | 15 | 50 | 16 | 800 |
| 30 | 100 | 16 | 1600 |
| 60 | 100 | 16 | 1600 |
| FR2  (24 250 MHz – 52 600 MHz) | 60 | 200 | 16 | 3200 |
| 120 | 400 | 16 | 6400 |

And then the following transmission bandwidths configurations are supported for each case (see Tables 11.2.1.2.2 and 11.2.1.2.3).

Table 11.2.1.2-2

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 11.2.1.2-3

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 |

In terms of scalability, the minimum and maximum channel bandwidths and the maximum scalability per component carrier are illustrated in Table 11.2.1.2.4.

Table 11.2.1.2-4

Bandwidth scalability of NR RIT

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 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 |

It is observed that up to 13 different bandwidths are supported for FR1, and up to 4 for FR2. **Therefore, bandwidth scalability capability is fulfilled by the NR RIT.**

### 11.2.2 Energy efficiency of NR RIT

11.2.2.1 Conclusion:CEG concluded that energy efficiency requirements are met by the NR RIT submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003).

11.2.2.2 Verification: The CEG carried out the inspection for this requirement for both the network and the UE.

##### 11.2.2.2.1 NR RIT network side

Based on the definition of network sleep time (as in the requirement Report ITU-R [M.2410](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2410-2017-MSW-E.docx)), the following sleep mode ratio equations were proposed in the submission documents:





where  indicates the ceiling of *x*, *µ* is the numerology (as defined in the self-evaluation report – Part 4 – in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003), e.g., *µ* =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 side can achieve a high sleep ratio in the unloaded case (see Tables 11.2.2.2.1-1 and 11.2.2.2.1-2).

Table 11.2.2.2.1-1

NR RIT network sleep ratio at slot level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SSB configuration | | SSB set periodicity *P*SSB | | | | | |
| SCS [kHz] | Number of SS/PBCH block per SSB set, *L* | 5 msec | 10 msec | 20 msec | 40 msec | 80 msec | 160 msec |
| 15 kHz | 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% |
| 30 kHz | 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% |
| 120 kHz | 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% |
| 240 kHz | 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 11.2.2.2.1-2

NR RIT network sleep ratio at symbol level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SSB configuration | | SSB set periodicity *P*SSB | | | | | |
| SCS [kHz] | Number of SS/PBCH block per SSB set, *L* | 5 msec | 10 msec | 20 msec | 40 msec | 80 msec | 160 msec |
| 15 kHz | 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% |
| 30 kHz | 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% |
| 120 kHz | 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% |
| 240 kHz | 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 sleep times that can be achieved by NR RIT network on different SSB periodicities, based on the above mechanisms, are provided in Table 11.2.2.2.1-3. It is observed that with a set period of SSB of 160 msec, more than 150 msec sleep duration can be obtained by NR RIT network. **Therefore, NR RIT network can achieve long sleep duration in the unloaded case and meets the network side energy efficiency requirement.**

Table 11.2.2.2.1-3

NR RIT network sleep duration (msec) at slot level

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SSB configuration | | SSB set periodicity *P*SSB | | | | | |
| SCS [kHz] | Number of SS/PBCH block per SSB set, *L* | 5 msec | 10 msec | 20 msec | 40 msec | 80 msec | 160 msec |
| 15 kHz | 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 |
| 30 kHz | 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 |
| 120 kHz | 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 |
| 240 kHz | 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 |

##### 11.2.2.2.2 NR RIT UE side

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 3.5 msec.

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

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

Table 11.2.2.2.2-1

NR RIT UE sleep ratio at slot level (for idle/inactive mode)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Paging cycle *N*PC\_RF \*10 (msec) | SCS(kHz) | SSB L | SSB reception time (msec) | SSB cycle (msec) | Number of SSB burst set | RRM measurement time per DRX (msec) | Transition time (msec) | Sleep ratio |
| RRC-Idle/Inactive | 320 | 240 | 32 | 1 | - | 1 | 3.5 | 10 | 95.5% |
| 2 560 | 15 | 2 | 1 | - | 1 | 3 | 10 | 99.5% |
| 2 560 | 15 | 2 | 1 | 160 | 2 | 3 | 10 | 93.2% |

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

Table 11.2.2.2.2-2

NR RIT UE sleep ratio at slot level (for connected mode)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | DRX cycle *T*SC\_msec \* *M*SC (msec) | Number of SSB burst set | DRX-onDurationTimer (msec) | RRM measurement time per DRX (msec) | Transition time (msec) | Sleep ratio |
| RRC-Connected | 320 | 1 | 2 | 3.5 | 10 | 95.2% |
| 320 | 1 | 10 | 3 | 10 | 92.8% |
| 2 560 | 1 | 100 | 3 | 10 | 95.6% |
| 10 240 | 1 | 1 600 | 3 | 10 | 84.2% |

**The CEG concludes that in both idle and connected states, the NR RIT** **UE can achieve a very high percentage of sleep ratio at the slot level.**

Parameters evaluated via Analysis

### 11.2.3 Peak data rate

11.2.3.1 Conclusion:The CEG concluded that peak data rate requirements are met by the NR RIT submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003).

11.1.3.2 Verification: This analysis has already been provided in Section 11.1.3 of the current report.

**In conclusion, the peak data rate values computed and explained in Section 11.1.3 apply to NR RIT, which is considered to have fulfilled the ITU technical performance requirements.**

### 11.2.4 Peak spectral efficiency

11.2.4.1 Conclusion:The CEG concluded that peak spectral efficiency requirements are met by the NR RIT submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003).

11.1.4.2 Verification: This analysis has already been provided in Section 11.1.4 of the current report.

**In conclusion, the peak spectral efficiency values computed and explained in Section 11.1.4 apply to NR RIT, which is considered to have fulfilled the ITU technical performance requirements.**

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

### 11.2.6 Area traffic capacity (InH, eMBB)

11.2.6.1 Conclusion: TheCEG concluded that the RIT area traffic requirement is met by the submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003).

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 Mbit/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 Figure 1, with a LOS probability as defined by channel model in Annex 1, Table A1-9 of Report [ITU-R M.2412](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2412-2017-MSW-E.docx). In the figure, internal walls are not explicitly shown but are modeled via the stochastic LOS probability model.

The type of site deployed (e.g. 1 TRxP per site or 3 TRxPs per site) is not defined and should be reported by the proponent.

Figure 1

Indoor Hotspot sites layout



If 12 TRxP are assumed in the above scenario, then can be computed as follows:

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

For FDD with DL with 32x4 MU-MIMO Type II Codebook, and SCS = 15 KHz the average spectrum efficiency may be 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 400 MHz aggregation bandwidth:

Channel Model A

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

Channel Model B

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

Observation 1: For an FDD configuration, the RIT area traffic capacity requirement 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 = 15 KHz and DDDSU frame structure, the average spectrum efficiency may be derived as:

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

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

So, for the above TDD configuration with 360MHz aggregated bandwidth the following area traffic capacities are found:

Channel Model A

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

Channel Model B

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

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

### 11.2.7 Latency (user-plane and control-plane)

### 11.2.8 Mobility interruption time

11.2.8.1 Conclusion: The CEG concluded that the RIT submission in Document [IMT‑2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003) is compliant with the mobility interruption time requirement of 0 msec as specified by Report [ITU‑R M.2410](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2410-2017-MSW-E.docx).

#### 11.2.8.2 Verification

Details of the analysis

The following scenarios were considered based on the submission in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003).

NR mobility scenarios:

Beam mobility

CA (Carrier Aggregation) mobility

##### 11.2.8.2.1 NR RIT Beam mobility

One of the new features of NR RIT 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 remaining beams, just their differences from 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 the gNB to schedule DL data on multiple beams on different slots.

A similar procedure is available for the UL, where PUSCH is sent using an SRS resource indicator (SRI) configured by the gNB. Thus, the 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 the gNB during mobility transitions. Therefore, 0msec mobility interruption time can be achieved by NR RIT for this scenario.**

##### 11.2.8.2.2 NR Carrier Aggregation mobility

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, 0 msec mobility interruption time is achieved by NR RIT for this case.

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

### 11.2.9 Link Budget Analysis

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. As part of the CEG study, the calculations provided by the proponent in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003) have been verified to determine whether the IMT-2020 targets would be met by their technology submission.

Inspection of the link budget template tables provided by the Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003) proponent 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 in Reports [ITU-R M.2411](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2411-2017-PDF-E.pdf) and [ITU-R M.2412](https://www.itu.int/pub/R-REP-M.2412-2017).

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 (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 the Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003). Furthermore, in the instances where a small difference was observed, the proponent 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 the ***Q-function*** is the tail distribution function of the standard normal distribution and:

In all eMBB and URLLC deployment scenarios, the cell coverage probabilities of 90% and 95% were 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 probability functional points along with the pathloss equations for channel models A and B, the SFM was derived as a function of the pathloss exponent.

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 is determined by the applicable pathloss equations found in Report [ITU‑R M.2412](https://www.itu.int/pub/R-REP-M.2412-2017) along with the rest of the shadow fading margins σ used 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 of the self-evaluation template in Document [IMT‑2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003). Note that for the sake of brevity, the proponent is referred to as “3GPP” in the following tables.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | SFM eMBB - Channel Model A | | | | | | | | | |
| Scenario | InH (4 GHz) | | DU (4 GHz) | | | | Rural (700 MHz) | | | |
| Results from: | **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 (4 GHz) | | DU (4 GHz) | | | | Rural (700 MHz) | | | |
| Results from: | **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 A | | | | | Scenario | UMa (700 MHz) | | | | | 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 URLLC – Channel Model B | | | | | Scenario | UMa (700 MHz) | | | | | 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 mMTC - zChannel Model A | | | | | | | | | | | |
| Scenario | UMa NB-IoT (700MHz) | | | | | | UMa eMTC (700MHz) | | | | | |
| Results from: | **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 from: | **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 Report [ITU-R M.2412](https://www.itu.int/pub/R-REP-M.2412-2017) for both channel models A and B. Note that the car penetration portion utilized a study conducted on LTE mobiles mounted on various car models that verified the agreed values for NLOS eMBB scenarios.

Also, for mMTC scenarios the high-loss equations for building penetration 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 against the values in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003). All differences are within a 1 dB range. Again note that the proponent is referred to as “3GPP” for the sake of brevity in the following tables.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Penetration margin eMBB - Channel Model A | | | | | | | | | |
| Scenario | InH (4GHz) | | DU (4GHz) | | | | Rural (700MHz) | | | |
| Results from: | **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 from: | **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 from: | **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 from: | **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 from: | **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 from: | **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 the proponent’s 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 proponent’s 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, 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 | INRS | UofT |
| 5% USE [bit/s/Hz] | DL | 0.300 | 0.331 | 0.359 |
| UL | 0.210 | … | … |

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 | INRS | UofT |
| 5% USE [bit/s/Hz] | DL | 0.300 | 0.416 | 0.381 |
| UL | 0.210 | … | … |

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 | INRS | UofT |
| 5% USE [bit/s/Hz] | DL | 0.300 | … | … |
| UL | 0.210 | … | … |

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 | INRS | UofT |
| 5% USE[bit/s/Hz] | DL | 0.300 | 0.610 | 0.324 |
| UL | 0.210 | … | … |

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 | INRS | UofT |
| 5% USE [bit/s/Hz] | DL | 0.225 | 0.248 | 0.380 |
| UL | 0.150 | 0.273 | 0.228 |

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 | INRS | UofT |
| 5% USE [bit/s/Hz] | DL | 0.225 | 0.328 | 0.430 |
| UL | 0.150 | 0.274 | 0.213 |

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 | INRS | UofT |
| 5% USE [bit/s/Hz] | DL | 0.225 | 0.490 | 0.350 |
| UL | 0.150 | 0.244 | 0.264 |

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 | INRS | UofT |
| 5% USE [bit/s/Hz] | DL | 0.225 | 0.494 | 0.370 |
| UL | 0.150 | 0.245 | 0.291 |

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 | INRS | UofT |
| 5% USE [bit/s/Hz] | DL | 0.120 | 0.174 | 0.162 |
| UL | 0.045 | 0.617 | 0.248 |

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 | INRS | UofT |
| 5% USE [bit/s/Hz] | DL | 0.120 | 0.171 | 0.159 |
| UL | 0.045 | 0.334 | 0.193 |

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 | INRS | UofT |
| 5% USE [bit/s/Hz] | DL | 0.120 | 0.278 | 0.187 |
| UL | 0.045 | 0.145 | 0.189 |

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 | INRS | UofT |
| 5% USE [bit/s/Hz] | DL | 0.120 | 0.349 | 0.370 |
| UL | 0.045 | 0.195 | 0.132 |

### 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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 9.000 | 10.750 | 9.812 |
| UL | 6.750 | … | … |

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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 9.000 | 11.095 | 10.109 |
| UL | 6.750 | … | … |

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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 9.000 | … | … |
| UL | 6.750 | … | … |

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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 9.000 | 17.811 | 10.851 |
| UL | 6.750 | … | … |

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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 7.800 | 11.200 | 11.270 |
| UL | 5.400 | 6.087 | 6.512 |

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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 7.800 | 14.371 | 13.371 |
| UL | 5.400 | 6.099 | 6.462 |

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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 7.800 | 13.752 | 11.360 |
| UL | 5.400 | 6.087 | 6.397 |

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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 7.800 | 13.521 | 13.144 |
| UL | 5.400 | 5.994 | 7.752 |

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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 3.300 | 11.600 | 6.152 |
| UL | 1.600 | 4.349 | 6.951 |

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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 3.300 | 9.609 | 7.490 |
| UL | 1.600 | 3.626 | 5.872 |

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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 3.300 | 13.891 | 6.480 |
| UL | 1.600 | 4.102 | 7.125 |

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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 3.300 | 10.384 | 13.144 |
| UL | 1.600 | 2.907 | 3.361 |

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 | INRS | UofT |
| ASE [bit/s/Hz/TRxP] | DL | 3.300 | 10.521 | … |
| UL | 1.600 | 3.500 | … |

### 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 | INRS | UofT |
| Connection density [device/km^2] | UL | 3.300 | 1.458,509 | 1,518,832 |

### 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 | INRS | UofT |
| Normalized traffic channel link data rate [bit/s/Hz] | LoS | 1.500 | … | … |
| NLoS | 1.500 | … | … |

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 | INRS | UofT |
| Normalized traffic channel link data rate [bit/s/Hz] | LoS | 1.500 | … | … |
| NLoS | 1.500 | … | … |

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 | INRS | UofT |
|
| Normalized traffic channel link data rate [bit/s/Hz] | LoS | 1.500 | … | … |
| NLoS | 1.500 | … | 2.710 |

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 | INRS | UofT |
|
| Normalized traffic channel link data rate [bit/s/Hz] | LoS | 1.500 | … | … |
| NLoS | 1.500 | … | … |

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 | INRS | UofT |
| Normalized traffic channel link data rate [bit/s/Hz] | LoS | 1.120 | 2.260 | 2.210 |
| NLoS | 1.120 | 1.907 | 1.950 |

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 | INRS | UofT |
| Normalized traffic channel link data rate [bit/s/Hz] | LoS | 1.120 | 2.210 | 2.060 |
| NLoS | 1.120 | 2.146 | 1.790 |

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 | INRS | UofT |
| Normalized traffic channel link data rate [bit/s/Hz] | LoS | 1.120 | 2.242 | … |
| NLoS | 1.120 | 1.890 | 1.180 |

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 | INRS | UofT |
| Normalized traffic channel link data rate [bit/s/Hz] | LoS | 1.120 | 1.751 | … |
| NLoS | 1.120 | 1.662 | … |

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 | INRS | UofT |
| Normalized traffic channel link data rate [bit/s/Hz] | LoS | 0.800 | 2.660 | 2.570 |
| NLoS | 0.800 | 2.545 | 2.130 |

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 | INRS | UofT |
| Normalized traffic channel link data rate [bit/s/Hz] | LoS | 0.800 | 2.308 | 2.180 |
| NLoS | 0.800 | 2.191 | 1.920 |

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 | INRS | UofT |
| Normalized traffic channel link data rate [bit/s/Hz] | LoS | 0.800 | 2.537 | 2.620 |
| NLoS | 0.800 | 2.376 | 2.150 |

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 | INRS | UofT |
| Normalized traffic channel link data rate [bit/s/Hz] | LoS | 0.800 | 2.451 | 2.140 |
| NLoS | 0.800 | 1.935 | 1.940 |

## 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

The CEG is on track to present its final report at the 34th meeting of WP 5D (19-26 February 2020).

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 1

IMT-2020  
EVALUATION

Peak Data Rate and Peak Spectral Efficiency Evaluations for NR

Document for discussion and acceptance

CEG Meeting

September 12th**,** 2019

# 1 Peak Spectral Efficiency and Peak Data Rate

As specified in Report [ITU-R M.2410](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2410-2017-MSW-E.docx), the minimum requirements for peak spectral efficiencies for the purpose of evaluation in the eMBB usage scenario are defined as below:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Antenna Configuration (No. of Spatial Layers) | Peak Spectral Efficiency (bit/s/Hz) | Peak Data Rate (Gbps) |
| Downlink | 8 | 30 | 20 |
| Uplink | 4 | 15 | 10 |

The following outlines the results of the detailed analyses of Peak Spectral Efficiency for both NR and LTE.

