|  |  |
| --- | --- |
| **Radiocommunication Study Groups** |  |
|  |  |
|  |  |
| Received: 8 February 2020 | **Document 5D/52-E** |
| **10 February 2020** |
| **English only  TECHNOLOGY ASPECTS** |
| Director, Radiocommunication Bureau[[1]](#footnote-1),[[2]](#footnote-2) | |
| FINAL Evaluation report from the 5G Infrastructure Association on IMT-2020 proposal IMT-2020/ 18 | |
|  | |

This contribution contains in Attachment 1 the Final Evaluation Report from the Independent Evaluation Group 5G Infrastructure Association (<http://www.itu.int/oth/R0A0600006E/en>). The report contains a subset of the detailed analysis of the analytical, inspection and simulation characteristics defined in ITU-R Reports M.2410-0, M.2411-0 and M.2412-0 [1] – [3] using a methodology described in Report ITU-R M.2412-0 [3].

The final report contains some analytical, simulation and inspection evaluation results.

The evaluation targets the RIT proposal contained in Document IMT-2020/18(Rev.1) [4] (Nufront RIT).

The attached evaluation report consists of 3 Parts:

• Part I: Administrative Aspects of 5G Infrastructure Association

• Part II: Technical Aspects of the work in 5G Infrastructure Association

• Part III: Conclusion

The report is structured according to the proposed structure in [5].

Attachment 1

[Part I 3](#_Toc32240130)

[Administrative aspects of 5G Infrastructure Association 3](#_Toc32240131)

[I.1 Name of the Independent Evaluation Group 3](#_Toc32240132)

[I.2 Introduction and background of 5G Infrastructure Association 3](#_Toc32240133)

[I.3 Method of work 5](#_Toc32240134)

[I.4 Administrative contact details 5](#_Toc32240135)

[I.5 Technical contact details 5](#_Toc32240136)

[I.6 Other pertinent administrative information 6](#_Toc32240137)

[I.7 Structure of this Report 6](#_Toc32240138)

Part II. Technical aspects of the work in 5G Infrastructure Association 7

[II.A What candidate technologies or portions of the candidate technologies this IEG is or might anticipate evaluating? 7](#_Toc32240139)

[II.B Confirmation of utilization of the ITU-R evaluation guidelines in Report ITU‑R M.2412 8](#_Toc32240140)

[II.C Documentation of any additional evaluation methodologies that are or might be developed by the Independent Evaluation Group to complement the evaluation guidelines 8](#_Toc32240141)

[II.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) 8](#_Toc32240142)

[II.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) 8](#_Toc32240144)

[II.E.1 5th percentile user spectral efficiency 9](#_Toc32240145)

[II.E.1.1 Basic parameters 9](#_Toc32240146)

[II.E.1.2 EUHT 10](#_Toc32240147)

[II.E.2 Average spectral efficiency 13](#_Toc32240148)

[II.E.2.1 Basic parameters 14](#_Toc32240149)

[II.E.2.2 EUHT 14](#_Toc32240150)

[II.E.3 Reliability 17](#_Toc32240153)

[II.E.3.1 Evaluation methodology and KPIs 17](#_Toc32240154)

[II.E.3.2 Evaluation results for EUHT 18](#_Toc32240155)

[II.F Questions and feedback to WP 5D and/or the proponents or other IEGs 19](#_Toc32240156)

Part III. Conclusion 22

[III.1 Completeness of submission 22](#_Toc32240157)

[III.2 Compliance with requirements 22](#_Toc32240158)

[III.2.1 Overall compliance 22](#_Toc32240159)

[III.2.2 Detailed compliance templates 22](#_Toc32240160)

[III.3 Number of test environments meeting all IMT-2020 requirements 25](#_Toc32240164)

Part I

Administrative aspects of 5G Infrastructure Association

# I.1 Name of the Independent Evaluation Group

The Independent Evaluation Group is called *5G Infrastructure Association*.

# I.2 Introduction and background of 5G Infrastructure Association

The 5G Infrastructure Association Independent Evaluation Group was launched by the 5G Infrastructure Association as part of 5G Public Private Partnership (5G PPP) in October 2016 by registration at ITU-R.

The 5G Public Private Partnership (5G PPP) is a sub-research program in Horizon 2020 of the European Commission. 5G Infrastructure Association is representing the private side in 5G PPP and the EU Commission the public side. The Association was founded end of 2013. The Contractual Arrangement on 5G PPP was signed by the EU Commission and representatives of 5G Infrastructure Association in December 2013. 5G PPP is structured in three program phases.

• In Phase 1 from July 1, 2015 to 2017 19 projects researched the basic concepts of 5G systems in all relevant areas and contributed to international standardization (<https://5g-ppp.eu/5g-ppp-phase-1-projects/>).

• Phase 2 started on June 1, 2017 with 23 projects (<https://5g-ppp.eu/5g-ppp-phase-2-projects/>). The focus of Phase 2 is on the optimization of the system and the preparation of trials.

• The Phase 3 is implemented with 14 projects (<https://5g-ppp.eu/5g-ppp-phase-3-projects/>)

– Part 1: 3 Infrastructure Projects,

– Part 2: 3 Automotive Projects and

– Part 3: 8 Advanced 5G validation trials across multiple vertical industries. This phase is addressing the development of trial platforms especially with vertical industries, large scale trials, cooperative, connected and automated mobility, 5G long term evolution as well as international cooperation.

In each phase around 200 organizations are cooperating in the established projects.

The main key challenges of the 5G PPP Program are to deliver solutions, architectures, technologies and standards for the ubiquitous 5G communication infrastructures of the next decade:

• Providing 1 000 times higher wireless area capacity and more varied service capabilities compared to 2010.