## 1.1 NR peak spectral efficiency

For the NR, the generic peak spectral efficiency per carrier component can be calculated using the formula given below:



where:

is the maximum coding rate

and

for the CC:

is the maximum number of MIMO layers

is the highest modulation order

is the scaling factor

is the numerology (as defined in TS 38.211)

is the average OFDM symbol duration in a subframe for numerology , that is, . (Normal cyclic prefix is assumed)

is the maximum RB allocation in bandwidth

with numerology is the UE supported maximum bandwidth in the given band or band combination.

is the overhead and takes the following values (3GPP 38.306) [2]:

– 0.14, for frequency range FR1 for DL

– 0.18, for frequency range FR2 for DL

– 0.08, for frequency range FR1 for UL

– 0.10, for frequency range FR2 for UL

For NR FDD frequency range of FR1 (410 MHz – 7125 MHz) DL peak spectral efficiencies for different channel bandwidths are calculated and presented in Table 2. The detailed assumptions used in the evaluation are provided in Table 1:

Table 1

Assumptions for peak spectral efficiency and peak data rate

|  |  |  |
| --- | --- | --- |
| Parameters | Downlink | Uplink |
|  | 8 | 4 |
|  | 8 | 8 |
|  | 1 | 1 |
|  | 948/1024 | 948/1024 |
|  | FR1: 0,1,2  FR2: 2,3 | FR1: 0,1,2  FR2: 2,3 |
|  | We have used maximum number of RBs for the specific component carrier bandwidth and SCS | We have used maximum number of RBs for the specific component carrier bandwidth and SCS |

Table 2

NR FDD frequency range of FR1 (410 MHz – 7125 MHz) DL peak spectral efficiency (bit/s/Hz)  
8-layer downlink transmission, with 256 QAM modulation,   
and a maximum coding rate of Rmax=0.9258

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS (KHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz | 25 MHz | 30 MHz | 40 MHz | 50 MHz | 60 MHz | 80 MHz | 90 MHz | 100 MHz |
| **15** | 42.80 | 44.51 | 45.08 | 45.37 | 45.54 | 45.65 | 46.23 | 46.23 | n/a | n/a | n/a | n/a |
| **30** | 37.66 | 41.09 | 43.37 | 43.66 | 44.51 | 44.51 | 45.37 | 45.54 | 46.23 | 46.44 | 46.61 | 46.74 |
| **60** | n/a | 37.66 | 41.09 | 41.09 | 42.46 | 43.37 | 43.66 | 44.51 | 45.08 | 45.80 | 46.04 | 46.23 |

For NR FDD frequency range of FR1 (410 MHz – 7125 MHz) UL peak spectral efficiency is calculated and presented in Table 3. The detailed assumptions are presented in Table 1.

Table 3

NR FDD frequency range of FR1 (410 MHz – 7125 MHz) UL peak spectral efficiency (bit/s/Hz)  
4-layer uplink transmission, with 256QAM modulation,   
and a maximum coding rate of Rmax=0.9258

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS (KHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz | 25 MHz | 30 MHz | 40 MHz | 50 MHz | 60 MHz | 80 MHz | 90 MHz | 100 MHz |
| **15** | 22.89 | 23.81 | 24.11 | 24.27 | 24.36 | 24.42 | 24.72 | 24.72 | n/a | n/a | n/a | n/a |
| **30** | 20.14 | 21.98 | 23.20 | 23.35 | 23.81 | 23.81 | 24.27 | 24.36 | 24.72 | 24.84 | 24.93 | 25.00 |
| **60** | n/a | 20.15 | 21.98 | 21.98 | 22.71 | 23.20 | 23.35 | 23.81 | 24.11 | 24.50 | 24.62 | 24.72 |

Similarly, for NR TDD frequency range of FR1 (410 MHz – 7 125 MHz) DL peak spectral efficiency is calculated and presented in Table 4. In TDD, effective bandwidth, which is the operating bandwidth normalized considering the uplink/downlink ratio, needs to be considered. The DL/UL ratio of 4:1 is evaluated.

Table 4

NR TDD frequency range of FR1 (410 MHz – 7 125 MHz) DL peak spectral efficiency (bit/s/Hz)  
8-layer downlink transmission, with 256QAM modulation,  
and a maximum coding rate of 0.9258, DL/UL 4:1

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS (KHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz | 25 MHz | 30 MHz | 40 MHz | 50 MHz | 60 MHz | 80 MHz | 90 MHz | 100 MHz |
| **15** | 42.80 | 44.51 | 45.08 | 45.37 | 45.54 | 45.65 | 46.23 | 46.23 | n/a | n/a | n/a | n/a |
| **30** | 37.66 | 41.09 | 43.37 | 43.66 | 44.51 | 44.51 | 45.37 | 45.54 | 46.23 | 46.44 | 46.61 | 46.74 |
| **60** | n/a | 37.66 | 41.09 | 41.09 | 42.46 | 43.37 | 43.66 | 44.51 | 45.08 | 45.80 | 46.04 | 46.23 |

Further, for NR TDD frequency range of FR1 (410 MHz – 7 125 MHz) UL peak spectral efficiency is calculated and presented in Table 5. The DL/UL ratio of 4:1 is evaluated.

Table 5

NR TDD frequency range of FR1 (410 MHz – 7 125 MHz) UL peak spectral efficiency (bit/s/Hz)  
4-layer uplink transmission, with 256QAM modulation,   
and a maximum coding rate of 0.9258, DL/UL 4:1

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS (KHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz | 25 MHz | 30 MHz | 40 MHz | 50 MHz | 60 MHz | 80 MHz | 90 MHz | 100 MHz |
| **15** | 22.89 | 23.81 | 24.11 | 24.27 | 24.36 | 24.42 | 24.72 | 24.72 | n/a | n/a | n/a | n/a |
| **30** | 20.14 | 21.98 | 23.20 | 23.35 | 23.81 | 23.81 | 24.27 | 24.36 | 24.72 | 24.84 | 24.93 | 25.00 |
| **60** | n/a | 20.15 | 21.98 | 21.98 | 22.71 | 23.20 | 23.35 | 23.81 | 24.11 | 24.50 | 24.62 | 24.72 |

For NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz), UL and DL peak spectral efficiencies are calculated and presented in Tables 6 and 7, respectively. In TDD mode, effective bandwidth, which is the operating bandwidth normalized by the uplink/downlink duty cycle ratio, needs to be considered. Again, the detailed assumptions are presented in Table 1. The DL/UL ratio of 4:1 is evaluated.

Table 6

NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz) DL peak spectral efficiency (bit/s/Hz)  
8-layer downlink transmission, with 256QAM modulation,   
And a maximum coding rate of 0.9258, DL/UL 4:1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (KHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| **60** | 43.20 | 45.20 | 45.20 | n/a |
| **120** | 43.83 | 45.20 | 45.20 | 45.20 |

Table 7

NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz) UL peak spectral efficiency (bit/s/Hz)  
4-layer uplink transmission, with 256QAM modulation,   
and a maximum coding rate of 0.9258, DL/UL 4:1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (KHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| **60** | 23.65 | 23.65 | 23.65 | n/a |
| **120** | 22.93 | 23.65 | 23.65 | 23.65 |

Similar tables (8 and 9) for the FR2 range can be calculated assuming a lower modulation order of 64 QAM.

Table 8

NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz) DL peak spectral efficiency (bit/s/Hz)  
8-layer downlink transmission, with 64QAM modulation,   
and a maximum coding rate of 0.9258, DL/UL 4:1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (KHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| **60** | 32.4 | 33.9 | 33.9 | n/a |
| **120** | 32.9 | 33.9 | 33.9 | 33.9 |

Table 9

NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz) UL peak spectral efficiency (bit/s/Hz)  
4-layer uplink transmission, with 64QAM modulation,   
and a maximum coding rate of 0.9258, DL/UL 4:1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (KHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| **60** | 17.74 | 17.74 | 17.74 | n/a |
| **120** | 17.20 | 17.74 | 17.74 | 17.74 |

Evidently, all the values in the tables 2 to 9 meet the peak spectral efficiency requirements outlined in Report ITU-R M.2410 evaluation criteria. For the 256QAM modulation order, spectral efficiency values exceed the target for instance 30 bits/s/Hz on the DL by a wide margin, thus leaving a significant margin for larger overheads than the values used in the analysis herein (e.g., OH=0.14 on the DL). Even in 64QAM modulation order scenario, which applies to FR2 range only, there is still some room left for a higher overhead both on the DL and UL, but in general, spectral efficiency calculated in tables 8 and 9 meets the ITU-R requirements.

## 1.2 Peak data rate calculation for the NR RIT

In what follows (Tables 10-14), the peak data rate is calculated following the methodology specified in § 4.1 of Report [ITU-R M.2410](https://www.itu.int/pub/R-REP-M.2410-2017), using peak spectral efficiency and maximum assignable channel bandwidth.

Table 10

NR FDD frequency range of FR1 (410 MHz – 7 125 MHz) DL peak data rate (Gbps)  
8-layer downlink transmission, with 256QAM modulation,   
and a maximum coding rate of 0.9258

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS (KHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz | 25 MHz | 30 MHz | 40 MHz | 50 MHz | 60 MHz | 80 MHz | 90 MHz | 100 MHz |
| **15** | 0.214 | 0.445 | 0.676 | 0.907 | 1.14 | 1.37 | 1.85 | 2.31 | n/a | n/a | n/a | n/a |
| **30** | 0.188 | 0.411 | 0.650 | 0.873 | 1.11 | 1.33 | 1.81 | 2.28 | 2.77 | 3.71 | 4.19 | 4.67 |
| **60** | n/a | 0.377 | 0.616 | 0.822 | 1.06 | 1.30 | 1.75 | 2.22 | 2.70 | 3.66 | 4.14 | 4.62 |

Table 11

NR FDD frequency range of FR1 (410 MHz – 7 125 MHz) UL peak data rate (Gbps)  
4-layer uplink transmission, with 256QAM modulation,   
and a maximum coding rate of 0.9258

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS (KHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz | 25 MHz | 30 MHz | 40 MHz | 50 MHz | 60 MHz | 80 MHz | 90 MHz | 100 MHz |
| **15** | 0.114 | 0.238 | 0.362 | 0.485 | 0.609 | 0.733 | 0.989 | 1.23 | n/a | n/a | n/a | n/a |
| **30** | 0.100 | 0.220 | 0.348 | 0.467 | 0.595 | 0.714 | 0.970 | 1.22 | 1.48 | 1.99 | 2.24 | 2.5 |
| **60** | n/a | 0.201 | 0.330 | 0.439 | 0.568 | 0.696 | 0.934 | 1.19 | 1.45 | 1.96 | 1.22 | 2.47 |

Table 12

NR TDD frequency range of FR1 (410 MHz – 7 125 MHz) DL peak data rate (Gbps)  
8-layer downlink transmission, with 256QAM modulation,   
and a maximum coding rate of 0.9258, DL/UL 4:1

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS (KHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz | 25 MHz | 30 MHz | 40 MHz | 50 MHz | 60 MHz | 80 MHz | 90 MHz | 100 MHz |
| **15** | 0.171 | 0.356 | 0.541 | 0.726 | 0.911 | 1.09 | 1.48 | 1.85 | n/a | n/a | n/a | n/a |
| **30** | 0.151 | 0.329 | 0.520 | 0.698 | 0.890 | 1.07 | 1.45 | 1.82 | 2.22 | 2.97 | 3.35 | 3.74 |
| **60** | n/a | 0.301 | 0.493 | 0.657 | 0.849 | 1.04 | 1.40 | 1.78 | 2.16 | 2.93 | 3.31 | 3.70 |

Table 13

NR TDD frequency range of FR1 (410 MHz – 7 125 MHz) UL peak data rate (Gbps)  
4-layer uplink transmission, with 256QAM modulation,   
and a maximum coding rate of 0.9258, DL/UL 4:1

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS (KHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz | 25 MHz | 30 MHz | 40 MHz | 50 MHz | 60 MHz | 80 MHz | 90 MHz | 100 MHz |
| **15** | 0.023 | 0.048 | 0.072 | 0.097 | 0.122 | 0.146 | 0.198 | 0.247 | n/a | n/a | n/a | n/a |
| **30** | 0.020 | 0.044 | 0.069 | 0.093 | 0.119 | 0.143 | 0.194 | 0.243 | 0.297 | 0.397 | 0.449 | 0.500 |
| **60** | n/a | 0.040 | 0.066 | 0.088 | 0.113 | 0.139 | 0.187 | 0.238 | 0.289 | 0.392 | 0.443 | 0.494 |

Table 14

NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz) DL peak data rate (Gbps)  
8-layer downlink transmission, with 256QAM modulation,   
and a maximum coding rate of 0.9258, DL/UL 4:1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (KHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| **60** | 1.81 | 3.61 | 7.23 | n/a |
| **120** | 1.75 | 3.61 | 7.23 | 14.46 |

If 100% transmission is assumed on the downlink instead of the 80% shown in Table 6, the outcome will be as shown in Table 15.

Table 15

NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz) DL peak data rate (Gbps)  
8-layer downlink transmission, with 256QAM modulation,   
and a maximum coding rate of 0.9258, DL only

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (KHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| **60** | 2.26 | 4.52 | 9.04 | n/a |
| **120** | 2.19 | 4.52 | 9.04 | 18.08 |

Considering the possibility of aggregating minimum two FR2 carriers with 400 MHz bandwidth each (800 MHz in total), a peak data rate of almost 36 Gbps is obtained. This would fulfil the minimum requirement of 20 Gbits/s as shown in Table 16.

Table 16

NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz) UL peak data rate (Gbps)  
4-layer uplink transmission, with 256QAM modulation,   
and a maximum coding rate of 0.9258, DL/UL 4:1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (KHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| **60** | 0.236 | 0.473 | 0.946 | n/a |
| **120** | 0.229 | 0.473 | 0.946 | 1.89 |

If 100% transmission is assumed on the uplink instead of the 20% shown in Table 8, the outcome will be as shown in Table 17.

Table 17

NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz) UL peak data rate (Gbps)  
4-layer uplink transmission, with 256QAM modulation,   
and a maximum coding rate of 0.9258, UL only

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (KHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| **60** | 1.18 | 2.36 | 4.73 | n/a |
| **120** | 1.15 | 2.36 | 4.73 | 9.46 |

Following the same methodology, but assuming 64QAM modulation order, the peak speeds in FR2 frequency range are calculated and the values are shown below in Table 18.

Table 18

NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz) DL peak data rate (Gbps)  
8-layer downlink transmission, with 6QAM modulation,   
and a maximum coding rate of 0.9258, DL/UL 4:1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (KHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| **60** | 1.36 | 2.71 | 5.42 | n/a |
| **120** | 1.31 | 2.71 | 5.42 | 10.85 |

If 100% of the transmission occurs on the downlink instead of the 80% shown in Table 6, the outcome is as shown in Table 19.

Table 19

NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz) DL peak data rate (Gbps)  
8-layer downlink transmission, with 64QAM modulation,   
and a maximum coding rate of 0.9258, DL only

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (KHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| **60** | 1.70 | 3.39 | 6.78 | n/a |
| **120** | 1.64 | 3.39 | 6.78 | 13.56 |

Considering the possibility of aggregating at least two FR2 carriers with 400 MHz each (800 MHz in total), a peak data rate of almost 27 Gbits/s is obtained. This would fulfil the minimum requirement of 20 Gbits/s even if 64QAM is used (see Table 20).

Table 20

NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz) UL peak data rate (Gbps)  
4-layer uplink transmission, with 64QAM modulation,  
and a maximum coding rate of 0.9258, DL/UL 4:1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (KHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| **60** | 0.18 | 0.35 | 0.71 | n/a |
| **120** | 0.17 | 0.35 | 0.71 | 1.42 |

If 100% transmission is assumed on the uplink instead of the 20% shown in Table 8, the outcome is as shown in Table 21.

Table 21

NR TDD frequency range of FR2 (24 250 MHz – 52 600 MHz) UL peak data rate (Gbps)  
4-layer uplink transmission, with 256QAM modulation,   
and a maximum coding rate of 0.9258, UL only

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (KHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| **60** | 0.89 | 1.77 | 3.55 | n/a |
| **120** | 0.86 | 1.77 | 3.55 | 7.10 |

## 1.3 LTE peak data rates and spectral efficiencies

In order to evaluate the LTE peak spectral efficiencies for different bandwidths, the peak speeds for the channel bandwidths listed in Table 22 are first calculated.

Table 22

LTE channel bandwidths and associated number of resource blocks

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Channel bandwidths | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| NRB | 25 | 50 | 75 | 100 |

To determine maximally supported peak LTE data rates assuming 8 spatial layers of transmission, the reliance is on the transport block sizes specified in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003) (more specifically, the Document TS 36.213, section 7.1.7 referenced therein).

Assuming 1024QAM on the downlink(Qm=10), and using the number of resource blocks listed in Table 22 (above), maximal transport block sizes for a single spatial (MIMO) layer from the same reference as in the above paragraph are listed below in Table 23.

Table 23

LTE transport block sizes for given channel bandwidths

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Channel bandwidths | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| NRB | 25 | 50 | 75 | 100 |
| TBS | 30576 | 61664 | 93800 | 125808 |

After mapping from one to four layers and accounting for 2 codewords (for 8-layer transmission), the peak data rates and spectral efficiency for the DL components are Table 24.

Table 24

LTE peak data rates and spectral efficiencies in the DL for 1 024QAM

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Channel bandwidths | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| Rpeak (Gbps) | 0.25 | 0.49 | 0.75 | 1.00 |
| SE | 49.78 | 49.12 | 50.05 | 50.26 |

Given that LTE allows up to 32 component carriers in carrier aggregation, the peak DL data rate can be as high as 32 Gbits/s assuming 20 MHz channels. At the same time, the peak spectral efficiency values of around 50 bits/s/Hz leave more than sufficient room for any overhead variation that would account for a mix of MBSFN and non-MBSFN sub-frames for example.

Similarly, for the UL, using the transport block size index of ITBS=34, a 20 MHz channel can have transport block size of 105 528 bits per transmit time interval, which is mapped onto 422 232 bits for a 4-layer UL transmission. This corresponds to about 420 Mb/s of peak data rates for a single 20 MHz channel, or to SEUL = 21 b/s/Hz.

# 2 Conclusion

Observation 1

The Peak Spectral Efficiency values computed in this Annex 1, for both NR and LTE, fulfil the ITU technical performance requirements.

Observation 2

The Peak Data Rate values computed in this Annex 1, for both NR and LTE, fulfil the ITU technical performance requirements.

# 3 References

[1] Report [ITU-R M.2410](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2410-2017-MSW-E.docx), Minimum requirements related to technical performance for IMT-2020 radio interface(s).

[2] Document referred to in Document [IMT-2020/3(Rev.4)](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0003): 3GPP 38.306, NR; User Equipment (UE) radio access capabilities.

Annex 2

This Annex to the CEG report presents the detailed assumptions used to generate the results of parameters that were meant to be evaluated via simulation. They were prepared by INRS – one of the academia partners – and are reproduced here to provide additional context to the results generated by the INRS simulator.

IMT-2020:

INITIAL EVALUATION REPORT (NR)

Document for communication

Update to CEG

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Source: Wireless Lab, EMT Centre, INRS.

# **Abbreviations**

3GPP 3rd Generation Partnership Project

ASE Average Spectral Efficiency

BS Base-station

BW Bandwidth

CP Control-plane or Cyclic Prefix

CSI Channel state information

CSI-RS Channel state information reference signal

DU Dense Urban

DL Downlink

DMRS Demodulation reference signal

eMBB enhanced mobile broadband

FDM Frequency division multiplexing

HARQ Hybrid automatic repeat request

InH Indoor Hotspot

ITU International Telecommunication Union

MIMO multiple-input multiple-output

NR New Radio

OFDM Orthogonal frequency division multiplexing

PDCCH Physical downlink control channel, PDSCH: Physical downlink shared channel

PUCCH Physical uplink control channel; PUSCH: Physical uplink shared channel

RIT Radio-interface technology

SCS Sub-carrier spacing

SINR/SNR Signal-to-interference noise ratio/Signal-to-noise ratio

SCM Stochastic channel model

TRxP Transmission and reception point

UE User equipment

USE User spectral Efficiency

UL Uplink

### A.2.1 Evaluation Assumptions and Configuration

#### A.2.1.1 Indoor Hotspot – eMBB

Table 2.1.1-1

Assumptions and Configuration of Indoor Hotspot-eMBB (Downlink Case)

|  |  |  |
| --- | --- | --- |
| Configuration A - Downlink | | |
|  | ITU-R M.2412 | INRS |
| **Baseline configuration** | | |
| Carrier frequency for evaluation | 4 GHz | 4 GHz |
| BS antenna height | 3 m | 3 m |
| Total transmit power per TRxP | 24 dBm for 20 MHz bandwidth 21 dBm for 10 MHz bandwidth | 21 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm |
| Inter-site distance | 20 m | 20 m |
| Number of antenna elements per TRxP | Up to 256 Tx/Rx | 32Tx/Rx,  (M,N,P,Mg,Ng) = (4,4,2,1,1) |
| Number of UE antenna elements | Up to 8 Tx/Rx | 4Tx/Rx, (M,N,P,Mg,Ng) = (1,2,2,1,1) |
| Device deployment | 100% indoor, Randomly and uniformly distributed over the area | 100% indoor, Randomly and uniformly distributed over the area |
| UE mobility model | Fixed and identical speed |v| of all UEs, randomly and uniformly distributed direction | Aligned with reference |
| UE speeds of interest | 100% indoor, 3 km/h | 100% indoor, 3 km/h |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB |
| UE noise figure | 7 dB | 7 dB |
| BS antenna element gain | 5 dBi | 5 dBi |
| UE antenna element gain | 0 dBi | 0 dBi |
| Thermal noise level | ‒174 dBm/Hz | ‒174 dBm/Hz |
| Traffic model | Full buffer | Full buffer |
| Simulation bandwidth | 20 MHz for TDD,  10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD |
| UE density | 10 UEs per TRxP, randomly and uniformly dropped throughout the geographical area | 10 UEs per TRxP, randomly and uniformly dropped throughout the geographical area |
| UE antenna height | 1.5 m | 1.5 m |
| Channdel Model | InH\_A, InH\_B | InH\_A |
| **Additional parameters** | | |
| Subcarrier spacing |  | 15 kHz |
| Symbols number per slot |  | 14 |
| Number of TXRU per TRxP |  | 32TXRU  (Mp,Np,P,Mg,Ng) = (4,4,2,1,1) |
| Number of TXRU per UE |  | 4TXRU, (1-to-1 mapping) (Mp,Np,P,Mg,Ng) = (1,2,2,1,1) |
| TRxP number per site |  | 1 |
| Mechanic tilt |  | 180deg in GCS  (pointing to the ground) |
| Electronic tilt |  | 90deg in LCS |
| Scheduling |  | Round Robin |
| ACK/NACK delay |  | Next available UL slot |
| MIMO mode |  | MU-MIMO |
| Guard band ratio |  | FDD: 6.4% (for 10 MHz) |
| BS receiver type |  | MMSE-IRC |
| Precoder derivation |  | FDD: NR Type II codebook based |
| Channel estimation |  | Non-ideal |
| Waveform |  | OFDM |
| Polarized antenna model |  | Model-2 (TR36.873) |
| Modulation |  | Up to 256QAM |

Table 2.1.1-2

Assumptions and Configuration of Indoor Hotspot-eMBB (Uplink Case)

|  |  |  |
| --- | --- | --- |
| Configuration A - Uplink | | |
|  | ITU-R M.2412 | INRS-EMT |
| **Baseline configuration** | | |
| Carrier frequency for evaluation | 4 GHz | 4 GHz |
| BS antenna height | 3 m | 3 m |
| Total transmit power per TRxP | 24 dBm for 20 MHz bandwidth 21 dBm for 10 MHz bandwidth | 21 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm |
| Inter-site distance | 20 m | 20 m |
| Number of antenna elements per TRxP | Up to 256 Tx/Rx | 32Rx cross-polarized antenna (M,N,P,Mg,Ng) = (4,4,2,1,1) |
| Number of UE antenna elements | Up to 8 Tx/Rx | 2Tx, (M,N,P,Mg,Ng) = (1,1,2,1,1) with 0°,90° polarization |
| Number of TXRU per UE |  | 2TXRU |
| Device deployment | 100% indoor, Randomly and uniformly distributed over the area | 100% indoor, Randomly and uniformly distributed over the area |
| UE mobility model | Fixed and identical speed |v| of all UEs, randomly and uniformly distributed direction | Aligned with reference |
| UE speeds of interest | 100% indoor, 3 km/h | 100% indoor, 3 km/h |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB |
| UE noise figure | 7 dB | 7 dB |
| BS antenna element gain | 5 dBi | 5 dBi |
| UE antenna element gain | 0 dBi | 0 dBi |
| Thermal noise level | ‒174 dBm/Hz | ‒174 dBm/Hz |
| Traffic model | Full buffer | Full buffer |
| Simulation bandwidth | 20 MHz for TDD,  10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD |
| UE density | 10 UEs per TRxP randomly and uniformly dropped throughout the geographical area | 10 UEs per TRxP randomly and uniformly dropped throughout the geographical area |
| UE antenna height | 1.5 m | 1.5 m |
| Channdel Model | InH\_A, InH\_B | InH\_A |
| **Additional parameters** | | |
| Subcarrier spacing |  | 15 kHz |
| Symbols number per slot |  | 14 |
| Number of TXRU per TRxP |  | 16TXRU, Vertical 1-to-2 (Mp,Np,P,Mg,Ng) = (2,4,2,1,1) |
| Number of TXRU per UE |  | 2TXRU, (1-to-1 mapping) (Mp,Np,P,Mg,Ng) = (1,1,2,1,1) |
| TRxP number per site |  | 1 |
| Mechanic tilt |  | 180deg in GCS  (pointing to the ground) |
| Electronic tilt |  | 90deg in LCS |
| Scheduling |  | Round Robin |
| ACK/NACK delay |  | Next available UL slot |
| MIMO mode |  | SU-MIMO |
| BS receiver type |  | MMSE-IRC |
| UE precoder scheme |  | Codebook based |
| UL CSI derivation |  | Non-precoded SRS based, with delay |
| Power control |  | α= 0.6, P0 =-60 dBm |
| RB allocation for Power backoff model |  | Continuous: follow TS 38.101; Non-continuous: additional 2 RB reduction |
| Channel estimation |  | Non-ideal |
| Waveform |  | OFDM |
| Polarized antenna model |  | Model-2 (TR36.873) |
| Modulation |  | Up to 256QAM |

#### A.2.1.2 Dense Urban – eMBB

Table 2.1.2-1

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

|  |  |  |
| --- | --- | --- |
| Configuration A - Downlink | | |
|  | ITU-R M.2412 | INRS-EMT |
| **Baseline configuration** | | |
| Carrier frequency for evaluation | 1 layer (Macro) with 4 GHz | 4 GHz |
| BS antenna height | 25 m | 25 m |
| Total transmit power per TRxP | 44 dBm for 20 MHz bandwidth 41 dBm for 10 MHz bandwidth | 41 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm |
| Percentage of high loss and low loss building type | 20% high loss, 80% low loss | 20% high loss, 80% low loss |
| Inter-site distance | 200 m | 200 m |
| Number of antenna elements per TRxP | Up to 256 Tx/Rx | 128Tx cross-polarized antenna (M,N,P,Mg,Ng) = (8,8,2,1,1) |
| Number of UE antenna elements | Up to 8 Tx/Rx | 4Rx (M,N,P,Mg,Ng) = (1,2,2,1,1) with 0°,90° polarization |
| Device deployment | 80% indoor,  20% outdoor (in-car) Randomly and uniformly distributed over the area under Macro layer | Aligned with reference |
| UE mobility model | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction. | Aligned with reference |
| UE speeds of interest | Indoor users: 3 km/h Outdoor users (in-car): 30 km/h | Aligned with reference |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB |
| UE noise figure | 7 dB | 7 dB |
| BS antenna element gain | 8 dBi | 8 dBi |
| UE antenna element gain | 0 dBi | 0 dBi |
| Thermal noise level | ‒174 dBm/Hz | ‒174 dBm/Hz |
| Traffic model | Full buffer | Full buffer |
| Simulation bandwidth | 20 MHz for TDD, 10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD |
| UE density | 10 UEs per TRxP Randomly and uniformly distributed over the area under Macro layer | Aligned with reference |
| UE antenna height | Outdoor UEs: 1.5 m Indoor UTs: 3(nfl – 1) + 1.5; nfl ~ uniform(1,Nfl) where Nfl ~ uniform(4,8) | Aligned with reference |
| Channdel Model | Macro layer: UMa\_A, UMa\_B Micro layer: UMi\_A, UMi\_B | UMa\_A |
| **Additional parameters** | | |
| Subcarrier spacing |  | 15 kHz |
| Symbols number per slot |  | 14 |
| Number of TXRU per TRxP |  | 32TXRU, Vertical 2-to-8 (Mp,Np,P,Mg,Ng) = (2,8,2,1,1) |
| TRxP number per site |  | 3 |
| Number of TXRU per UE |  | 4TXRU (Mp,Np,P,Mg,Ng) = (1,2,2,1,1) (1-to-1 mapping) |
| Mechanic tilt |  | 90deg in GCS (pointing to the horizontal direction) |
| Electronic tilt |  | 105deg in LCS |
| Scheduling |  | Round Robin |
| ACK/NACK delay |  | Next available UL slot |
| MIMO mode |  | MU-MIMO |
| Guard band ratio |  | FDD: 6.4% (for 10 MHz) |
| BS receiver type |  | MMSE-IRC |
| Precoder derivation |  | FDD: NR Type II codebook based |
| Channel estimation |  | Non-ideal |
| Waveform |  | OFDM |
| Polarized antenna model |  | Model-2 (TR36.873) |
| Modulation |  | Up to 256QAM |

Table 2.1.2-2

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

|  |  |  |
| --- | --- | --- |
| Configuration A - Uplink | | |
|  | ITU-R M.2412 | INRS-EMT |
| **Baseline configuration** | | |
| Carrier frequency for evaluation | 1 layer (Macro) with 4 GHz | Aligned with reference |
| BS antenna height | 25 m | 25 m |
| Total transmit power per TRxP | 44 dBm for 20 MHz bandwidth 41 dBm for 10 MHz bandwidth | 41 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm |
| Percentage of high loss and low loss building type | 20% high loss, 80% low loss | 20% high loss, 80% low loss |
| Inter-site distance | 200 m | 200 m |
| Number of antenna elements per TRxP | Up to 256 Tx/Rx | 128Rx cross-polarized antenna (M,N,P,Mg,Ng) = (8,8,2,1,1) |
| Number of UE antenna elements | Up to 8 Tx/Rx | 2Tx (M,N,P,Mg,Ng) = (1,1,2,1,1) with 0°,90° polarization |
| Device deployment | 80% indoor,  20% outdoor (in-car) Randomly and uniformly distributed over the area under Macro layer | Aligned with reference |
| UE mobility model | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction. | Aligned with reference |
| UE speeds of interest | Indoor users: 3 km/h Outdoor users (in-car): 30 km/h | Aligned with reference |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB |
| UE noise figure | 7 dB | 7 dB |
| BS antenna element gain | 8 dBi | 8 dBi |
| UE antenna element gain | 0 dBi | 0 dBi |
| Thermal noise level | ‒174 dBm/Hz | ‒174 dBm/Hz |
| Traffic model | Full buffer | Full buffer |
| Simulation bandwidth | 20 MHz for TDD,  10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD |
| UE density | 10 UEs per TRxP Randomly and uniformly distributed over the area under Macro layer | Aligned with reference |
| UE antenna height | Outdoor UEs: 1.5 m Indoor UTs: 3(nfl – 1) + 1.5; nfl ~ uniform(1,Nfl) where Nfl ~ uniform(4,8) | Aligned with reference |
| Channdel Model | UMa\_A, UMa\_B | UMa\_A |
| **Additional parameters** | | |
| Subcarrier spacing |  | 15 kHz |
| Symbols number per slot |  | 14 |
| Number of TXRU per TRxP |  | 16TXRU (Mp,Np,P,Mg,Ng) = (1,8,2,1,1) Vertical 1-to-8 |
| TRxP number per site |  | 3 |
| Number of TXRU per UE |  | 2TXRU (Mp,Np,P,Mg,Ng) = (1,1,2,1,1) (1-to-1 mapping) |
| Mechanic tilt |  | 90deg in GCS  (pointing to the horizontal direction) |
| Electronic tilt |  | 105deg in LCS |
| Scheduling |  | Robin Robin |
| ACK/NACK delay |  | Next available UL slot |
| MIMO mode |  | SU-MIMO |
| BS receiver type |  | MMSE-IRC |
| UE precoder scheme |  | Codebook based |
| UL CSI derivation |  | Non-precoded SRS based, with delay |
| Power control |  | α= 0.6, P0 =-60 dBm |
| RB allocation for Power backoff model |  | Continuous: follow TS 38.101; Non-continuous: additional 2 RB reduction |
| Channel estimation |  | Non-ideal |
| Waveform |  | OFDM |
| Polarized antenna model |  | Model-2 (TR36.873) |
| Modulation |  | Up to 256QAM |

#### A.2.1.3 Rural – eMBB

Table 2.1.3-1

Assumptions and Configuration of Rural-eMBB (Downlink Case) – Configuration A

|  |  |  |
| --- | --- | --- |
| Configuration A - Downlink | | |
|  | ITU-R M.2412 | INRS-EMT |
| **Baseline configuration** | | |
| Carrier frequency for evaluation | 700 MHz | 700 MHz |
| BS antenna height | 35 m | 35 m |
| Total transmit power per TRxP | 49 dBm for 20 MHz bandwidth 46 dBm for 10 MHz bandwidth | 46 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm |
| Percentage of high loss and low loss building type | 100% low loss | 100% low loss |
| Inter-site distance | 1732 m | 1732 m |
| Number of antenna elements per TRxP | Up to 64 Tx/Rx | 64Tx cross-polarized antenna  (M,N,P,Mg,Ng) = (8,4,2,1,1) (dH,dV) = (0.5, 0.8)λ |
| Number of UE antenna elements | Up to 4 Tx/Rx | 2Rx (M,N,P,Mg,Ng) = (1,1,2,1,1) 0°,90° polarization |
| Device deployment | 50% indoor, 50% outdoor (in-car) Randomly and uniformly distributed over the area | Aligned with reference |
| UE mobility model | Fixed and identical speed |v| of all UEs, randomly and uniformly distributed direction | Aligned with reference |
| UE speeds of interest | Indoor users: 3 km/h; Outdoor users (in-car): 120 km/h; 500 km/h for evaluation of mobility in high-speed case | Indoor users: 3 km/h; Outdoor users (in-car): 120 km/h; |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB |
| UE noise figure | 7 dB | 7 dB |
| BS antenna element gain | 8 dBi | 8 dBi |
| UE antenna element gain | 0 dBi | 0 dBi |
| Thermal noise level | ‒174 dBm/Hz | ‒174 dBm/Hz |
| Traffic model | Full buffer | Full buffer |
| Simulation bandwidth | 20 MHz for TDD,  10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD |
| UE density | 10 UEs per TRxP Randomly and uniformly distributed over the area | Aligned with reference |
| UE antenna height | 1.5 m | 1.5 m |
| Channdel Model | RMa\_A, RMa\_B | RMa\_A |
| Additional parameters | | |
| Subcarrier spacing |  | 15 kHz |
| Symbols number per slot |  | 14 |
| Number of TXRU per TRxP |  | 8TXRU (Mp,Np,P,Mg,Ng) = (1,4,2,1,1) Vertical 1-to-8 |
| TRxP number per site |  | 3 |
| Number of TXRU per UE |  | 2TXRU,  (Mp,Np,P,Mg,Ng) = (1,1,2,1,1) (1-to-1 mapping) |
| Mechanic tilt |  | 90deg in GCS (pointing to the horizontal direction) |
| Electronic tilt |  | 100deg in LCS |
| Scheduling |  | Round Robin |
| ACK/NACK delay |  | Next available UL slot |
| MIMO mode |  | MU-MIMO |
| Guard band ratio |  | FDD: 6.4% (for 10 MHz) |
| BS receiver type |  | MMSE-IRC |
| Precoder derivation |  | FDD: NR Type II codebook based |
| Channel estimation |  | Non-ideal |
| Waveform |  | OFDM |
| Polarized antenna model |  | Model-2 (TR36.873) |
| Modulation |  | Up to 256QAM |