• Saving up to 90 % of energy per service provided. The main focus will be in mobile communication networks where the dominating energy consumption comes from the radio access network.

• Reducing the average service creation time cycle from 90 hours to 90 minutes.

• Creating a secure, reliable and dependable Internet with a “zero perceived” downtime for services provision.

• Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people.

• Enabling advanced User controlled privacy.

The Independent Evaluation Group is currently supported by the following 5G PPP Phase 2 projects:

• 5G Essence,

• 5G MoNArch,

• 5G Xcast,

• One 5G and

• To-Euro-5G CSA

and the 5G PPP Phase 3 projects

• 5G Genesis,

• 5G Solutions,

• 5G Tours,

• 5G VINNI,

• Clear5G,

• Full5G CSA,

• Global5G.org CSA

and the 5G Infrastructure Association members

• Huawei,

• Intel,

• Nokia,

• Telenor,

• Turkcell and

• ZTE Wistron Telecom AB

This Evaluation Group is evaluating some of all 16 evaluation characteristics according to Table 2 by means of analytical, inspection and simulation activities in order to perform a full evaluation. For simulation purposes simulators at different Evaluation Group member are used, where different evaluation characteristics are mapped to different simulators. Simulators are being calibrated where needed in order to provide comparable results. Calibration results and the calibration approach are published (c.f. Section I-6) in order to provide this information to the other Independent Evaluation Groups to support the consensus building process in ITU-R WP 5D.

# I.3 Method of work

The 5G Infrastructure Association Evaluation Group is organized as Working Group in 5G PPP under the umbrella of the 5G Infrastructure Association. Evaluation activities are executed according to a commonly agreed plan and conducted work through e.g.:

• Physical meetings and frequent telephone conferences where the activities are planned and where action items are given and followed up.

• Frequent email and telephone discussions among partners on detailed issues on an ad-hoc basis.

• File sharing on the web.

• Participation in the ITU-R Correspondence Group dedicated to the IMT-2020 evaluation topics.

In addition, the Evaluation Group participated in a workshop organized by 3GPP on October 24 and 25, 2018 in Brussels and the ITU-R WP5D Evaluation Workshop on December 10 and 11, 2019 in Geneva at the 33rd meeting of Working Party 5D. In that workshop the Evaluation Group presented the work method, work plan, channel model calibration status, baseline system calibration assumptions, and available evaluation results.

At and after the ITU-R workshop the Evaluation Group communicated with other Evaluation Groups as well regarding calibration and is making material openly available.

Open issues in the system description were discussed and clarified with Nufront.

The assessment of the proponent submission and self-evaluation has been made by analytical, inspection and simulation methods as required in Reports ITU-R M.2410-0 [1], M.2411-0 [2] and M.2412-0 [3], see Table 2 in M.2412-0 [3] in Section I-6 for details.

# I.4 Administrative contact details

Dr Werner Mohr, Working Group chair, Email: [werner.mohr@nokia.com](mailto:werner.mohr@nokia.com)

# I.5 Technical contact details

Members of the Evaluation Group:

|  |  |  |
| --- | --- | --- |
| [Hakan Batıkhan](mailto:hakan.batikhan@turkcell.com.tr) | Turkcell | [hakan.batikhan@turkcell.com.tr](mailto:hakan.batikhan@turkcell.com.tr) |
| Ioannis-Prodromos Belikaidis | WINGS ICT Solutions | [iobelika@wings-ict-solutions.eu](mailto:iobelika@wings-ict-solutions.eu) |
| Ömer Bulakci | Huawei | [Oemer.Bulakci@huawei.com](mailto:Oemer.Bulakci@huawei.com) |
| Jose Luis Carcel | Universitat Politecnica de Valencia | [jocarcer@iteam.upv.es](mailto:jocarcer@iteam.upv.es) |
| [Yang Changqing](mailto:changqing.yang@huawei.com) | Huawei | [changqing.yang@huawei.com](mailto:changqing.yang@huawei.com) |
| Marcos Rates Crippa | University of Kaiserslautern | [crippa@eit.uni-kl.de](mailto:crippa@eit.uni-kl.de) |
| Panagiotis Demestichas | WINGS ICT Solutions | [pdemest@wings-ict-solutions.eu](mailto:pdemest@wings-ict-solutions.eu) |
| [Salih Ergut](mailto:salih.ergut@turkcell.com.tr) | Turkcell | [salih.ergut@turkcell.com.tr](mailto:salih.ergut@turkcell.com.tr) |
| Manuel Fuentes | Universitat Politecnica de Valencia | [mafuemue@iteam.upv.es](mailto:mafuemue@iteam.upv.es) |
| Eduardo Garro | Universitat Politecnica de Valencia | [edgarcre@iteam.upv.es](mailto:edgarcre@iteam.upv.es) |
| Andreas Georgakopoulos | WINGS ICT Solutions | [andgeorg@wings-ict-solutions.eu](mailto:andgeorg@wings-ict-solutions.eu) |
| Ioannis Giannoulakis | National Centre for Scientific Research Demokritos | giannoul@iit.demokritos.gr |
| Athanasios (Thanos) Gkiolias | WINGS ICT Solutions | agkiolias@wings-ict-solutions.eu |
| David Gomez-Barquero | Universitat Politecnica de Valencia | [dagobar@iteam.upv.es](mailto:dagobar@iteam.upv.es) |
| Marco Gramaglia | UC3M | [mgramagl@it.uc3m.es](mailto:mgramagl@it.uc3m.es) |
| Ole Grondalen | Telenor | [ole.grondalen@telenor.com](mailto:ole.grondalen@telenor.com) |
| [Nazli Guney](mailto:nazli.guney@turkcell.com.tr) | Turkcell | [nazli.guney@turkcell.com.tr](mailto:nazli.guney@turkcell.com.tr) |
| Marie-Helene Hamon | Orange | [mhelene.hamon@orange.com](mailto:mhelene.hamon@orange.com) |
| [Ahmet Kaplan](mailto:ahmet.kaplan@turkcell.com.tr) | Turkcell | [ahmet.kaplan@turkcell.com.tr](mailto:ahmet.kaplan@turkcell.com.tr) |
| Cemil Karakus | Turkcell | [cemil.karakus@turkcell.com.tr](mailto:cemil.karakus@turkcell.com.tr) |
| Evangelos Kosmatos | WINGS ICT Solutions | [vkosmatos@wings-ict-solutions.eu](mailto:vkosmatos@wings-ict-solutions.eu) |
| Anastasios Kourtis | National Centre for Scientific Research Demokritos | [kourtis@iit.demokritos.gr](mailto:kourtis@iit.demokritos.gr) |
| Fotis Lazarakis | National Centre for Scientific Research Demokritos | [flaz@iit.demokritos.gr](mailto:flaz@iit.demokritos.gr) |
| Ji Lianghai | University of Kaiserslautern | [ji@eit.uni-kl.de](mailto:ji@eit.uni-kl.de) |
| Hans-Peter Mayer | Nokia | [hans-peter.mayer.ext@nokia-bell-labs.com](mailto:hans-peter.mayer.ext@nokia-bell-labs.com) |
| Werner Mohr | Nokia | [werner.mohr@nokia.com](mailto:werner.mohr@nokia.com) |
| Volker Pauli | Nomor | [pauli@nomor.de](mailto:pauli@nomor.de) |
| [Athul Prasad](mailto:athul.prasad@nokia-bell-labs.com) | Nokia Bell-Labs | [athul.prasad@nokia-bell-labs.com](mailto:athul.prasad@nokia-bell-labs.com) |
| Christoph Schmelz | Nokia | [christoph.schmelz@nokia-bell-labs.com](mailto:christoph.schmelz@nokia-bell-labs.com) |
| Hans Schotten | DFKI/University of Kaiserslautern | [schotten@eit.uni-kl.de](mailto:schotten@eit.uni-kl.de) |
| Egon Schulz | Huawei | [egon.schulz@huawei.com](mailto:egon.schulz@huawei.com) |
| Vera Stravroulaki | WINGS ICT Solutions | [veras@wings-ict-solutions.eu](mailto:veras@wings-ict-solutions.eu) |
| Ingo Viering | Nomor | [viering@nomor.de](mailto:viering@nomor.de) |
| [Shangbin Wu](mailto:shangbin.wu@samsung.com) | Samsung | [shangbin.wu@samsung.com](mailto:shangbin.wu@samsung.com) |
| Shao Jiafeng | Huawei | [shaojiafeng@huawei.com](mailto:shaojiafeng@huawei.com) |
| [Wu Yong](mailto:wuyong@huawei.com) | Huawei | [wuyong@huawei.com](mailto:wuyong@huawei.com) |
| Xi Meng | ZTE Wistron Telecom AB | [meng.xi@zte.com.cn](mailto:meng.xi@zte.com.cn) |
| Yu Jian | Huawei | jason.yujian@huawei.com |

# I.6 Other pertinent administrative information

5G Infrastructure Association and 5G PPP homepage:

<https://5g-ppp.eu/5g-ppp-imt-2020-evaluation-group/>

# I.7 Structure of this Report

This Report consists of 3 Parts:

• Part I: Administrative Aspects of 5G Infrastructure Association

• Part II: Technical Aspects of the work in 5G Infrastructure Association

• Part III: Conclusion

The report is structured according to the proposed structure in [5].

Part II

Technical aspects of the work in 5G Infrastructure Association

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

In this report, *final* results are presented for the RIT proposals in [4] for EUHT with a focus on the Nufront submission to ITU-R by means of analytical, inspection and simulation evaluation. The complete simulation evaluations will be provided in the final evaluation report. Table 1 shows the evaluated proposals.

Table 1

Evaluated technology proposals

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 3GPP | | China | Korea | ETSI TC DECT  DECT Forum | | Nufront | TSDSI |
| SRIT | RIT | 5G NR RIT | DECT2020 |
| - | - | - | - | - | - | ✓ | - |

Table 2 is summarizing the different evaluation characteristics.

Table 2

Summary of evaluation methodologies

|  |  |  |  |
| --- | --- | --- | --- |
| Characteristic for evaluation | High-level assessment method | Evaluation methodology in ITU-R Report M.2412-0 | Related section of Reports ITU-R M.2410-0 and ITU-R M.2411-0 |
| Peak data rate | Analytical | § 7.2.2 | Report ITU-R M.2410-0, § 4.1 |
| Peak spectral efficiency | Analytical | § 7.2.1 | Report ITU-R M.2410-0, § 4.2 |
| User experienced data rate | Analytical for single band and single layer;  Simulation for multi-layer | § 7.2.3 | Report ITU-R M.2410-0, § 4.3 |
| 5th percentile user spectral efficiency | Simulation | § 7.1.2 | Report ITU-R M.2410-0, § 4.4 |
| Average spectral efficiency | Simulation | § 7.1.1 | Report ITU-R M.2410-0, § 4.5 |
| Area traffic capacity | Analytical | § 7.2.4 | Report ITU-R M.2410-0, § 4.6 |
| User plane latency | Analytical | § 7.2.6 | Report ITU-R M.2410-0, § 4.7.1 |
| Control plane latency | Analytical | § 7.2.5 | Report ITU-R M.2410-0, § 4.7.2 |
| Connection density | Simulation | § 7.1.3 | Report ITU-R M.2410-0, § 4.8 |
| Energy efficiency | Inspection | § 7.3.2 | Report ITU-R M.2410-0, § 4.9 |
| Reliability | Simulation | § 7.1.5 | Report ITU-R M.2410-0, § 4.10 |
| Mobility | Simulation | § 7.1.4 | Report ITU-R M.2410-0, § 4.11 |
| Mobility interruption time | Analytical | § 7.2.7 | Report ITU-R M.2410-0, § 4.12 |
| Bandwidth | Inspection | § 7.3.1 | Report ITU-R M.2410-0, § 4.13 |
| Support of wide range of services | Inspection | § 7.3.3 | Report ITU-R M.2411-0, § 3.1 |
| Supported spectrum band(s)/range(s) | Inspection | § 7.3.4 | Report ITU-R M.2411-0, § 3.2 |

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

5G Infrastructure Association confirms that the evaluation guidelines provided in Report ITU-R M.2412-0 [3] have been utilized.

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

The following additional evaluation methodologies have been applied by this Evaluation Group:

• Updating of already available link-level and system-level simulators according to the submitted RITs as well as to ITU-R requirements

• These link-level and system-level simulators have been calibrated with respect to externally available results.

# II.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)

This Final Evaluation Report is summarizing the available evaluation results by end of January 2020. The evaluation template is completed in Section III-2. These results have a gap with the self-evaluation of the proponent Nufront.

## II.D.1 Identify gaps/deficiencies in submitted material and/or self-evaluation

There were obviously gaps and deficiencies identified in the submission of Nufront.

# II.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)

In the following Sections details are provided on

• 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.

Analytical, inspection evaluation and simulation-based evaluation

## II.E.1 5th percentile user spectral efficiency

The ITU-R minimum requirements on 5th percentile user spectral efficiency are given in [1]. The following requirements and remarks are extracted from [1]:

*The 5th percentile user spectral efficiency is the 5% point of the CDF of the normalized user throughput. The normalized user throughput is defined as the number of correctly received bits, i.e. the number of bits contained in the SDUs delivered to Layer 3, over a certain period of time, divided by the channel bandwidth and is measured in bit/s/Hz.*

*The channel bandwidth for this purpose is defined as the effective bandwidth times the frequency reuse factor, where the effective bandwidth is the operating bandwidth normalized appropriately considering the uplink/downlink ratio.*

*With Ri (Ti) denoting the number of correctly received bits of user i, Ti the active session time for user i and W the channel bandwidth, the (normalized) user throughput of user i, ri, is defined according to equation (4).*

**

*This requirement is defined for the purpose of evaluation in the eMBB usage scenario.*

*The minimum requirements for 5th percentile user spectral efficiency for various test environments are summarized in Table 3.*

*Table 3*

*5th percentile user spectral efficiency*

|  |  |  |
| --- | --- | --- |
| *Test environment* | *Downlink  (bit/s/Hz)* | *Uplink  (bit/s/Hz)* |
| *Indoor Hotspot – eMBB* | *0.3* | *0.21* |
| *Dense Urban – eMBB (NOTE 1)* | *0.225* | *0.15* |
| *Rural – eMBB* | *0.12* | *0.045* |
| *NOTE 1 – This requirement will be evaluated under Macro TRxP layer of Dense Urban – eMBB test environment as described in Report ITU-R M.2412-0.* | | |

*The performance requirement for Rural-eMBB is not applicable to Rural-eMBB LMLC (low mobility large cell) which is one of the evaluation configurations under the Rural- eMBB test environment.*

*The conditions for evaluation including carrier frequency and antenna configuration are described in Report ITU-R M.2412-0 for each test environment.*

### II.E.1.1 Basic parameters

The 5th percentile user spectral efficiency (SE) is evaluated by system level simulations. The used simulator is calibrated against the results of the calibration which Nufront performed in the context of self-evaluation, see [4]. System level simulations are performed for TDD technique.

Furthermore, as required in [3], the 5th percentile user spectral efficiency is assessed jointly with the average spectral efficiency using the same simulations.

### II.E.1.2 EUHT

The evaluation of the 5th percentile user spectral efficiency is conducted for the three different test environments of eMBB indoor hotspot, dense urban and rural. The test environments and evaluation configuration parameters are described in [3]. Further evaluation assumptions can be found in Appendix [1], [2].

#### II.E.1.2.1 Indoor Hotspot – eMBB

Two modes are considered for the Indoor Hotspot – eMBB test environment, namely operating with one or three sectors per site. For each mode, two configurations are applied. Evaluation configuration A with a carrier frequency of 4 GHz represents FR1, while evaluation configuration B with a carrier frequency of 30 GHz represents FR2.

##### II.E.1.2.1.1 Evaluation configuration A (CF = 4 GHz)

Table 4 and Table 5 show the evaluation results for EUHT of downlink and uplink 5th percentile user spectral efficiency for Indoor Hotspot – eMBB Configuration A in both operation modes.

Table 4

5th percentile user SE for EUHT with frame structure ‘DL:UL = 2:1’ in Indoor Hotspot – eMBB Config. A (Source 1)

|  |  |  |  |
| --- | --- | --- | --- |
| **Operation mode** | **5th percentile user SE [bit/s/Hz]** | | **Requirement [bit/s/Hz]** |
| **1 sector per site** | **3 sectors per site** |
| **Downlink** | 0.239 | - | 0.3 |
| **Uplink** | 0.171 | - | 0.21 |

TABLE 5

5th percentile user SE for EUHT with frame structure ‘DL:UL = 2:1’ in Indoor Hotspot – eMBB Config. A (Source 2)

|  |  |  |  |
| --- | --- | --- | --- |
| **Operation mode** | **5th percentile user SE [bit/s/Hz]** | | **Requirement [bit/s/Hz]** |
| **1 sector per site** | **3 sectors per site** |
| **Downlink** | 0.24 | 0.03 | 0.3 |
| **Uplink** | 0.16 | 0.08 | 0.21 |

It is observed that EUHT cannot fulfill downlink and uplink 5th percentile user spectral efficiency requirement for Indoor Hotspot – eMBB test environment in Configuration A in both operation modes.