Table 2.1.3-2

Assumptions and Configuration of Rural-eMBB (Uplink Case) – Configuration A

|  |  |  |
| --- | --- | --- |
| Configuration A - Uplink | | |
|  | ITU-R M.2412 | INRS-EMT |
| **Baseline configuration** | | |
| Carrier frequency for evaluation | 700 MHz | 700 MHz |
| BS antenna height | 35 m | 35 m |
| Total transmit power per TRxP | 49 dBm for 20 MHz bandwidth 46 dBm for 10 MHz bandwidth | 46 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm |
| Percentage of high loss and low loss building type | 100% low loss | 100% low loss |
| Inter-site distance | 1732 m | 1732 m |
| Number of antenna elements per TRxP | Up to 256 Tx/Rx | 64Rx cross-polarized antenna  (M,N,P,Mg,Ng) = (8,4,2,1,1) (dH,dV) = (0.5, 0.8)λ |
| Number of UE antenna elements | Up to 8 Tx/Rx | 1Tx (M,N,P,Mg,Ng) = (1,1,1,1,1) 0°,90° polarization |
| Device deployment | 100% indoor Randomly and uniformly distributed over the area | 50% indoor, 50% outdoor (in car) Randomly and uniformly distributed over the area |
| UE mobility model | Fixed and identical speed |v| of all UEs, randomly and uniformly distributed direction | Aligned with reference |
| UE speeds of interest | 100% indoor, 3 km/h | Aligned with reference |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB |
| UE noise figure | 7 dB | 7 dB |
| BS antenna element gain | 8 dBi | 8 dBi |
| UE antenna element gain | 0 dBi | 0 dBi |
| Thermal noise level | ‒174 dBm/Hz | ‒174 dBm/Hz |
| Traffic model | Full buffer | Full buffer |
| Simulation bandwidth | 20 MHz for TDD,  10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD |
| UE density | 10 UEs per TRxP randomly and uniformly dropped throughout the geographical area | Aligned with reference |
| UE antenna height | 1.5 m | 1.5 m |
| Channdel Model | UMa\_A, UMa\_B | UMa\_A |
| Additional parameters | | |
| Subcarrier spacing |  | 15 kHz |
| Symbols number per slot |  | 14 |
| Number of TXRU per TRxP |  | 8TXRU (Mp,Np,P,Mg,Ng) = (1,4,2,1,1) Vertical 1-to-8 |
| TRxP number per site |  | 3 |
| Number of TXRU per UE |  | 1TXRU,  (Mp,Np,P,Mg,Ng) = (1,1,1,1,1) (1-to-1 mapping) |
| Mechanic tilt |  | 90deg in GCS  (pointing to the horizontal direction) |
| Electronic tilt |  | 100deg in LCS |
| Scheduling |  | Round Robin |
| ACK/NACK delay |  | Next available UL slot |
| MIMO mode |  | SU-MIMO |
| BS receiver type |  | MMSE-IRC |
| UE precoder scheme |  | Codebook based |
| UL CSI derivation |  | Non-precoded SRS based, with delay |
| Power control |  | α= 0.8, P0 =-76 dBm |
| RB allocation for Power backoff model |  | Continuous: follow TS 38.101; Non-continuous: additional 2 RB reduction |
| Channel estimation |  | Non-ideal |
| Waveform |  | OFDM |
| Polarized antenna model |  | Model-2 (TR36.873) |
| Modulation |  | Up to 256QAM |

Table 2.1.3-3

Assumptions and Configuration of Rural-eMBB (Downlink Case) – Configuration B

|  |  |  |
| --- | --- | --- |
| Configuration B - Downlink | | |
|  | ITU-R M.2412 | INRS-EMT |
| **Baseline configuration** | | |
| Carrier frequency for evaluation | 4 GHz | 4 GHz |
| BS antenna height | 35 m | 35 m |
| Total transmit power per TRxP | 49 dBm for 20 MHz bandwidth 46 dBm for 10 MHz bandwidth | 46 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm |
| Percentage of high loss and low loss building type | 100% low loss | 100% low loss |
| Inter-site distance | 1732 m | 1732 m |
| Number of antenna elements per TRxP | Up to 64 Tx/Rx | 128Tx cross-polarized antenna  (M,N,P,Mg,Ng) = (8,8,2,1,1) (dH,dV) = (0.5, 0.8)λ |
| Number of UE antenna elements | Up to 4 Tx/Rx | 4Rx (M,N,P,Mg,Ng) = (1,2,2,1,1) 0°,90° polarization |
| Device deployment | 50% indoor, 50% outdoor (in-car) Randomly and uniformly distributed over the area | Aligned with reference |
| UE mobility model | Fixed and identical speed |v| of all UEs, randomly and uniformly distributed direction | Aligned with reference |
| UE speeds of interest | Indoor users: 3 km/h; Outdoor users (in-car): 120 km/h; 500 km/h for evaluation of mobility in high-speed case | Indoor users: 3 km/h; Outdoor users (in-car): 120 km/h; |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB |
| UE noise figure | 7 dB | 7 dB |
| BS antenna element gain | 8 dBi | 8 dBi |
| UE antenna element gain | 0 dBi | 0 dBi |
| Thermal noise level | ‒174 dBm/Hz | ‒174 dBm/Hz |
| Traffic model | Full buffer | Full buffer |
| Simulation bandwidth | 20 MHz for TDD,  10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD |
| UE density | 10 UEs per TRxP Randomly and uniformly distributed over the area | Aligned with reference |
| UE antenna height | 1.5 m | 1.5 m |
| Channdel Model | RMa\_A, RMa\_B | RMa\_A |
| **Additional parameters** | | |
| Subcarrier spacing |  | 15 kHz |
| Symbols number per slot |  | 14 |
| Number of TXRU per TRxP |  | 32TXRU,  (Mp,Np,P,Mg,Ng) = (2,8,2,1,1) |
| TRxP number per site |  | 3 |
| Number of TXRU per UE |  | 4TXRU, (Mp,Np,P,Mg,Ng) = (1,2,2,1,1) (1-to-1 mapping) |
| Mechanic tilt |  | 90deg in GCS (pointing to the horizontal direction) |
| UT attachment |  | Based on RSRP (Eq. (8.1-1) in TR 36.873) from port 0 |
| Scheduling |  | Round Robin |
| ACK/NACK delay |  | Next available UL slot |
| MIMO mode |  | MU-MIMO |
| Guard band ratio |  | FDD: 6.4% (for 10 MHz) |
| BS receiver type |  | MMSE-IRC |
| Precoder derivation |  | FDD: NR Type II codebook based |
| Channel estimation |  | Non-ideal |
| Waveform |  | OFDM |
| Polarized antenna model |  | Model-2 (TR36.873) |
| Modulation |  | Up to 256QAM |

Table 2.1.3-4

Assumptions and Configuration of Rural-eMBB (Uplink Case) – Configuration B

|  |  |  |
| --- | --- | --- |
| Configuration B - Uplink | | |
|  | ITU-R M.2412 | INRS |
| **Baseline configuration** | | |
| Carrier frequency for evaluation | 4 GHz | 4 GHz |
| BS antenna height | 35 m | 35 m |
| Total transmit power per TRxP | 49 dBm for 20 MHz bandwidth 46 dBm for 10 MHz bandwidth | 46 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm |
| Percentage of high loss and low loss building type | 100% low loss | 100% low loss |
| Inter-site distance | 1732 m | 1732 m |
| Number of antenna elements per TRxP | Up to 256 Tx/Rx | 128Rx cross-polarized antenna  (M,N,P,Mg,Ng) = (8,8,2,1,1) (dH,dV) = (0.5, 0.8)λ |
| Number of UE antenna elements | Up to 8 Tx/Rx | 1Tx (M,N,P,Mg,Ng) = (1,1,1,1,1) 0°,90° polarization |
| Device deployment | 50% indoor, 50% outdoor (in car) Randomly and uniformly distributed over the area | Aligned with reference |
| UE mobility model | Fixed and identical speed |v| of all UEs, randomly and uniformly distributed direction | Aligned with reference |
| UE speeds of interest | 100% indoor, 3 km/h | Indoor users: 3 km/h; Outdoor users (in-car): 120 km/h; |
| Inter-site interference modeling | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB |
| UE noise figure | 7 dB | 7 dB |
| BS antenna element gain | 8 dBi | 8 dBi |
| UE antenna element gain | 0 dBi | 0 dBi |
| Thermal noise level | ‒174 dBm/Hz | ‒174 dBm/Hz |
| Traffic model | Full buffer | Full buffer |
| Simulation bandwidth | 20 MHz for TDD,  10 MHz+10 MHz for FDD | 10 MHz+10 MHz for FDD |
| UE density | 10 UEs per TRxP randomly and uniformly dropped throughout the geographical area | Aligned with reference |
| UE antenna height | 1.5 m | 1.5 m |
| Channdel Model | UMa\_A, UMa\_B | UMa\_A |
| **Additional parameters** | | |
| Subcarrier spacing |  | 15 kHz |
| Symbols number per slot |  | 14 |
| Number of TXRU per TRxP |  | 32TXRU (Mp,Np,P,Mg,Ng) = (2,8,2,1,1) Vertical 1-to-4 |
| TRxP number per site |  | 3 |
| Number of TXRU per UE |  | 1TXRU,  (Mp,Np,P,Mg,Ng) = (1,1,1,1,1) (1-to-1 mapping) |
| Mechanic tilt |  | 90deg in GCS  (pointing to the horizontal direction) |
| Electronic tilt |  | 100deg in LCS |
| Scheduling |  | Round Robin |
| ACK/NACK delay |  | Next available UL slot |
| MIMO mode |  | SU-MIMO |
| BS receiver type |  | MMSE-IRC |
| UE precoder scheme |  | Codebook based |
| UL CSI derivation |  | Non-precoded SRS based, with delay |
| Power control |  | α= 0.6, P0 =-70 dBm |
| RB allocation for Power backoff model |  | Continuous: follow TS 38.101; Non-continuous: additional 2 RB reduction |
| Channel estimation |  | Non-ideal |
| Waveform |  | OFDM |
| Polarized antenna model |  | Model-2 (TR36.873) |
| Modulation |  | Up to 256QAM |

### A.2.2 Comparison of the configurations used by the candidate submissions

In Table A.2.2-1, it is assumed that only the 3GPP (RIT and SRIT) configurations need be provided, as the ITU has determined that the same evaluation would apply to the submissions from China and Korea. On the other hand, the SRIT submission from Dect-Forum/ETSI has different requirements that need to be taken into account in Table 23. ETSI SRIT consists of two component RITs, “DECT-2020-NR” and “3GPP-NR”. The 3GPP-NR component RIT for ETSI is the same as the “3GPP 5G CANDIDATE FOR INCLUSION IN IMT-2020: SUBMISSION 2 FOR IMT-2020 (RIT)” in the package provided by the 3GPP proponent.