##### II.E.1.2.1.2 Evaluation configuration B (CF = 30 GHz)

Table 6 shows the evaluation results for EUHT of downlink and uplink 5th percentile user spectral efficiency for Indoor Hotspot – eMBB Configuration B in both operation modes.

TABLE 6

5th percentile user SE for EUHT with frame structure ‘DL:UL = 2:1’ in Indoor Hotspot – eMBB Config. B (Source 2)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Operation mode** | **BW [MHz]** | **5th percentile user SE [bit/s/Hz]** | | **Requirement [bit/s/Hz]** |
| **1 sector per site** | **3 sectors per site** |
| **Downlink** | 100 | 0.06 | 0.01 | 0.3 |
| **Uplink** | 100 | 0.05 | 0.10 | 0.21 |

It is observed that EUHT cannot fulfil downlink and uplink 5th percentile user spectral efficiency requirement for Indoor Hotspot – eMBB test environment in Configuration B in both operation modes.

#### II.E.1.2.2 Dense Urban – eMBB

Configuration A (carrier frequency of 4 GHz) and Configuration B (carrier frequency of 30 GHz) are applied for the Dense Urban – eMBB test environment.

In addition to the system bandwidth determined in ITU-R M.2412-0 [3], downlink system-level simulations are performed with a larger component carrier bandwidth. The larger bandwidth provides a more efficient usage of bandwidth and a smaller overhead. The simulation results with the larger bandwidth are used to calculate the user experienced data rate, see Section III-E.3.

##### II.E.1.2.2.1 Evaluation configuration A (CF = 4 GHz)

The downlink and uplink evaluation results for EUHT for Dense Urban – eMBB Configuration A are provided in Table 7 and Table 8.

TABLE 7

5th percentile user SE for EUHT with frame structure ‘DL:UL = 2:1’ in Dense Urban – eMBB Config. A  
(Source 1)

|  |  |  |  |
| --- | --- | --- | --- |
| **Operation mode** | **BW [MHz]** | **5th percentile user SE [bit/s/Hz]** | **Requirement [bit/s/Hz]** |
| **Downlink** | 20 | 0.294 | 0.225 |
| **Uplink** | 20 | 0.09 | 0.15 |

TABLE 8

5th percentile user SE for EUHT with frame structure ‘DL:UL = 2:1’ in Dense Urban – eMBB Config .A   
(Source 2)

|  |  |  |  |
| --- | --- | --- | --- |
| **Operation mode** | **BW [MHz]** | **5th percentile user SE [bit/s/Hz]** | **Requirement [bit/s/Hz]** |
| **Downlink** | 20 | 0.25 | 0.225 |
| **Uplink** | 20 | 0.10 | 0.15 |

It is observed that EUHT fulfils the downlink, while cannot meet uplink 5th percentile user spectral efficiency requirement for Dense Urban – eMBB test environment in Configuration A.

##### II.E.1.2.2.2 Evaluation configuration B (CF = 30 GHz)

The downlink and uplink evaluation results for EUHT for Dense Urban – eMBB Configuration B are provided in Table 9.

Table 9

5th percentile user SE for EUHT with frame structure ‘DL:UL = 2:1’ in Dense Urban – eMBB Config. B

(Source 2)

|  |  |  |  |
| --- | --- | --- | --- |
| Operation mode | BW [MHz] | 5th percentile user SE [bit/s/Hz] | Requirement [bit/s/Hz] |
| Downlink | 100 | 0.001 | 0.225 |
| Uplink | 100 | 0.0 | 0.15 |

It is observed that EUHT cannot fulfil neither downlink nor uplink 5th percentile user spectral efficiency requirement for Dense Urban – eMBB test environment in Configuration B.

#### II.E.1.2.3 Rural – eMBB

For Rural – eMBB test environment, Configuration B with a carrier frequency of 4 GHz is evaluated.

##### II.E.1.2.3.1 Evaluation configuration B (CF = 4 GHz)

The evaluation results for EUHT for downlink and uplink in Rural – eMBB Configuration B are provided in Table 10.

Table 10

5th percentile user SE for EUHT with frame structure ‘DL:UL = 2:1’ in Rural – eMBB Config. B (Source 2)

|  |  |  |
| --- | --- | --- |
|  | **5th percentile user SE [bit/s/Hz]** | **Requirement [bit/s/Hz]** |
| **Downlink** | - | 0.12 |
| **Uplink** | 0.017 | 0.045 |

It is observed that EUHT cannot fulfill uplink 5th percentile user spectral efficiency requirement for Rural – eMBB test environment in Configuration B.

## II.E.2 Average spectral efficiency

The ITU-R minimum requirements on average spectral efficiency are given in [1]. The following requirements and remarks are extracted from [1]:

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

*The channel bandwidth for this purpose is defined as the effective bandwidth times the frequency reuse factor, where the effective bandwidth is the operating bandwidth normalized appropriately considering the uplink/downlink ratio.*

*Let Ri (T) denote the number of correctly received bits by user i (downlink) or from user i (uplink) in a system comprising a user population of N users and M TRxPs. Furthermore, let W denote the channel bandwidth and T the time over which the data bits are received. The average spectral efficiency, SEavg is then defined according to equation (5).*

**

*This requirement is defined for the purpose of evaluation in the eMBB usage scenario.*

*The minimum requirements for average spectral efficiency for various test environments are summarized in Table 13.*

*Table 13*

*Average spectral efficiency*

|  |  |  |
| --- | --- | --- |
| *Test environment* | *Downlink (bit/s/Hz/TRxP)* | *Uplink (bit/s/Hz/TRxP)* |
| *Indoor Hotspot – eMBB* | *9* | *6.75* |
| *Dense Urban – eMBB (Note 1)* | *7.8* | *5.4* |
| *Rural – eMBB* | *3.3* | *1.6* |
| *NOTE 1 – This requirement applies to Macro TRxP layer of the Dense Urban – eMBB test environment as described in Report ITU-R M.2412-0.* | | |

*The performance requirement for Rural-eMBB is also applicable to Rural-eMBB LMLC which is one of the evaluation configurations under the Rural- eMBB test environment. The details (e.g. 8 km inter-site distance) can be found in Report ITU‑R M.2412-0.*

*The conditions for evaluation including carrier frequency and antenna configuration are described in Report ITU-R M.2412-0 for each test environment.*

### II.E.2.1 Basic parameters

The average spectral efficiency (SE) is evaluated by system level simulations. The used simulator is calibrated against the results of the calibration which Nufront performed in the context of self-evaluation, see [6]. System level simulations are performed for TDD technique.

Furthermore, as required in [3] and as mentioned in Section III-4.1, the average spectral efficiency is assessed jointly with the 5th percentile user spectral efficiency using the same simulations.

### II.E.2.2 EUHT

The evaluation of the average spectral efficiency is conducted for the three different test environments of eMBB. The test environments and evaluation configuration parameters are described in [3]. Further evaluation assumptions can be found in Appendix [1], [2].

#### II.E.2.2.1 Indoor Hotspot – eMBB

Two modes are considered for the Indoor Hotspot – eMBB test environment, namely operating with one or three sectors per site. For each mode, two configurations are applied. Evaluation configuration A with a carrier frequency of 4 GHz represents FR1, while evaluation configuration B with a carrier frequency of 30 GHz represents FR2.

In addition to the system bandwidth determined in ITU-R M.2412-0 [3], downlink system-level simulations are performed with a larger component carrier bandwidth. The larger bandwidth provides a more efficient usage of bandwidth and a smaller overhead. The simulation results with the larger bandwidth are used to calculate the area traffic capacity, see Section III-6.

#### II.E.2.2.1.1 Evaluation configuration A (CF = 4 GHz)

Table 11 and Table 12 provide the evaluation results for EUHT of downlink and uplink average spectral efficiency for Indoor Hotspot – eMBB Configuration A in both operation modes.

Table 11

Average SE for EUHT with frame structure ‘DL:UL = 2:1’ in Indoor Hotspot – eMBB Config. A (Source 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Operation mode** | **BW [MHz]** | **Average SE [bit/s/Hz/TRxP]** | | **Requirement [bit/s/Hz/TRxP]** |
| **1 sector per site** | **3 sectors per site** |
| **Downlink** | 20 | 7.348 | - | 9 |
| **Uplink** | 20 | 4.08 | - | 6.75 |

Table 12

Average SE for EUHT with frame structure ‘DL:UL = 2:1’ in Indoor Hotspot – eMBB Config. A (Source 2)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Operation mode** | **BW [MHz]** | **Average SE [bit/s/Hz/TRxP]** | | **Requirement [bit/s/Hz/TRxP]** |
| **1 sector per site** | **3 sectors per site** |
| **Downlink** | 20 | 7.34 | 4.99 | 9 |
| **Uplink** | 20 | 3.93 | 2.71 | 6.75 |

It is observed that EUHT cannot fulfill downlink and uplink average spectral efficiency requirement for Indoor Hotspot – eMBB test environment in Configuration A in both operation modes.

### II.E.2.2.1.2 Evaluation configuration B (CF = 30 GHz)

The Table 13 provides the evaluation results for EUHT of downlink and uplink average spectral efficiency for Indoor Hotspot – eMBB Configuration B in both operation modes.

Table 13

Average SE for EUHT with frame structure ‘DL:UL = 2:1’ in Indoor Hotspot – eMBB Config. B (Source 2)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Operation mode** | **BW [MHz]** | **Average SE [bit/s/Hz/TRxP]** | | **Requirement [bit/s/Hz/TRxP]** |
| **1 sector per site** | **3 sectors per site** |
| **Downlink** | 100 | 5.42 | 4.77 | 9 |
| **Uplink** | 100 | 2.48 | 3.61 | 6.75 |

It is observed that EUHT cannot fulfill downlink and uplink average spectral efficiency requirement for Indoor Hotspot – eMBB test environment in Configuration B in both operation modes.

### II.E.2.2.2 Dense Urban – eMBB

Configuration A (carrier frequency of 4 GHz) and Configuration B (carrier frequency 30 GHz) are applied for the Dense Urban – eMBB test environment.

##### II.E.2.2.2.1 Evaluation configuration A (CF = 4 GHz)

The downlink and uplink evaluation results for EUHT for Dense Urban – eMBB Configuration A are provided in Table 14 and Table 15.

Table 14

Average SE for EUHT with frame structure ‘DL:UL = 2:1’ in Dense Urban – eMBB Config. A (Source 1)

|  |  |  |
| --- | --- | --- |
| **Operation mode** | **Average SE [bit/s/Hz/TRxP]** | **Requirement [bit/s/Hz/TRxP]** |
| **Downlink** | 7.409 | 7.8 |
| **Uplink** | 3.627 | 5.4 |

Table 15

Average SE for EUHT with frame structure ‘DL:UL = 2:1’ in Dense Urban – eMBB Config. A (Source 2)

|  |  |  |
| --- | --- | --- |
| **Operation mode** | **Average SE [bit/s/Hz/TRxP]** | **Requirement [bit/s/Hz/TRxP]** |
| **Downlink** | 7.68 | 7.8 |
| **Uplink** | 3.58 | 5.4 |

It is observed that EUHT cannot fulfill the downlink and uplink average spectral efficiency requirement for Dense Urban – eMBB test environment in Configuration A.