Table A.2.2-1

Assumptions and Configuration of the proposed candidates

|  | 3GPP-RIT | 3GPP-SRIT | ETSI-SRIT  (DECT-2020-NR) | TSDSI | NuFront |
| --- | --- | --- | --- | --- | --- |
| Test environment | All the five test environments | All the five test environments | This proposal addresses all the five test environments across the three usage scenarios (eMBB, mMTC, and URLLC) as described in Report ITU-R M.2412-0.  Within the SRIT, the DECT-2020 NR component address two usage scenarios (mMTC and URLLC) as described in ITU-R M.2412.0.  The eMBB usage scenario is addressed by the 3GPP NR component. | All the five test environments | All the five test environments |
| Multiple access schemes | - DL/UL  OFDMA:  Synchronous/scheduling-based  Mutually orthogonal frequency assignments for UE transmission.  One RB consist of 12 subcarriers. Multiple sub-carrier spacings (15kHz, 30kHz, 60kHz and 120kHz) are supported including for data  CP-OFDM for DL/UL and possibly DFT-spread in UL  Spectral confinement technique is transparent to the receiver.  TDMA:  One slot consisting of 14 OFDM symbols, or 2~13 OFDM symbols non-slot (for DL) or 1~13 OFDM symbols (for UL) within one slot. The physical length of one slot ranges from 0.125ms to 1ms depending on the sub-carrier spacing  CDMA:  • Inter-cell interference suppressed by processing gain of channel coding  (for more details on channel-coding, see Item  5.2.3.2.2.3 and the reference therein).  SDMA:  • Possibility to transmit to/from multiple users using the same time/frequency resource (SDMA a.k.a. “multi-user MIMO (for more details on the advanced antenna capabilities, see Item 5.2.3.2.9 and the reference therein)  • UL transmission scheme without scheduling grant is supported.  •The above scheme is applied to eMBB and URLLC. | For NR component RIT:  - Downlink and Uplink:  The multiple access is a combination of  • OFDMA: Synchronous/scheduling-based; the transmission to/from different UEs uses mutually orthogonal frequency assignments. Granularity in frequency assignment: One resource block consisting of 12 subcarriers. Multiple sub-carrier spacings are supported including 15kHz, 30kHz, 60kHz and 120kHz for data (see Item 5.2.3.2.7 and reference therein).  n CP-OFDM is applied for both downlink and uplink. DFT-spread OFDM can also be configured for uplink.  n Spectral confinement technique(s) (e.g. filtering, windowing, etc.) for a waveform at the transmitter is transparent to the receiver. When such confinement techniques are used, the spectral utilization ratio can be enhanced.  • TDMA: Transmission to/from different UEs with separation in time. Granularity: One slot consisting of 14 OFDM symbols, or 2, 4, 7 OFDM symbols within one slot. The  physical length of one slot ranges from 0.125ms to 1ms depending on the sub-carrier spacing (for more details on the frame structure, see Item 5.2.3.2.7 and the references therein).  • CDMA: Inter-cell interference suppressed by processing gain of channel coding allowing for a frequency reuse of one (for more details on channel-coding, see Item 5.2.3.2.2.3 and the reference therein).  • SDMA: Possibility to transmit to/from multiple users using the same time/frequency resource (SDMA a.k.a. “multi-user MIMO”) as part of the advanced-antenna capabilities (for more details on the advanced-antenna capabilities, see Item 5.2.3.2.9 and the least an UL transmission scheme without scheduling grant is supported.  The above scheme is at least applied to eMBB and URLLC. (Note: Synchronous means that timing offset between UEs is within cyclic prefix by e.g. timing alignment.)  For LTE component RIT:  - Downlink and Uplink:  The multiple access is a combination of  • OFDMA: Synchronous/scheduling-based is supported for both DL and UL; the  transmission to/from different UEs uses mutually orthogonal frequency assignments. In  addition, non-orthogonal multiple access is supported for DL (known as MUST, see  [36.211] sub-clause 7.1.2 for more details). Granularity in frequency assignment: One  resource block consisting of 12 subcarriers. Sub-carrier spacings of 15kHz is supported  for uni-cast data and subcarrier spacings of 15kHz, 7.5kHz and 1.25kHz are supported  for multi-cast data (see Item 5.2.3.2.7 and reference therein).  n CP-OFDM is applied for downlink. DFT-spread OFDM is applied for uplink.  • TDMA: Transmission to/from different UEs with separation in time. Granularity: One  subframe of length 1 ms, or slot of 7 OFDM symbols (0.5ms), or sub-slot of length 2~3  OFDM symbols (0.143ms~0.214ms) (for more details on the frame structure, see Item  5.2.3.2.7 and the references therein).  • CDMA: Inter-cell interference suppressed by processing gain of channel coding  allowing for a frequency reuse of one (for more details on channel-coding, see Item  5.2.3.2.2.3 and the reference therein).  • SDMA: Possibility to transmit to/from multiple users using the same time/frequency  resource (SDMA a.k.a. “multi-user MIMO”) as part of the advanced-antenna capabilities  (for more details on the advanced-antenna capabilities, see Item 5.2.3.2.9 and the  reference therein)  For NB-IoT, the multiple access is a combination of OFDMA, TDMA and CDMA, where  OFDMA and TDMA are as follows  • OFDMA:  n UL: DFT-spread OFDM. Granularity in frequency domain: A single sub-carrier  with either 3.75 kHz or 15 kHz sub-carrier spacing, or 3, 6, or 12 sub-carriers with  a sub-carrier spacing of 15 kHz. A resource block consists of 12 sub-carriers with  15 kHz sub-carrier spacing, or 48 sub-carriers with 3.75 kHz sub-carrier spacing  → 180 kHz.  n DL: Granularity in frequency domain: one resource block consisting of 12  subcarriers with 15 kHz sub-carrier spacing→ 180 kHz  • TDMA: Transmission to/from different UEs with separation in time  n UL: Granularity: One resource unit of 1 ms, 2 ms, 4 ms, 8 ms, with 15 kHz subcarrier  spacing, depending on allocated number of sub-carrier(s); or 32 ms with  3.75 kHz sub-carrier spacing (for more details on the frame structure, see Item  5.2.3.2.7 and the references therein)  n DL: Granularity: One resource unit (subframe) of length 1 ms.  n Repetition of a transmission is supported. | For DECT-2020 NR component RIT:  Both time-division and frequency-division multiple access. The system can simultaneously use multiple frequency sub-channels, and within each, sequential uplink or downlink transfers may occur. Time-overlapping transmit/receive is not supported: the FP device can perform independent transmission to multiple PP devices on a given time interval; on a different time interval the FP device can receive transmissions from multiple PP devices.  An FP device can support simultaneous links to multiple PP devices.  Nominal sub-carrier spacing is 27 kHz with a nominal time slot duration of 416.67µs. Additional sub-carrier spacings up to 432 kHz are supported depending on deployment. | - DL/UL  OFDMA:  Synchronous/scheduling-based  Mutually orthogonal frequency assignments for UE transmission.  One RB consist of 12 subcarriers. Multiple sub-carrier spacings (15kHz, 30kHz, 60kHz and 120kHz) are supported including for data  CP-OFDM for DL/UL and possibly DFT-spread in UL  Spectral confinement technique is transparent to the receiver.  TDMA:  One slot consisting of 14 OFDM symbols, or 2~13 OFDM symbols non-slot (for DL) or 1~13 OFDM symbols (for UL) within one slot. The physical length of one slot ranges from 0.125ms to 1ms depending on the sub-carrier spacing  CDMA:  • Inter-cell interference suppressed by processing gain of channel coding  (for more details on channel-coding, see Item  5.2.3.2.2.3 and the reference therein).  SDMA:  • Possibility to transmit to/from multiple users using the same time/frequency resource (SDMA a.k.a. “multi-user MIMO (for more details on the advanced antenna capabilities, see Item 5.2.3.2.9 and the reference therein)  • UL transmission scheme without scheduling grant is supported.  •The above scheme is applied to eMBB and URLLC. | Downlink and uplink  The multiple access is a combination of  • OFDMA: The base station allocates mutually orthogonal frequencies to different users to transfer data. The minimum frequency resource packet of the OFDMA is 16 sub-carriers (Resource Unit, RU). The sub-carrier spacing of EUHT IMT bands is 78.125KHz. If bandwidth is 10MHz/5MHz, the sub-carrier spacing will be 39.0625KHz/19.53KHz. The sub-carrier spacing of EUHT higher frequency bands is 390.625KHz.  The CP-OFDM is applied for both downlink and uplink. The CP ratio can be configured to 1/4 or 1/8.  -TDMA: The base station allocates different OFDM symbols to different users to transfer data. The granularity is one OFDM symbol.  • SDMA: Transmission to/from multiple users uses the same time/frequency resource. (For more details, see Item 5.2.3.2.9). |
| Baseband modulation scheme and symbol rate after modulation | DL  For data and higher-layer control information: QPSK, 16QAM, 64QAM and 256QAM  L1/L2 control: QPSK  Symbol rate: 1344ksymbols/s per 1440kHz RB  UL  For both data and higher-layer control information: π/2-BPSK (when precoding is enabled), QPSK, 16QAM, 64QAM and 256QAM  L1/L2 control: BPSK, π/2-BPSK, QPSK  Symbol rate: 1344ksymbols/s per 1440kHz RB  The above is at least applied to eMBB. | For NR component RIT:  - Downlink:  • For both data and higher-layer control information: QPSK, 16QAM, 64QAM and  256QAM (see [38.211] sub-clause 7.3.1.2).  • L1/L2 control: QPSK (see [38.211] sub-clause 7.3.2.4).  • Symbol rate: 1344ksymbols/s per 1440kHz resource block (equivalently 168ksymbols/s  per 180kHz resource block)  - Uplink:  • For both data and higher-layer control information: π/2-BPSK (when precoding is  enabled), QPSK, 16QAM, 64QAM and 256QAM (see [38.211] sub-clause 6.3.1.2).  • L1/L2 control: BPSK, π/2-BPSK, QPSK (see [38.211] sub-clause 6.3.2).  • Symbol rate: 1344ksymbols/s per 1440kHz resource block (equivalently 168ksymbols/s  per 180kHz resource block)  The above is at least applied to eMBB.  For LTE component RIT:  - Downlink:  • For both data and higher-layer control information: QPSK, 16QAM, 64QAM and  256QAM (see [36.211] sub-clause 6.3.2). 1024QAM is being specified.  • L1/L2 control: QPSK (see [36.211] sub-clauses 6.7.2, 6.8.3, and 6.8A.3)  • Symbol rate: 168ksymbols/s per 180kHz resource block  - Uplink:  • For both data and higher-layer control information: QPSK, 16QAM, 64QAM and  256QAM are supported (see [36.211] sub-clause 5.3.2).  • L1/L2 control: BPSK, QPSK (see [36.211] sub-clause 5.4)  • Symbol rate: 168ksymbols/s per 180kHz resource block  For NB-IoT, the modulation scheme is as follows.  • Data and higher-layer control: π/2-BPSK (uplink only), π/4-QPSK (uplink only), QPSK  • L1/L2 control: π/2-BPSK (uplink), QPSK (downlink)  Symbol rate: 168 ksymbols/s per 180 kHz resource block. For UL, less than one resource block  may be allocated. | For data and control OFDM with 24 Khz nominal symbol rate used, we have one of the following configuration:  (modulation, code rate, Allowed constellation error)  (BPSK,1/4,-4)  (BPSK,1/2,-5)  (QPSK,1/2,-10)  (QPSK,3/4,-13)  (16QAM,1/2,-16)  (16QAM,3/4,-19)  (64QAM ,2/3,-22)  (64QAM ,3/4,-25)  (64QAM ,5/6,-27)  (256QAM,3/4,-30)  (256QAM,5/6,-32)  (1024QAM ,3/4,-35)  (1024QAM ,5/6,-37) | DL  For data and higher-layer control information: QPSK, 16QAM, 64QAM and 256QAM  L1/L2 control: QPSK  Symbol rate: 1344ksymbols/s per 1440kHz RB  UL  For both data and higher-layer control information: π/2-BPSK (when precoding is enabled), QPSK, 16QAM, 64QAM and 256QAM  L1/L2 control: BPSK, π/2-BPSK, QPSK  Symbol rate: 1344ksymbols/s per 1440kHz RB  The above is at least applied to eMBB. | For IMT bands:  - Downlink and Uplink  • For both data and higher-layer control information: BPSK, QPSK, 16QAM, 64QAM，256QAM, 1024QAM.  • L1/L2 control: BPSK and QPSK  • Symbol rate: 69.4K symbols/s (The OFDM symbol rate is 14.4us when the 1/8-ratio CP is applied)  For higher frequency bands:  - Downlink and Uplink  • For both data and higher-layer control information: BPSK, QPSK, 16QAM, 64QAM，256QAM, 1024QAM.  • L1/L2 control: QPSK  • Symbol rate: 347.2K symbols/s (OFDM sampling rate: 400MHz, FFT: 1024 points, CP ratio: 1/8). |
| Average power ratio after baseband filtering (dB) | The PAPR depends on the waveform and the number of component carriers.  The single component carrier transmission is assumed herein when providing the PAPR. For DFT-spread OFDM, PAPR would depend on modulation scheme as well.  For uplink using DFT-spread OFDM, the cubic metric (CM) can also be used as one of the  methods of predicting the power de-rating from signal modulation characteristics, if needed.  DL  PAPR is 8.4dB (99.9%)  UL  For CP-OFDM PAPR is 8.4dB (99.9%)  DFT-spread PAPR (99.9%) is:  4.5 db for π/2-BPSK  5.8 dB for QPSK  6.5 dB for 16QAM  6.6 dB for 64QAM  6.7 dB for 256QAM  CM (99.9%) is:  0.3 dB for π/2-BPSK  1.2 dB for QPSK  2.1 dB for 16QAM  2.3 dB for 64QAM  2.4 dB for 256QAM | The PAPR depends on the waveform and the number of component carriers. The single  component carrier transmission is assumed herein when providing the PAPR. For DFT-spread  OFDM, PAPR would depend on modulation scheme as well.  For uplink using DFT-spread OFDM, the cubic metric (CM) can also be used as one of the  methods of predicting the power de-rating from signal modulation characteristics, if needed.  For NR component RIT:  - Downlink:  The PAPR is 8.4dB (99.9%)  - Uplink:  • For CP-OFDM:  The PAPR is 8.4dB (99.9%)  • For DFT-spread OFDM:  The PAPR is provided in the table on page 4.  Spectrum shaping can be used for a user with π/2 BPSK DFT-S-OFDM for above 24 GHz.  For LTE component RIT:  - Downlink:  The PAPR is 8.4dB (99.9%).  - Uplink:  • For DFT-spread OFDM:  The PAPR is provided in the table on page 4.  For NB-IoT,  - Downlink:  The PAPR is 8.0dB (99.9%) on 180kHz resource.  - Uplink:  The PAPR is 0.23 – 5.6 dB (99.9 %) depending on sub-carriers allocated for available NBIoT  UL modulation.  PAPR-reduction algorithm for NR and LTE:  Any PAPR-reduction algorithm is transmitter-implementation specific for uplink and downlink. | Expected PAPR range is [7, 12] dB.  More details in 5.2.3.2.2.2.2. | The PAPR depends on the waveform and the number of component carriers.  The single component carrier transmission is assumed herein when providing the PAPR. For DFT-spread OFDM, PAPR would depend on modulation scheme as well.  For uplink using DFT-spread OFDM, the cubic metric (CM) can also be used as one of the  methods of predicting the power de-rating from signal modulation characteristics, if needed.  DL  PAPR is 8.4dB (99.9%)  UL  For CP-OFDM PAPR is 8.4dB (99.9%)  DFT-spread PAPR (99.9%) is:  4.5 db for π/2-BPSK  5.8 dB for QPSK  6.5 dB for 16QAM  6.6 dB for 64QAM  6.7 dB for 256QAM  CM (99.9%) is:  0.3 dB for π/2-BPSK  1.2 dB for QPSK  2.1 dB for 16QAM  2.3 dB for 64QAM  2.4 dB for 256QAM | The PAPR depends on the waveform and the number of sub-carriers.  Downlink and Uplink  Both the uplink PAPR and the downlink PAPR are 8.6dB (99.9%).  All the PAPR reduction algorithms are implemented at the transmitter irrespective of uplink or downlink. The CFR (Crest Factor Reduction) algorithm may be used to reduce the PAPR to 7dB or even lower. |
| Physical channel bit rate (M or Gbit/s) for supported bandwidths | The physical channel bit rate depends on the modulation scheme, number of spatial-multiplexing layer, number of RB in the channel bandwidth and the subcarrier spacing used.  The physical channel bit rate per layer:  Where:  is the number of bits per modulation symbol :  2 dB for QPSK  4 dB for 16QAM  6 dB for 64QAM  8 dB for 256QAM  μ depends on the subcarrier spacing, Δ𝑓, given by | For NR component RIT:  The physical channel bit rate depends on the modulation scheme, number of spatial-multiplexing  layer, number of resource blocks in the channel bandwidth and the subcarrier spacing used. The  physical channel bit rate per layer can be expressed as  Rlayer = N\_mod x N\_RB x 2^μ x 168 kbps  where  - N\_mod is the number of bits per modulation symbol for the applied modulation scheme  (QPSK: 2, 16QAM: 4, 64QAM: 6, 256QAM: 8)  - N\_RB is the number of resource blocks in the aggregated frequency domain which depends  on the channel bandwidth.  - μ depends on the subcarrier spacing, Δ𝑓, given by Δ𝑓 = 2^μ ∙ 15 [𝑘𝐻𝑧], 𝜇 = 0,1,…3  For LTE component RIT:  The physical channel bit rate depends on the modulation scheme, number of spatial-multiplexing  layers and number of resource blocks in the channel bandwidth. The physical channel bit rate per  layer can be expressed as  R\_layer = N\_mod x N\_RB x 168 kbps  where  - N\_mod is the number of bits per modulation symbol for the applied modulation scheme  (QPSK: 2, 16QAM: 4, 64QAM: 6, 256QAM: 8, 1024QAM: 10)  - N\_RB is the number of resource blocks in the aggregated frequency domain which depends  on the channel bandwidth (e.g. N\_RB =25 for 5 MHz, N\_RB =50 for 10 MHz, and N\_RB =100 for 20 MHz. For channel bandwidth larger than 20 MHz (carrier aggregation), the  channel bit rate will scale accordingly.  NB-IoT only supports transmission of a single layer and the physical channel bit rate is as above, but with N\_mod limited to 1(BPSK) or 2 (QPSK) and N\_RB= 1. For MBMS, 1.25 kHz and 7.5 kHz subcarrier spacing are also supported, scaling the physical channel bit rate accordingly. | physical channel bit rate (Mbps) depends on the Bandwidth (MHz), occupied bandwidth (MHz), subcarrier spacing (KHz):  (BW,oc BW, Δ𝑓)=BR  (0.864,0.648,27)= 28.8  (1.728,1.512,27)=74.88  (3.456,3.131,27)=155.52  (6.912,6.588,27)=336.96  (13.824,13.5,27)=673.92  (20.736,17.928,27)=915.84  (27.648,27,27)=1347.84  (55.296,52.704,216)=2695.68  (110.592,108,216)=5391.36  (165.888,146.424,216)=7326.72  (221.184,216,216)=10782.72 | The physical channel bit rate depends on the modulation scheme, number of spatial-multiplexing layer, number of RB in the channel bandwidth and the subcarrier spacing used.  The physical channel bit rate per layer:  Where:  is the number of bits per modulation symbol :  2 dB for QPSK  4 dB for 16QAM  6 dB for 64QAM  8 dB for 256QAM  μ depends on the subcarrier spacing, Δ𝑓, given by | The bit rate of the physical channel depends on the modulation mode, code rate, number of spatial streams, number of valid data subcarriers and FFT size of channel bandwidth, cyclic prefix (CP) length, and subcarrier spacing. For each spatial stream, the bit rate of the physical channel can be expressed as  R\_c is the coding rate.  N\_BPSC is the number of the bits used by each subcarrier modulation symbol (BPSK&SQPSK: 1, QPSK: 2, 16QAM: 4, 64QAM: 6, 256QAM: 8, 1024QAM: 10)  -N\_SD is the number of valid data subcarriers. NFFT is the FFT size of the channel bandwidth. NCP is the cyclic prefix length.  -∆f is the subcarrier spacing. Please refer to section 5.2.3.2.7.  -N\_ss is number of spatial streams. |
| Applications and services support with various bit rate requirements | For a given combination of modulation scheme, code rate, and number of spatial-multiplexing layers, the data rate available to a user can be controlled through assigning different number of RB for the transmission.  For multiple services, the available/assigned resource and ,thus, the available data rate is shared between the rvices. | For a given combination of modulation scheme, code rate, and number of spatial-multiplexing  layers, the data rate available to a user can be controlled by the scheduler by assigning different number of resource blocks for the transmission. In case of multiple services, the  available/assigned resource, and thus the available data rate, is shared between the services. | For the nominal ,the proposed RIT layer 1 supports 145 different data rates in [120 Kbps – 1.1 Gbps]. Lower data rates are associated with more robust transmission characteristics.  Higher data rates require more favourable link conditions and tighter system specifications.  For the data rates are up to 8.6 Gbps can be supported with FFT size = 1024. | For a given combination of modulation scheme, code rate, and number of spatial-multiplexing layers, the data rate available to a user can be controlled through assigning different number of RB for the transmission.  For multiple services, the available/assigned resource and ,thus, the available data rate is shared between the rvices. | For the specified combinations of modulation modes, code rates and spatial multiplexing layers, the scheduler can control the effective data rates of users by allocating different resource unit (subcarrier set) quantities. When there are multiple services, the allocable resources and the available resource-based data rates can be shared by all the services. |