##### II.E.2.2.2.2 Evaluation configuration B (CF = 30 GHz)

The downlink and uplink evaluation results for EUHT for Dense Urban – eMBB Configuration B are provided in Table 16.

Table 16

Average SE for NR with frame structure ‘DL:UL = 2:1’ TDD Dense Urban – eMBB Config. B (Source 2)

|  |  |  |
| --- | --- | --- |
| **Operation mode** | **Average SE [bit/s/Hz/TRxP]** | **Requirement [bit/s/Hz/TRxP]** |
| **Downlink** | 5.53 | 7.8 |
| **Uplink** | 1.70 | 5.4 |

It is observed that EUHT cannot fulfill neither downlink nor uplink average spectral efficiency requirement for Dense Urban – eMBB test environment in Configuration B.

#### II.E.2.2.3 Rural – eMBB

For Rural – eMBB test environment, Configuration B with a carrier frequency of 4 GHz is evaluated.

##### II.E.2.2.3.1 Evaluation configuration B (CF = 4 GHz)

The evaluation results for EUHT for downlink and uplink in Rural – eMBB Configuration B are provided in Table 17.

Table 17

Average SE for EUHT with frame structure ‘DL:UL = 2:1’ in Rural – eMBB Config. B (Source 2)

|  |  |  |
| --- | --- | --- |
| **Operation mode** | **Average SE [bit/s/Hz/TRxP]** | **Requirement [bit/s/Hz/TRxP]** |
| **Downlink** | - | 3.3 |
| **Uplink** | 3.6 | 1.6 |

It is observed that EUHT cannot fulfill uplink average spectral efficiency requirement for Rural – eMBB test environment in Configuration B.

## II.E.3 Reliability

The ITU-R minimum requirements on reliability are given in [1]. The following requirements and remarks are extracted from [1]:

*Reliability relates to the capability of transmitting a given amount of traffic within a predetermined time duration with high success probability.*

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

*This requirement is defined for the purpose of evaluation in the URLLC usage scenario.*

*The minimum requirement for the reliability is 1-10−5 success probability of transmitting a layer 2 PDU (protocol data unit) of 32 bytes within 1 ms in channel quality of coverage edge for the Urban Macro-URLLC test environment, assuming small application data (e.g. 20 bytes application data + protocol overhead).*

*Proponents are encouraged to consider larger packet sizes, e.g. layer 2 PDU size of up to 100 bytes.*

## II.E.3.1 Evaluation methodology and KPIs

The ITU-R minimum requirements on reliability are given in [1]. Specifically, reliability relates to the capability of transmitting a given amount of traffic within a predetermined time duration with high success probability. Reliability is the success probability of transmitting a layer 2/3 packet within a required maximum time, which is the time it takes to deliver a small data packet from the radio protocol layer 2/3 SDU ingress point to the radio protocol layer 2/3 SDU egress point of the radio interface at a certain channel quality. This requirement is defined for the purpose of evaluation in the URLLC usage scenario.

The minimum requirement for the reliability is 1-10−5 success probability of transmitting a layer 2 PDU (protocol data unit) of 32 bytes within 1 ms in channel quality of coverage edge for the Urban Macro-URLLC test environment, assuming small application data (e.g. 20 bytes application data + protocol overhead).

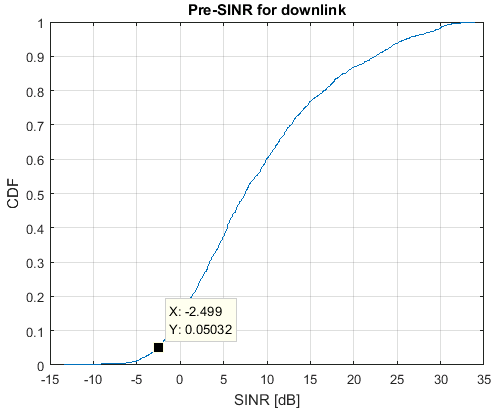
## II.E.3.2 Evaluation results for EUHT

Reliability for EUHT is evaluated under Urban Macro – URLLC test environment. Both downlink and uplink are evaluated. The detailed evaluation assumptions for system level and link level simulation can be found in Appendix C.

The downlink SINR distribution obtained from system level simulation is illustrated in Figure 1. The 5%-tile SINR applied for link level simulation is -2.5 dB.

Figure 1

Downlink SINR distribution obtained from system level simulation



Based on the system level simulation and link level simulation, the evaluation result for downlink reliability is provided in Table 18.

TABLE 18

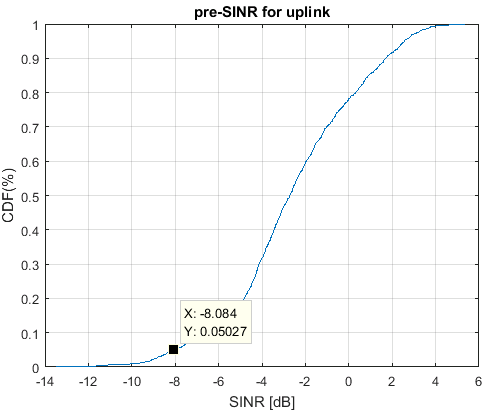
Evaluation results of downlink reliability

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Scheme and Antenna Configuration | Subcarrier Spacing [kHz] | Frame structure | Channel condition | Reliability | ITU Req. |
| 8x2 SU-MIMO | 78.125 | DL:UL=2:1 | NLOS | 99.54% | 99.999% |

The uplink SINR distribution obtained from system level simulation is illustrated in Figure 2. The 5%-tile SINR applied for link level simulation is -8.0 dB.