| Handover | Inter-System HO: - supported between 5G Core Network and EPC. - HO between NR in 5GC and E-UTRA in EPC is supported via inter-RAT HO. - HO between E-UTRA in 5GC and E-UTRA in EPC is supported via intra- E-UTRA HO with change of CN type. - The source eNB/ng-eNB decides HO procedure to trigger. -UE has to know the target CN type from the HO command during intra-LTE inter-System HO, intra-LTE intra-System HO.  Intra-System HO:  Intra-NR HO: network controlled mobility applies to UE in RRC\_Connected and is categorized in 2 types: - Cell level mobility: requires explicit RRC signaling to be triggered. - Beam level mobility: doesn’t require RRC signaling to be triggered (dealt at lower layers), RRC not required to know which beam is being used.  Data forwarding, in-sequence delivery and duplication avoidance at handover can be guaranteed between target gNB and source gNB.  Intra-RAT HO:  - Intra 5GC inter RAT mobility is supported between NR and E-UTRA. - Inter RAT measurements in NR are limited to E-UTRA and the source RAT should be able to support and configure Target RAT measurement and reporting.  - The in-sequence and lossless handover is supported for the handover between gNB and ng-eNB.  - Both Xn and NG based inter-RAT handover between NG-RAN nodes is supported. Whether the handover is over Xn or CN is transparent to the UE. -The target RAT receives the UE NG-C context information and based on this information configures the UE with a complete RRC message and Full configuration .  Measurement  In RRC\_CONNECTED, the UE measures multiple beams (N best beams above an absolute threshold) of a cell and average it to derive cell quality.  Filtering takes place at two different levels: at the physical layer to derive beam quality and then at RRC level to derive cell quality from multiple beams.  Cell quality from beam measurements is derived in the same way for the serving cell(s) and for the non-serving cell(s).  Measurement reports may contain the measurement results of the X best beams if the UE is configured to do so by the gNB | See pages 13-14 for inter- and intra-system handover. | Intra-System handover - Intra-System handover may be intra-cell or inter cell.  - Intra-cell handover may be controlled by either the PP or the FP and triggered when quality on allocated carrier-slot-combinations becomes poor and other free carrier-slot-combinations exist.  - Detection of free carrier-slot-combinations is based on a spectrum sensing paradigm and takes into account the activity of other uncoordinated systems. Seamless handover is supported. The PP sends a handover-request to the FP on the selected random access channel. If the FP accepts the request, then it indicates the position of the new traffic channel and the data will be switched over. After that the old channel will be released.  Inter-cell handover is generally controlled by the PP and triggered when quality on allocated carrier-slot combinations  becomes poor and another suitable FP is becoming stronger. Seamless handover is supported.  The PP sends a handover-request to the new FP on the selected random access channel. If the FP accepts the  request, then it indicates the position of the new traffic channel and the data will be switched over. After that the old channel will be released.  Inter-System handover (for proposed IMT-2020 RIT):  Inter-System handover is performed in the same way as inter-cell handover. Seamless handover is supported.  Both systems should be interconnected by the proper network infrastructure.  Inter-System handover to other IMT systems (other than IMT-2020)  Inter-System handover to IMT-2000 TDMA FDMA (DECT) is supported.  Handover to IMT-2000 TDMA FDMA is controlled by the PP and triggered when another suitable FP  becomes stronger. Seamless handover is supported. The PP sends a handover-request to the FP on the  selected channel. After the new connection is confirmed by the FP, the data is switched over to the new  connection and the old one is released. Both systems should be interconnected by the proper network  infrastructure. | Inter-System HO: - supported between 5G Core Network and EPC. - HO between NR in 5GC and E-UTRA in EPC is supported via inter-RAT HO. - HO between E-UTRA in 5GC and E-UTRA in EPC is supported via intra- E-UTRA HO with change of CN type. - The source eNB/ng-eNB decides HO procedure to trigger. -UE has to know the target CN type from the HO command during intra-LTE inter-System HO, intra-LTE intra-System HO.  Intra-System HO:  Intra-NR HO: network controlled mobility applies to UE in RRC\_Connected and is categorized in 2 types: - Cell level mobility: requires explicit RRC signaling to be triggered. - Beam level mobility: doesn’t require RRC signaling to be triggered (dealt at lower layers), RRC not required to know which beam is being used.  Data forwarding, in-sequence delivery and duplication avoidance at handover can be guaranteed between target gNB and source gNB.  Intra-RAT HO:  - Intra 5GC inter RAT mobility is supported between NR and E-UTRA. - Inter RAT measurements in NR are limited to E-UTRA and the source RAT should be able to support and configure Target RAT measurement and reporting.  - The in-sequence and lossless handover is supported for the handover between gNB and ng-eNB.  - Both Xn and NG based inter-RAT handover between NG-RAN nodes is supported. Whether the handover is over Xn or CN is transparent to the UE. -The target RAT receives the UE NG-C context information and based on this information configures the UE with a complete RRC message and Full configuration .  Measurement  In RRC\_CONNECTED, the UE measures multiple beams (N best beams above an absolute threshold) of a cell and average it to derive cell quality.  Filtering takes place at two different levels: at the physical layer to derive beam quality and then at RRC level to derive cell quality from multiple beams.  Cell quality from beam measurements is derived in the same way for the serving cell(s) and for the non-serving cell(s).  Measurement reports may contain the measurement results of the X best beams if the UE is configured to do so by the gNB | See 5.2.3.2.5 for inter- and intra-system handover. |
| Radio resource management | NR performs radio resource management.  RRM functions include:  - Radio bearer control (RBC): the establishment, maintenance and release of radio bearer involves the configuration of radio resource. This is located in gNB/ng-eNB.  - Radio Admission Control (RAC): RAC is to admit or reject the establishment of new radio bearer. It considers QoS requirement, the priority level, overall resource situation.  This is located in gNB/ng-eNB.  - Connection Mobility Control (CMC): it controls the number of UEs in idle mode and connected mode. In idle mode, cell reselection algorithm is controlled by parameter  setting and in the connected mode, gNB controls UE mobility via handover and RRC  connection release with redirection.  Dynamic/flexible radio resource management  NR supports dynamic and flexible radio resource management by packet scheduling that  allocates and de-allocates resources to user and control plane packets.  Load balancing(LB)  Load balancing has the task to handle uneven distribution of the traffic load over multiple cells.  The purpose of LB is thus to influence the load distribution for the higher resource utilization and  QoS. LB is achieved in NR with hand-over, redirection or cell reselection. | For both LTE and NR:  General:  LTE/NR performs radio resource management to ensure the efficient use of the available radio  resource. RRM functions include:  - Radio bearer control (RBC): the establishment, maintenance and release of radio bearer  involves the configuration of radio resource. This is located in gNB/ng-eNB.  - Radio Admission Control (RAC): RAC is to admit or reject the establishment of new radio bearer. It considers QoS requirement, the priority level, overall resource situation.  This is located in gNB/ng-eNB.  - Connection Mobility Control (CMC): it controls the number of UEs in idle mode and connected mode. In idle mode, cell reselection algorithm is controlled by parameter setting and in the connected mode, gNB controls UE mobility via handover and RRC  connection release with redirection.  Dynamic/flexible radio resource management  LTE/NR supports dynamic and flexible radio resource management by packet scheduling that allocates and de-allocates resources to user and control plane packets.  Load balancing (LB)  Load balancing has the task to handle uneven distribution of the traffic load over multiple cells.  The purpose of LB is thus to influence the load distribution for the higher resource utilization and  QoS. LB is achieved in NR with hand-over, redirection or cell reselection. | Radio resource management is based on the implementation of the cognitive radio, spectrum sensing paradigm and is able to take into account the activity of other systems –coordinated or uncoordinated operating in the same area.  Channels are automatically selected and allocated based on measurement of background RSSI.  The FP may also take into account carrier slot positions in order to allocate the most convenient resource blocks for system efficiency.  Both FP and PP participate in the process. No radio planning is needed in any case. | NR performs radio resource management.  RRM functions include:  - Radio bearer control (RBC): the establishment, maintenance and release of radio bearer involves the configuration of radio resource. This is located in gNB/ng-eNB.  - Radio Admission Control (RAC): RAC is to admit or reject the establishment of new radio bearer. It considers QoS requirement, the priority level, overall resource situation.  This is located in gNB/ng-eNB.  - Connection Mobility Control (CMC): it controls the number of UEs in idle mode and connected mode. In idle mode, cell reselection algorithm is controlled by parameter  setting and in the connected mode, gNB controls UE mobility via handover and RRC  connection release with redirection.  Dynamic/flexible radio resource management  NR supports dynamic and flexible radio resource management by packet scheduling that  allocates and de-allocates resources to user and control plane packets.  Load balancing(LB)  Load balancing has the task to handle uneven distribution of the traffic load over multiple cells.  The purpose of LB is thus to influence the load distribution for the higher resource utilization and  QoS. LB is achieved in NR with hand-over, redirection or cell reselection. | The RRM mechanism is implemented based on the following methods  General  The RRM functions in EUHT system include:  - Radio connection control: CAPs can establish, modify and release radio connection.  - Admission Control: The CAPs can manage admission control by the priority access control and the load balancing strategy.  - Mobility Management: The CAPs can support mobility by cell reselection, handover and multi-connection.  Dynamic/flexible radio resource management  EUHT supports the dynamic and flexible radio resource management. It allocates the resources to data and controls the transmission of the plane packets by scheduling the packets.  Load balancing (LB)  EUHT supports load balancing functions. When a cell is overloaded, the access control can be realized by means of RACH back off, or by connecting, releasing and redirecting it to other cells.  EUHT-higher frequency bands can support load balancing among different beams, which is mainly implemented by scheduling. |
| Frame structure | Frame length, sub-carrier spacing, and time slots:  One radio frame of length 10 ms consisting of 10 subframes, each of length 1 ms.  Each subframe consists of an OFDM sub-carrier spacing dependent number of slots.  Each slot consists of 14 OFDM symbols (twelve OFDM symbols in case of extended cyclic prefix)  - 15 kHz SCS: 1 ms slot, 1 slot per sub-frame  - 30 kHz SCS: 0.5 ms slot, 2 slots per sub-frame  - 60 kHz SCS: 0.25 ms slot, 4 slots per sub-frame  - 120 kHz SCS: 0.125 ms slot, 8 slots per sub-frame  - 240 kHz SCS: 0.0625 ms slot (only used for synchronization, not for data)  Data transmissions can be scheduled on a slot basis, as well as on a partial slot basis, where the partial slot transmissions that may occur several times within one slot. The supported partial slot allocations and scheduling intervals are 2, 4 and 7 symbols for normal cyclic prefix, and 2, 4 and 6 symbols for extended cyclic prefix.  The slot structure supports zero, one or two DL/UL switches per slot, and dynamic selection of the link direction for each slot independently. Typically one symbol would be allocated as guard, but different number of symbols, or even full slot could be allocated as guard.  Downlink control channel structure:  Downlink control signaling is time and frequency multiplexed with data on a scheduling interval  basis. The control region can span over 1-3 OFDM symbols in the beginning of the allocation,  flexibly allocating 1-14 symbols for data transmission, including the time and frequency part of the control region that was not used for control signaling.  Uplink control channel structure:  Uplink control signaling can be both time-multiplexed with the data of the same UE and time and  frequency multiplexed with control and data of other UEs when the UE has no data to be  transmitted. Uplink control signaling is piggy-backed with data i.e. transmitted with data on the PUSCH when the UE has data to be transmitted.  Power control bit rate:  No specific power-control rate is defined, but a power control command can be sent at any slot, leading to a sub-carrier spacing specific maximum power control rate of 1/2/4/8 kHz for SCS of 15/30/60/120 kHz respectivel | Pages 17,18,19 (frame length, number of time slots per frame, sub-carrier spacing, power control bit rate, etc). | The basic frame structure consists of 24 time slots in 10 ms (for 27 kHz sub-carrier spacing). Half slots can be used for some services. Slots can be concatenated to form multi-slot transmissions. Any slot can be used  for uplink or downlink transmission (i.e. there is no pre-set direction for the slot). When there is a change in the source of the transmission, then a guard space is used. Several transmissions to/from different PPs may occur simultaneously on non-overlapping channels. The transmissions are scheduled in such a way that none of the devices is required to transmit and receive simultaneously. For higher sub-carrier spacing the number  of slots per frame can vary accordingly. The frame structure parameters for 27 kHz sub-carrier spacing are summarized in Table 5 page 13. | Frame length, sub-carrier spacing, and time slots:  One radio frame of length 10 ms consisting of 10 subframes, each of length 1 ms.  Each subframe consists of an OFDM sub-carrier spacing dependent number of slots.  Each slot consists of 14 OFDM symbols (twelve OFDM symbols in case of extended cyclic prefix)  - 15 kHz SCS: 1 ms slot, 1 slot per sub-frame  - 30 kHz SCS: 0.5 ms slot, 2 slots per sub-frame  - 60 kHz SCS: 0.25 ms slot, 4 slots per sub-frame  - 120 kHz SCS: 0.125 ms slot, 8 slots per sub-frame  - 240 kHz SCS: 0.0625 ms slot (only used for synchronization, not for data)  Data transmissions can be scheduled on a slot basis, as well as on a partial slot basis, where the partial slot transmissions that may occur several times within one slot. The supported partial slot allocations and scheduling intervals are 2, 4 and 7 symbols for normal cyclic prefix, and 2, 4 and 6 symbols for extended cyclic prefix.  The slot structure supports zero, one or two DL/UL switches per slot, and dynamic selection of the link direction for each slot independently. Typically one symbol would be allocated as guard, but different number of symbols, or even full slot could be allocated as guard.  Downlink control channel structure:  Downlink control signaling is time and frequency multiplexed with data on a scheduling interval  basis. The control region can span over 1-3 OFDM symbols in the beginning of the allocation,  flexibly allocating 1-14 symbols for data transmission, including the time and frequency part of the control region that was not used for control signaling.  Uplink control channel structure:  Uplink control signaling can be both time-multiplexed with the data of the same UE and time and  frequency multiplexed with control and data of other UEs when the UE has no data to be  transmitted. Uplink control signaling is piggy-backed with data i.e. transmitted with data on the PUSCH when the UE has data to be transmitted.  Power control bit rate:  No specific power-control rate is defined, but a power control command can be sent at any slot, leading to a sub-carrier spacing specific maximum power control rate of 1/2/4/8 kHz for SCS of 15/30/60/120 kHz respectivel | The frame structure related information is as follows:  For IMT bands:  ‐ The physical frame length can be dynamically adjusted within the permissible range (0.1-14ms). Typical frame length can be: 1, 1.25, 1.6, 2, 2.5, 4, 5, 6.25, 8 and 10ms.  ‐Typical physical frame consists of a downlink scheduling period and an uplink scheduling period. The downlink scheduling period consists of one short preamble symbol, one long preamble symbol, one SICH symbol, the CCHs, the DL-TCH, DL-SCH and the DGI. The uplink scheduling period consists of the UL-SCH, the UL-SRCH, the UL-TCH, UL-RACH and the UGI. The system information channel broadcasts frame structure. It can allocate the uplink and downlink service channels and short signalling resources in the frame. The minimum resource allocation unit is resource unit (RU), which is 16 sub-carriers in single OFDM symbol.  ‐The sub-carrier spacing is 78.125KHz (39.0625KHz/19.53KHz is optional).  ‐The ratio of the cyclic prefix is 1/8 or 1/4 of DFT length, so the time length of CP is correspondingly 0.8us or 1.6us.  ‐The DL/UL ratio can be adjusted flexibly according to the real scenarios. The typical values of the uplink and downlink guard interval time lengths respectively occupy two symbols. However, other different symbol lengths can be used too.  ‐The length of the CCH is also variable and contains at least 2 OFDM symbols.  No specific power control rate is defined. However, the power control signalling, which supports the open-loop power control and the close-loop power control, can be transmitted in any frame. Maximum power control rate is 10 kHz for 0.1ms frame.  For higher frequency bands:  ‐Each radio frame length is 20ms. It consists of two types of sub-frames. The length of the SICH/RACH sub-frame is 1ms and the length of the TCH sub-frame is 1ms. The sub-frames use the single carrier mode and the OFDM mode to transmit. In the OFDM mode, the number of the DFT points is 1024. The sub-carrier spacing is 390.625 kHz. The cycle prefix (CP) ratio is 1/4 or 1/8. The SICH/RACH sub-frame uses the single carrier transmission mode and it is used in the beam training and the communication connection establishment. The SICH/RACH sub-frame uses at most 64 different beams to transmit. The SICH/RACH sub-frame contains a frame header (which is used in frame detection, synchronization, frequency offset estimation, AGC and STA RX beam training, AGC) and the information part of the SICH.  ‐The TCH sub-frame uses the OFDM mode to transmit. The TCH sub-frame is used in the transmission of the uplink and downlink data. Meanwhile, it is used for channel tracking and beam tracking.  ‐ The TCH sub-frame length can be dynamically adjusted within the permissible range (0.1-10ms). Typical frame length can be: 1,2,5,10ms.  ‐The TCH sub-frame contains the downlink transmission period (DL-preamble, DRS, CCH, DL-TCH, DL-TRN), the uplink transmission period (UL-preamble, UL-TCH, UL-TRN) and the guard intervals. The DL/UL ratio is configured through the CCH. The guard interval occupies two symbols.  Control channel structure:  ‐The CCH is transmitted in a specified time-frequency domain, which spans over 2-30 OFDM symbols.  ‐Power control bit rate:  No specific power control rate is defined. However, the power control signalling, which supports the open-loop power control and the close-loop power control, can be transmitted in any frame. Maximum power control rate is 1 kHz for 1ms frame. |
| Frequency bands supported by the RIT/SRIT | 450-6000Mhz:  Band number n1: - UL band: 1920 – 1980 MHz  - DL band: 2110 – 2170 MHz  Band number n2: - UL band: 1850 – 1910 MHz  - DL band: 1930 – 1990 MHz  Band number n3: - UL band: 1710 – 1785 MHz  - DL band: 1805 – 1880 MHz  Band number n5: - UL band: 824 – 849 MHz  - DL band: 869 – 894 MHz  Band number n7: - UL band: 2500 – 2570 MHz  - DL band: 2620 – 2690 MHz  Band number n8: - UL band: 880 – 915 MHz  - DL band: 925 – 960 MHz  Band number n20: - UL band: 832 – 862 MHz  - DL band: 791 – 821 MHz  Band number n28: - UL band: 703 – 748 MHz  - DL band: 758 – 803 MHz  Band number n38: - UL band: 2570 – 2620 MHz  - DL band: 2570 – 2620 MHz  Band number n41: - UL band: 2496 – 2690 MHz  - DL band: 2496 – 2690 MHz  Band number n50: - UL band: 1432 – 1517 MHz  - DL band: 1432 – 1517 MHz  Band number n51: - UL band: 1427 – 1432 MHz  - DL band: 1427 – 1432 MHz  Band number n66: - UL band: 1710 – 1780 MHz  - DL band: 2110 – 2200 MHz  Band number n70: - UL band: 1695 – 1710 MHz  - DL band: 1995 – 2020 MHz  Band number n71: - UL band: 663 – 698 MHz  - DL band: 617 – 652 MHz  Band number n74: - UL band: 1427 – 1470 MHz  - DL band: 1475 – 1518 MHz  Band number n75: - UL band: NA  - DL band: 1432 – 1517 MHz  Band number n76: - UL band: NA  - DL band: 1427 – 1432 MHz  Band number n77: - UL band: 3.3 – 4.2 GHz  - DL band: 3.3 – 4.2 GHz  Band number n78: - UL band: 3.3 – 3.8 GHz  - DL band: 3.3 – 3.8 GHz  Band number n79: - UL band: 4.4 – 5 GHz  - DL band: 4.4 – 5 GHz  Band number n80: - UL band: 1710 – 1785 MHz  - DL band: NA  Band number n81: - UL band: 880 – 915 MHz  - DL band: NA  Band number n82: - UL band: 832 – 862 MHz  - DL band: NA  Band number n83: - UL band: 703 – 748 MHz  - DL band: NA  Band number n84: - UL band: 1920 – 1980 MHz  - DL band: NA  Band number n86: - UL band: 2496 – 2960 MHz  - DL band: NA  24250-52600Mhz:  Band number n257: - UL band: 26.5 – 29.5 GHz  - DL band: 26.5 – 29.5 GHz  Band number n258: - UL band: 24.25 – 27.5 GHz  - DL band: 24.25 – 27.5 GHz Band number n260: - UL band: 37 – 40 GHz  - DL band: 37 – 40 GHz | Tables on pages 21-22-23 | The candidate RIT is designed to operate over:  1) The frequency band currently allocated to DECT service (1880 MHz – 1900 MHz)  2) The frequency bands currently allocated to IMT-2000 FT service (1900 MHz – 1980 MHz and 2010 MHz – 2025 MHz)  3) Any other frequency band that may be allocated in the future to the service, including bands above 24.25 GHz  In particular license exempt frequencies at 5 GHz band have been considered as possible | 450-6000Mhz:  Band number n1: - UL band: 1920 – 1980 MHz  - DL band: 2110 – 2170 MHz  Band number n2: - UL band: 1850 – 1910 MHz  - DL band: 1930 – 1990 MHz  Band number n3: - UL band: 1710 – 1785 MHz  - DL band: 1805 – 1880 MHz  Band number n5: - UL band: 824 – 849 MHz  - DL band: 869 – 894 MHz  Band number n7: - UL band: 2500 – 2570 MHz  - DL band: 2620 – 2690 MHz  Band number n8: - UL band: 880 – 915 MHz  - DL band: 925 – 960 MHz  Band number n20: - UL band: 832 – 862 MHz  - DL band: 791 – 821 MHz  Band number n28: - UL band: 703 – 748 MHz  - DL band: 758 – 803 MHz  Band number n38: - UL band: 2570 – 2620 MHz  - DL band: 2570 – 2620 MHz  Band number n41: - UL band: 2496 – 2690 MHz  - DL band: 2496 – 2690 MHz  Band number n50: - UL band: 1432 – 1517 MHz  - DL band: 1432 – 1517 MHz  Band number n51: - UL band: 1427 – 1432 MHz  - DL band: 1427 – 1432 MHz  Band number n66: - UL band: 1710 – 1780 MHz  - DL band: 2110 – 2200 MHz  Band number n70: - UL band: 1695 – 1710 MHz  - DL band: 1995 – 2020 MHz  Band number n71: - UL band: 663 – 698 MHz  - DL band: 617 – 652 MHz  Band number n74: - UL band: 1427 – 1470 MHz  - DL band: 1475 – 1518 MHz  Band number n75: - UL band: NA  - DL band: 1432 – 1517 MHz  Band number n76: - UL band: NA  - DL band: 1427 – 1432 MHz  Band number n77: - UL band: 3.3 – 4.2 GHz  - DL band: 3.3 – 4.2 GHz  Band number n78: - UL band: 3.3 – 3.8 GHz  - DL band: 3.3 – 3.8 GHz  Band number n79: - UL band: 4.4 – 5 GHz  - DL band: 4.4 – 5 GHz  Band number n80: - UL band: 1710 – 1785 MHz  - DL band: NA  Band number n81: - UL band: 880 – 915 MHz  - DL band: NA  Band number n82: - UL band: 832 – 862 MHz  - DL band: NA  Band number n83: - UL band: 703 – 748 MHz  - DL band: NA  Band number n84: - UL band: 1920 – 1980 MHz  - DL band: NA  Band number n86: - UL band: 2496 – 2960 MHz  - DL band: NA  24250-52600Mhz:  Band number n257: - UL band: 26.5 – 29.5 GHz  - DL band: 26.5 – 29.5 GHz  Band number n258: - UL band: 24.25 – 27.5 GHz  - DL band: 24.25 – 27.5 GHz Band number n260: - UL band: 37 – 40 GHz  - DL band: 37 – 40 GHz | See IMT bands and EUHT higher frequency bands tables in 5.2.3.2.8.3 |
| Minimum amount of spectrum required to deploy a contiguous network,  including guardbands (MHz)? | The minimum amount of paired spectrum is 2 x 5 MHz.  The minimum amount of unpaired spectrum is 5 MHz. | For NR component RIT:  The minimum amount of paired spectrum is 2 x 5 MHz. The minimum amount of unpaired  spectrum is 5 MHz.  For LTE component RIT:  The minimum amount of paired spectrum is 2 x 1.4 MHz, and the minimum amount of unpaired  spectrum is 1.4 MHz, except for NB-IoT.  For NB-IoT, the minimum amount of spectrum is 0.2 MHz. | Minimum practical spectrum for a contiguous network is assumed to be 10 MHz.  Operation over 5 MHz may be possible with certain restrictions.  In EU region, 20 MHz are assumed to be available as minimum spectrum | The minimum amount of paired spectrum is 2 x 5 MHz.  The minimum amount of unpaired spectrum is 5 MHz. | For IMT bands:  The minimum spectrum bandwidth is 5MHz.  For higher frequency bands: The minimum spectrum bandwidth is 50MHz. |
| Minimum and maximum transmission bandwidth (MHz) measured at the 3dB down points | The 3 dB bandwidth is not part of the specifications, however:  The minimum 99% channel bandwidth (occupied bandwidth of single component carrier)  Is: - 5 MHz for frequency range 450 – 6000 MHz; - 50 MHz for frequency range 24250 – 52600 MHz  The maximum 99% channel bandwidth (occupied bandwidth of single component carrier) is: -100 MHz for frequency range 450 – 6000 MHz. - 400 MHz for frequency range 24250 – 52600 MHz.  Multiple component carriers can be aggregated to achieve up to 6.4 GHz of transmission bandwidth | For NR component RIT:  The 3 dB bandwidth is not part of the specifications, however:  - The minimum 99% channel bandwidth (occupied bandwidth of single component carrier) is:  o 5 MHz for frequency range 450 – 6000 MHz;  o 50 MHz for frequency range 24250 – 52600 MHz  - The maximum 99% channel bandwidth (occupied bandwidth of single component carrier) is:  o 100 MHz for frequency range 450 – 6000 MHz;  o 400 MHz for frequency range 24250 – 52600 MHz.  - Multiple component carriers can be aggregated to achieve up to 6.4 GHz of transmission  bandwidth.  For LTE component RIT:  The 3 dB bandwidth is not part of the specifications, however:  - The minimum 99% channel bandwidth (occupied bandwidth of single component carrier) is 1.4 MHz.  - The maximum 99% channel bandwidth (occupied bandwidth of single component carrier) is 20 MHz.  - Multiple component carriers can be aggregated to achieve up to 640 MHz of transmission bandwidth.  For NB-IoT, the minimum 99% channel bandwidth is 0.2 MHz. | Minimum transmission bandwidth is about 1.512 MHz.  Maximum transmission bandwidth if : - sub-carrier spacing then 27 MHz  - then 216 MHz. | The 3 dB bandwidth is not part of the specifications, however:  The minimum 99% channel bandwidth (occupied bandwidth of single component carrier)  Is: - 5 MHz for frequency range 450 – 6000 MHz; - 50 MHz for frequency range 24250 – 52600 MHz  The maximum 99% channel bandwidth (occupied bandwidth of single component carrier) is: -100 MHz for frequency range 450 – 6000 MHz. - 400 MHz for frequency range 24250 – 52600 MHz.  Multiple component carriers can be aggregated to achieve up to 6.4 GHz of transmission bandwidth | For IMT bands:  The 3dB bandwidth is BW=20MHz: 9.3\*2=18.6MHz.  BW=40MHz: 19.3\*2=38.6MHz  BW=80MHz: 39.3\*2=78.6MHz  For higher frequency bands: BW = 400MHz: The 3dB bandwidth is 375MHz.. |
| Duplexing schemes | NR supports paired and unpaired spectrum and allows : - FDD operation on a paired spectrum, different transmission directions in either part of a paired spectrum.  - TDD operation on an unpaired spectrum where the transmission direction of time resources is not dynamically changed, and TDD operation on an unpaired spectrum where the transmission direction of most time resources can be dynamically changing.  DL and UL transmission directions for data can be dynamically assigned on a per-slot basis.  For FDD operation, it supports full-duplex FDD. - For both base station and terminal, a duplexer is needed for full-duplex FDD. - For full-duplex FDD, the required transmit/receive isolation is a UE function of: the Tx emission mask (emission level on the Rx frequency) , the TX-Rx frequency spacing , the Tx- Rx duplex filter isolation, the TX and RX configuration (RB location, RB power and RB allocation) and the required Rx desense criteria. - For the supported operating bands, the parameters including the minimum (up/down) Tx to Rx frequency separation and the minimum Tx-Rx band gap are being defined in 3GPP.  For different transmission directions in either part of a paired spectrum, a duplexer is needed for both base station and the terminal. The required frequency separation between the paired spectrum is the same as full-duplex FDD. The supported DL/UL resource assignment configurations for TDD can be applied.  For TDD operation, it supports variable DL/UL resource assignment ranging in a radio frame from 10/0 (ten downlink slots and no uplink slot) to 0/10 (no downlink slot and ten uplink slots). It also supports a slot with DL part and UL part. DL and UL transmission directions for data can be dynamically assigned on a per-slot basis. Adjacent cells using the same carrier frequency can use the same or different DL/UL resource assignment configuration. - For both the base station and the terminal, duplexer is not needed. - The TDD guard time is configurable to meet different deployment scenarios. | Pages 24-25 | The proposed RIT utilizes both TDD and FDD on contiguous or non-contiguous frequency segments.  Frequency segments and time slots are allocated to PP devices for DL and UL transmissions by the FP device.  FP devices can transmit (DL) or receive (UL) on contiguous or non-contiguous frequency segments.  PP devices can transmit (DL) or receive (UL) on contiguous frequency segments only.  At each slot time and across all allocated segments, the FP device can be either in UL mode or in DL mode but not both. | NR supports paired and unpaired spectrum and allows : - FDD operation on a paired spectrum, different transmission directions in either part of a paired spectrum.  - TDD operation on an unpaired spectrum where the transmission direction of time resources is not dynamically changed, and TDD operation on an unpaired spectrum where the transmission direction of most time resources can be dynamically changing.  DL and UL transmission directions for data can be dynamically assigned on a per-slot basis.  For FDD operation, it supports full-duplex FDD. - For both base station and terminal, a duplexer is needed for full-duplex FDD. - For full-duplex FDD, the required transmit/receive isolation is a UE function of: the Tx emission mask (emission level on the Rx frequency) , the TX-Rx frequency spacing , the Tx- Rx duplex filter isolation, the TX and RX configuration (RB location, RB power and RB allocation) and the required Rx desense criteria. - For the supported operating bands, the parameters including the minimum (up/down) Tx to Rx frequency separation and the minimum Tx-Rx band gap are being defined in 3GPP.  For different transmission directions in either part of a paired spectrum, a duplexer is needed for both base station and the terminal. The required frequency separation between the paired spectrum is the same as full-duplex FDD. The supported DL/UL resource assignment configurations for TDD can be applied.  For TDD operation, it supports variable DL/UL resource assignment ranging in a radio frame from 10/0 (ten downlink slots and no uplink slot) to 0/10 (no downlink slot and ten uplink slots). It also supports a slot with DL part and UL part. DL and UL transmission directions for data can be dynamically assigned on a per-slot basis. Adjacent cells using the same carrier frequency can use the same or different DL/UL resource assignment configuration. - For both the base station and the terminal, duplexer is not needed. - The TDD guard time is configurable to meet different deployment scenarios. | • EUHT supports the TDD mechanism in both paired and unpaired spectrum.  • The TDD guard time interval is configurable to meet different usage scenarios.  • The DL/UL ratio is configurable in unit of OFDM symbol per frame basis. |
| Support of Advanced antenna capabilities and spatial multiplexing | The multi-antenna systems in NR supports the following MIMO transmission schemes at both the UE and the base station: - Spatial multiplexing with DM-RS based closed loop, open loop and semi-open loop transmission schemes are supported. For DL, codebook and reciprocity based precoding are supported. For UL, codebook and non-codebook based transmission are supported.  - Spatial transmit diversity is supported by using specification transparent diversity schemes. - Hybrid beamforming including both digital and analog beamforming is supported. Beam management with periodic and aperiodic beam refinement is also supported.  NR supports  -DL: 1,2,4,8,12,16,24,32 antenna port  -UL: 1,2,4 antenna port  Base Station and UE support rectangular antenna arrays.  The rectangular panel array antenna can be described by the following tuple where is the number of panels in a column, is the number of panels in row, 𝑀,𝑁 are the number of vertical, horizontal antenna elements within a panel and 𝑃 is number of polarizations per antenna element.  (see figure in page 60)  The spacing in vertical and horizontal dimensions between the panels is specified by and between antenna elements by .  NR specification is flexible to support various antenna spacing, number of antenna elements, antenna port layouts and antenna virtualization approaches.  In NR, special multiplexing is supported: - in DL: Single codeword is supported for 1-4 layer transmissions and two codewords are supported for 5-8 layer transmissions.  - in UL Only single codeword is supported for 1- 4 layer transmissions.  Both open and closed loop MIMO are supported in NR, where for demodulation of data, receiver does not require knowledge of the precoding matrix used at the transmitter.  Dynamic switching between different transmission schemes is also supported  Both single user and multi user MIMO are supported.  Single user MIMO transmissions:  - DL: up to 8 orthogonal DM-RS ports are supported  - UL : up to 4 orthogonal DMRS ports are supported.  Multi-user MIMO up to 12 orthogonal DM-RS ports with up to 4 orthogonal ports per UE are supported.  NR supports coordinated multipoint transmission/reception, which could be used to implement different forms of cooperative multi-antenna (MIMO) transmission schemes. | For NR component RIT:  The multi-antenna systems in NR supports the following MIMO transmission schemes at both the  UE and the base station:  ‐ Spatial multiplexing with DM-RS based closed loop, open loop and semi-open loop  transmission schemes are supported. Both codebook and non-codebook based  transmission is supported in DL and UL.  ‐ Spatial transmit diversity is supported by using specification transparent diversity schemes  ‐ Hybrid beamforming including both digital and analog beamforming is supported. Beam  management with periodic and aperiodic beam refinement is also supported.  For LTE component RIT  The multi-antenna systems in LTE supports the following MIMO transmission scheme at both the UE and the base station:  ‐ Spatial multiplexing with CRS and UE specific RS based closed loop, open loop and semiopen loop transmission schemes are supported. Both codebook and non-codebook based transmission is supported in DL. Codebook based transmission is supported in UL.  ‐ Spatial transmit diversity is supported based on space frequency block coding, frequency switched transmit diversity. Specification transparent diversity schemes are also supported  ‐ Hybrid beamforming including both digital and analog beamforming is supported. (pages 26-27 for further details) | The proposed RIT supports multiplexing of space-time streams with antenna configuration  ( and/or can be configured to increase diversity and/or to enable digital beamforming. Space-time Block Coding (STBC) is also supported (2 × 1 configuration).  Both FP and PP can be equipped with antennas where .  Target antenna spacing is λ/4, where λ is the wavelength of the carrier signal.  Antenna range supported by test models is  The proposed RIT supports: - Open and closed loop MIMO - Single-user MIMO and multi-user MIMO | The multi-antenna systems in NR supports the following MIMO transmission schemes at both the UE and the base station: - Spatial multiplexing with DM-RS based closed loop, open loop and semi-open loop transmission schemes are supported. For DL, codebook and reciprocity based precoding are supported. For UL, codebook and non-codebook based transmission are supported.  - Spatial transmit diversity is supported by using specification transparent diversity schemes. - Hybrid beamforming including both digital and analog beamforming is supported. Beam management with periodic and aperiodic beam refinement is also supported.  NR supports  -DL: 1,2,4,8,12,16,24,32 antenna port  -UL: 1,2,4 antenna port  Base Station and UE support rectangular antenna arrays.  The rectangular panel array antenna can be described by the following tuple where is the number of panels in a column, is the number of panels in row, 𝑀,𝑁 are the number of vertical, horizontal antenna elements within a panel and 𝑃 is number of polarizations per antenna element.  (see figure in page 60)  The spacing in vertical and horizontal dimensions between the panels is specified by and between antenna elements by .  NR specification is flexible to support various antenna spacing, number of antenna elements, antenna port layouts and antenna virtualization approaches.  In NR, special multiplexing is supported: - in DL: Single codeword is supported for 1-4 layer transmissions and two codewords are supported for 5-8 layer transmissions.  - in UL Only single codeword is supported for 1- 4 layer transmissions.  Both open and closed loop MIMO are supported in NR, where for demodulation of data, receiver does not require knowledge of the precoding matrix used at the transmitter.  Dynamic switching between different transmission schemes is also supported  Both single user and multi user MIMO are supported.  Single user MIMO transmissions:  - DL: up to 8 orthogonal DM-RS ports are supported  - UL : up to 4 orthogonal DMRS ports are supported.  Multi-user MIMO up to 12 orthogonal DM-RS ports with up to 4 orthogonal ports per UE are supported.  NR supports coordinated multipoint transmission/reception, which could be used to implement different forms of cooperative multi-antenna (MIMO) transmission schemes. | EUHT system multi-antenna system supports the following MIMO transmission mechanisms at both the STA and the CAP:  ‐ The spatial multiplexing of the DRS-based closed loop and semi-open loop transmission schemes is supported. For both DL and UL, the precoding based on CSI feedback and reciprocity is supported.  ‐ The CAP supports the transmit diversity.  ‐ For higher frequency bands, hybrid beamforming including both digital beamforming and analog beamforming is supported. Both the periodic beam refinement and the aperiodic beam refinement are supported at the STA side and the CAP side. |
| Synchronization requirements | Common general aspects  Tight BS-to-BS synchronization not required.  Tight BS-to-network synchronization not required.  BS support a logical synchronization port for phase-, time- and/or frequency synchronization. (read more page 68)  Common SFN initialization time shall be provided for all BSs in synchronized TDD area.  A certain RAN-CN Hyper SFN synchronization is required in case of extended Idle mode DRX.  Some accuracy requirements  BS transmit signals accuracy.  Cell phase synchronization accuracy:  - The cell phase synchronization accuracy measured at BS antenna connectors shall be better than 3μs.  the synchronization mechanisms  A UE receives the following  synchronization signals (SS) in order to perform cell search: the primary synchronization signal  (PSS) and secondary synchronization signal (SSS).  PSS used for initial symbol boundary, cyclic prefix, sub frame boundary, initial frequency synchronization to the cell.  SSS is used for radio frame boundary identification.  PSS and SSS together used for cell ID detection.  Other synchronization mechanisms are defined see more info in [38.213] subclause 4 and [38.211] subclause 7.4.2 | Common general aspects  Tight BS-to-BS synchronization is not required. Likewise, tight BS-to-network synchronization is not required.  The BS shall support a logical synchronization port for phase-, time- and/or frequency  synchronization, e.g. to provide.  - accurate maximum relative phase difference for all BSs in synchronized TDD area  - continuous time without leap seconds traceable to common time reference for all BSs in synchronized TDD area;  - FDD time domain inter-cell interference coordination.  Furthermore, common SFN initialization time shall be provided for all BSs in synchronized TDD area. A certain RAN-CN Hyper SFN synchronization is required in case of extended Idle mode DRX.  Some accuracy requirements  BS transmit signals accuracy:  - LTE: Frequency and timing accuracy of BS transmit signal is within ±0.05 ppm observed over a period of one subframe (1 ms).  - NR: The information will be provided in later update. Cell phase synchronization accuracy:  - NR: The cell phase synchronization accuracy measured at BS antenna connectors shall be better than [3] μs.  - LTE: for Wide Area BS (not considering Home BS), the cell phase synchronization accuracy measured at BS antenna connectors shall be better than 3 μs for small cells (radius up to 3km), 10 μs for large cells (radius above 3km). | Two synchronization mechanisms: Packet level synchronization and Frame synchronization.  Packet level synchronization: each packet contains a synchronization pattern. See figures 4 and 5 page 32  Frame synchronization: see figure 6 page 33. | Common general aspects  Tight BS-to-BS synchronization not required.  Tight BS-to-network synchronization not required.  BS support a logical synchronization port for phase-, time- and/or frequency synchronization. (read more page 68)  Common SFN initialization time shall be provided for all BSs in synchronized TDD area.  A certain RAN-CN Hyper SFN synchronization is required in case of extended Idle mode DRX.  Some accuracy requirements  BS transmit signals accuracy.  Cell phase synchronization accuracy:  - The cell phase synchronization accuracy measured at BS antenna connectors shall be better than 3μs.  the synchronization mechanisms  A UE receives the following  synchronization signals (SS) in order to perform cell search: the primary synchronization signal  (PSS) and secondary synchronization signal (SSS).  PSS used for initial symbol boundary, cyclic prefix, sub frame boundary, initial frequency synchronization to the cell.  SSS is used for radio frame boundary identification.  PSS and SSS together used for cell ID detection.  Other synchronization mechanisms are defined see more info in [38.213] subclause 4 and [38.211] subclause 7.4.2 | EUHT system supports three synchronization modes: the network synchronization based on the IEEE 1588v2 protocol, the GPS synchronization and the independently researched and developed photoelectric synchronization mechanism. These three modes backup each other. They can be switched flexibly and very high reliability can be achieved. Different base stations can reach the time synchronization accuracy of less than 1 us by adopting the network synchronization based on the IEEE 1588 V2 protocol. If the number of the arcades is small, the accuracy of 500 ns can be reached. The synchronization accuracy of the GPS mode is 500 ns. If the independently researched and developed photoelectric synchronization scheme is adopted, the synchronization accuracy of less than 1us can be reached. In short, the deployment of the current EUHT synchronization scheme is simple, reliable and accurate. In addition, the synchronization requirement of EUHT is also lower, no more than 4us.  EUHT adopts the half-duplex TDD mode. The synchronization between base stations and the synchronization mechanism between the base station and the network are needed.  EUHT adopts the PPS (plus per second) to achieve the inter-base-station frame synchronization and resist inter-cell Interference.  - It provides the common system frame number SFN to achieve the frame-level synchronization of the air interfaces and assist some operations such as network entry and handover.  -- It achieves the BS time synchronization through the Ethernet synchronization and provides absolute clock information for the system.  Accuracy requirements:  CAP transmit signal accuracy:  -Frequency accuracy: The frequency deviation is within ±0.5 ppm. The observation time is 1ms.  The cell phase synchronization accuracy measured at the CAP antenna connector is better than 3us. |
| Scheduling mechanisms | In NR physical control and shared channels can be separately and dynamically scheduled for both uplink and downlink. A scheduling unit for downlink shared channel may span from 2-14 symbols and for uplink shared channel from 1-14 symbols (14 symbols comprise a “slot”). Sub-carrier spacing for different physical channels may be dynamically changed by switching bandwidth-parts (BWP).  Typically, NR scheduling is based on the instantaneous radio-link quality as seen by the different users, and the traffic demand and quality-of-service requirements of individual users and in the cell as a whole. The former is based on CQI reports from the terminals (downlink) or measurements of sounding signals from the terminals (uplink). Based on this the base station may e.g. apply a proportional fair scheduling algorithm. The QoS assessment is supported by means of receiving QoS information from the “higher layers”.  For non-full buffer traffic like VOIP (or any traffic having similar characteristics) semi-persistent scheduling in DL can be applied, by which a user can be allocated time-frequency resources in a semi-persistent manner, i.e., fixed resources are allocated at certain intervals without L1/L2 control signaling each time. This is especially useful to reduce the L1/L2 control signaling overhead and to increase VoIP capacity. In addition, with UL Configured Grants, the scheduler can allocate uplink resources to users. When a configured uplink grant is active, if the user cannot find an uplink grant assigned via downlink control channel an uplink transmission according to the configured uplink grant can be made. Otherwise, if the user finds an uplink grant assigned via downlink control channel, this assignment overrides the configured uplink grant.  In general for TDD operation a slot may be used for dynamically allocating DL or UL transmissions or both.  NR supports slot aggregation in downlink and uplink, by which time-frequency resources can be allocated consecutively to a user for a longer period than a slot by a single L1/L2 control signaling. A larger transport block size or a lower coding rate can be supported by this technique. This is especially useful when the coverage needs to be extended.  As another option to extend coverage or improve reliability in addition to slot aggregation, a set of MCS tables supporting very low code rate for both DL and UL can be used.  The scheduler may pre-empt an ongoing transmission to one user with a latency-critical transmission to another user. The scheduler can configure users to monitor interrupted transmission indications. If a user receives the interrupted transmission indication, the user may assume that no useful information to that user was carried by the resource elements included in the indication, even if some of those resource elements were already scheduled to this user. Alternatively, instead of transmitting interruption indication, the scheduler may retransmit only the preempted code blocks to a UE and instruct to do proper transport block decoding with other already received code blocks.  For the downlink and the uplink, intercell-interference coordination can be realized by the scheduler that is transparent to the physical layer. | For NR component RIT:  In NR physical control and shared channels can be separately and dynamically scheduled for both uplink and downlink. A scheduling unit for downlink shared channel may span from 2-14 symbols and for uplink shared channel from 1-14 symbols (14 symbols comprise a “slot”). Sub-carrier spacing for different physical channels may be dynamically changed by switching bandwidth-parts (BWP).  Typically, NR scheduling is based on the instantaneous radio-link quality as seen by the different users, and the traffic demand and quality-of-service requirements of individual users and in the cell as a whole. The former is based on CQI reports from the terminals (downlink) or measurements of sounding signals from the terminals (uplink). Based on this the base station may e.g. apply a proportional fair scheduling algorithm. The QoS assessment is supported by means of receiving QoS information from the “higher layers”.  For non-full buffer traffic like VOIP (or any traffic having similar characteristics) semi-persistent scheduling in DL can be applied, by which a user can be allocated time-frequency resources in a semi-persistent manner, i.e., fixed resources are allocated at certain intervals without L1/L2 control signaling each time. This is especially useful to reduce the L1/L2 control signaling overhead and to increase VoIP capacity. In addition, with UL Configured Grants, the scheduler can allocate uplink resources to users. When a configured uplink grant is active, if the user cannot find an uplink grant assigned via downlink control channel an uplink transmission according to the configured uplink grant can be made. Otherwise, if the user finds an uplink grant assigned via downlink control channel, this assignment overrides the configured uplink grant.  In general for TDD operation a slot may be used for dynamically allocating DL or UL transmissions or both.  NR supports slot aggregation in downlink and uplink, by which time-frequency resources can be allocated consecutively to a user for a longer period than a slot by a single L1/L2 control signaling. A larger transport block size or a lower coding rate can be supported by this technique. This is especially useful when the coverage needs to be extended.  As another option to extend coverage or improve reliability in addition to slot aggregation, a set of MCS tables supporting very low code rate for both DL and UL can be used.  The scheduler may pre-empt an ongoing transmission to one user with a latency-critical transmission to another user. The scheduler can configure users to monitor interrupted transmission indications. If a user receives the interrupted transmission indication, the user may assume that no useful information to that user was carried by the resource elements included in the indication, even if some of those resource elements were already scheduled to this user. Alternatively, instead of transmitting interruption indication, the scheduler may retransmit only the preempted code blocks to a UE and instruct to do proper transport block decoding with other already received code blocks.  For the downlink and the uplink, intercell-interference coordination can be realized by the scheduler that is transparent to the physical layer.  For LTE component RIT:  In LTE dynamic scheduling on a 1 ms (subframe) basis is applied to both uplink and downlink if short TTI is not configured. Typically, LTE scheduling is based on the instantaneous radio-link quality as seen by the different users, and the traffic demand and quality-of-service requirements of individual users and in the cell as a whole. The former is based on CQI reports from the terminals (downlink) or measurements of sounding signals from the terminals (uplink). Based on this the base station may e.g. apply a proportional fair scheduling algorithm. The QoS assessment is supported by means of receiving QoS information from the “higher layers”.  If short TTI is configured, a scheduler may allocate DL and UL shared channel transmission durations of either slots (7 OFDM/SC-FDMA symbols) or subslots (2 OFDM/SC-FDMA symbols). The DL and UL transmission duration does not have to be the same.  For VoIP traffic (or any traffic having similar characteristics) semi-persistent scheduling can be applied, by which a user can be allocated time-frequency resources in a semi-persistent manner, i.e., fixed resources are allocated at certain intervals without L1/L2 control signaling each time. This is especially useful to reduce the L1/L2 control signaling overhead and to increase VoIP capacity.  Moreover, LTE supports TTI bundling, by which time-frequency resources can be allocated consecutively to a user for a longer period than 1 ms by a single L1/L2 control signaling. A larger transport block size or a lower coding rate can be supported by this technique. This is especially useful when the coverage needs to be extended.  For TDD operation in general a subframe is semi-statically configured for DL or UL transmission. However, dynamic reconfiguration of certain subframes is also possible to adapt to traffic and interference conditions.  Intercell-interference coordination mechanisms may also be realized by the scheduler. To aid inter-cell coordination, LTE defines two indicators exchanged between base stations: The High-interference Indicator (HI) provides information to neighboring cells about the part of the cell bandwidth upon which the cell intends to schedule its cell-edge users. The Overload Indicator (OI) provides information on the uplink interference level experienced in each part of the cell bandwidth.  For the downlink, intercell-interference coordination can be realized using a Relative Narrowband TX Power (RNTP) indicator.  For NB-IoT the scheduler controls the transmission duration of control channels in number of subframes in a semi-static fashion while the transmission duration of shared channels can be varied dynamically. This is beneficial for extending coverage.  For a user capable of V2X communication, two sidelink resource allocation modes are defined: eNB-controlled and UE-Autonomous resource allocation modes. In eNB controlled mode, all sidelink transmissions (i.e. sidelink control and shared channel transmissions) are scheduled by the base station. In UE-Autonomous resource allocation mode, UE autonomously selects resources for sidelink transmission within preconfigured sidelink resource pools based on predefined sensing and resource selection procedures. In both modes, either dynamic or semi-persistent resource allocations can be used.  For a user capable of V2X communication multiple semi-persistent configurations can be configured in uplink and sidelink, regardless of the specific services the UE is operating. This, along with sidelink resource selection procedures conditioned on sensing sidelink transmissions from other users reduces probability of collisions and improve system performance. | DECT-2020 channels use the same basic time/frequency structure as traditional DECT. The basic frame time of 10 ms is split into 24 time-slots. Time-slots can be aggregated. Half-slots for some packet types are also supported. DECT-2020 can also operate in a frameless mode. The basic channel width is 1.728 MHz. Multiple contiguous channels can be aggregated. Channels can be separately and dynamically scheduled for both uplink and downlink.  A DECT-2020 FP device can initiate packet transmission on a half or single channel, or a combination of channels, to a single PP or to multiple PP devices. DECT-2020 FPs can receive packets on a half or single channel or a combination of channels, from a single PP or from multiple PP devices. Transitions from transmit mode to receive mode and from receive mode to transmit mode are separated by a nominal guard time interval. A DECT-2020 PP device can initiate packet transmission on a half or single channel or a number of contiguous channels. DECT-2020 PPs can receive packets on a half or single channel or a number of contiguous channels.  The technology supports both non-scheduled and scheduled operation. | In NR physical control and shared channels can be separately and dynamically scheduled for both uplink and downlink. A scheduling unit for downlink shared channel may span from 2-14 symbols and for uplink shared channel from 1-14 symbols (14 symbols comprise a “slot”). Sub-carrier spacing for different physical channels may be dynamically changed by switching bandwidth-parts (BWP).  Typically, NR scheduling is based on the instantaneous radio-link quality as seen by the different users, and the traffic demand and quality-of-service requirements of individual users and in the cell as a whole. The former is based on CQI reports from the terminals (downlink) or measurements of sounding signals from the terminals (uplink). Based on this the base station may e.g. apply a proportional fair scheduling algorithm. The QoS assessment is supported by means of receiving QoS information from the “higher layers”.  For non-full buffer traffic like VOIP (or any traffic having similar characteristics) semi-persistent scheduling in DL can be applied, by which a user can be allocated time-frequency resources in a semi-persistent manner, i.e., fixed resources are allocated at certain intervals without L1/L2 control signaling each time. This is especially useful to reduce the L1/L2 control signaling overhead and to increase VoIP capacity. In addition, with UL Configured Grants, the scheduler can allocate uplink resources to users. When a configured uplink grant is active, if the user cannot find an uplink grant assigned via downlink control channel an uplink transmission according to the configured uplink grant can be made. Otherwise, if the user finds an uplink grant assigned via downlink control channel, this assignment overrides the configured uplink grant.  In general for TDD operation a slot may be used for dynamically allocating DL or UL transmissions or both.  NR supports slot aggregation in downlink and uplink, by which time-frequency resources can be allocated consecutively to a user for a longer period than a slot by a single L1/L2 control signaling. A larger transport block size or a lower coding rate can be supported by this technique. This is especially useful when the coverage needs to be extended.  As another option to extend coverage or improve reliability in addition to slot aggregation, a set of MCS tables supporting very low code rate for both DL and UL can be used.  The scheduler may pre-empt an ongoing transmission to one user with a latency-critical transmission to another user. The scheduler can configure users to monitor interrupted transmission indications. If a user receives the interrupted transmission indication, the user may assume that no useful information to that user was carried by the resource elements included in the indication, even if some of those resource elements were already scheduled to this user. Alternatively, instead of transmitting interruption indication, the scheduler may retransmit only the preempted code blocks to a UE and instruct to do proper transport block decoding with other already received code blocks.  For the downlink and the uplink, intercell-interference coordination can be realized by the scheduler that is transparent to the physical layer. | EUHT adopts the TDD mode. The uplink and the downlink are dynamically scheduled respectively. The supported scheduling algorithms include the proportional fair scheduling algorithm and the semi-static scheduling algorithm:  -The dynamic scheduling requires determining the measurement report and self-adaptive mechanism described in Section 5.2.3.2.10.1 such as MIMO antennas, modulation codes and beams.  -The proportional fair algorithm also requires considering the priorities of different users, the QoS requirements of services, and the current service cache situation, which is suitable for full-buffer services.  -For non-full buffer services, such as VOIP and signal control, semi-static scheduling can be adopted; the burst model of services can be referred to, and a small amount of resources can be reserved periodically to ensure various service quality requirements and the radio resource |

# A.3 References

[1] Report ITU-R M.2412, IMT-2020.EVAL.

[2] IMT-2020/ZZZ, Initial evaluation Report from TPCEG on the IMT-2020 proposal in Document [IMT-2020/3(Rev.1)](https://www.itu.int/md/R15-IMT.2020-C-0003/en), TPCEG, September 09, 2018.

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1. \* Submitted on behalf of the Canadian Evaluation Group (CEG) [↑](#footnote-ref-1)
2. \*\* The CEG notes that the results presented in this Interim Report are not final. The CEG reserves its right to re-visit (and revise) any portion of this Report it deems necessary. [↑](#footnote-ref-2)