Figure 2

Uplink SINR distribution obtained from system level simulation



Based on the system level simulation and link level simulation, the evaluation result for uplink reliability is provided in Table 19.

TABLE 19

Evaluation results of uplink reliability

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Scheme and Antenna Configuration | Subcarrier Spacing [kHz] | Frame structure | Channel condition | Reliability | ITU Req. |
| 2x8 SU-MIMO | 78.125 | DL:UL=2:1 | NLOS | 92.37% | 99.999% |

It is observed that Nufront cannot fulfil the reliability requirements for downlink and uplink.

# II.F Questions and feedback to WP 5D and/or the proponents or other IEGs

Based provided self-evaluation report and specification, it is difficult to evaluate some technical performance requirements to meet ITU-R defined.

Moreover, there are mismatch between Characteristics template for EUHT and EUHT Specification. For example:

(Example-1)

|  |  |
| --- | --- |
| 5.2.3.2.6.3 | *Connection/session management*  The mechanisms for connection/session management over the air-interface should be described. For example:  – The support of multiple protocol states with fast and dynamic transitions.  – The signalling schemes for allocating and releasing resources.  *EUHT supports the following states:*  *-* ***MAC\_IDLE****:*  *- System message broadcast;*  *- Cell re-selection;*  *-* ***DRX for CN paging;***  ***- MAC\_INACTIVE****;*  *- System message broadcast;*  *- Cell re-selection;*  *-* ***DRX for RAN paging;***  *- The STA AS context is stored in the STA and RAN.*  *-* ***MAC\_CONNECTED****:*  *- The radio resource connection is established for STA;*  *- The STA AS context is stored in the STA and RAN;*  *- Transfer of unicast data to/from the STA, etc.;*  *- Mobility of the network control.*  *Transition between MAC states:*  *‐****From MAC\_IDLE to MAC\_CONNECTED: Radio resource connection setup***  ***‐From MAC\_CONNECTED to MAC\_IDLE: Radio resource connection release***  ***‐From MAC\_INACTIVE to MAC\_CONNECTED: Radio resource connection recovery***  ***‐From MAC\_CONNECTED to MAC\_INACTIVE: Radio resource connection suspension***  ***‐From MAC\_INACTIVE to MAC\_IDLE: Radio resource connection release***  *‐From MAC\_IDLE to MAC\_INACTIVE: not supported* |

Comment:

• The definition of **MAC\_IDLE** cannot be found in EUHC specification (i.e. the terminology **MAC\_IDLE** cannot be found)

• Nothing about **paging** can be found in EUHT specification

• The definition of **MAC\_INACTIVE** cannot be found in EUHC specification (i.e. the terminology **MAC\_INACTIVE** cannot be found)

• The definition of **MAC\_CONNECTED** cannot be found in EUHC specification (i.e. the terminology **MAC\_CONNECTED** cannot be found)

• The terminology **radio resource connection** cannot be found in EUHT specification, and none of the message/procedure (e.g. **radio resource connection setup/release/recovery/suspension**) can be found in EUHT specification.

(Example-2)

|  |  |
| --- | --- |
| 5.2.3.2.23.2 | Describe any capabilities/features to flexibly deploy a range of services across different usage scenarios (eMBB, URLLC, and mMTC) in an efficient manner, (e.g., a proposed RIT/SRIT is designed to use a single continuous or multiple block(s) of spectrum).  *In different application scenarios, EUHT has multiple flexible configuration attributes, which facilitate the performance improvement of the RIT.*  *- The eMBB services can benefit from the following components.*  *- The maximum aggregated bandwidth supported by EUHT is 1600MHz for Sub-6GHz bands, 6400MHz for mmWave bands, which can improve the data transmission rate.*  *- EUHT supports 8\*8 MIMO. Its maximum modulation mode is 1024 QAM, which can improve the data transmission rate.*  *- The URLLC services can benefit from the following components.*  *The following low latency structures can effectively improve the characteristics of the URLLC.*  *- The scheduling unit of EUHT is the resource unit and the time interval is less than 1ms. The reduced processing time budget at the STA side can lower the time delay.*  *- Front loaded DRS can be used to complete the channel estimation before valid data arrive.*  *- Instantly returning ACK/NACK can reduce the user plane delay.*  *- The mMTC services can benefit from the following components.*  *- Reducing the PAPR can increase the Tx power and facilitate the better coverage.*  *- Flexible frame length configuration facilitates the better coverage.*  *- The high aggregation level of the downlink control channel facilitates the better coverage.*  *- The super long* ***DRX*** *cycle in the MAC\_ACTIVE state can reduce the power consumption of the terminal and extend the battery service life.*  *- A few data can be transmitted when they are randomly received. They needn’t be transformed into the MAC \_CONNECT state, which can reduce the signalling overhead.*  *- The OFDMA (low power consumption) STAs to a broadband system is supported. The resource unit in OFDMA is as narrow as 312.5KHz.*  *- The retransmission mechanism can increase the control channel and the service channel coverage.* |

Comment: The terminology **DRX** cannot be found in EUHT specification.

PART III

Conclusion

# III.1 Completeness of submission

5G Infrastructure Association finds that the submission in [4] and are ‘complete’ according to [2].

However, some technical issues were announced by some sector members in Working Party 5D #33. Moreover, some mismatch between EUHT Specification and Characteristics template for EUHT are shown in II-F. Therefore, EUHT technical completeness is suspicious.

# III.2 Compliance with requirements

These are the main conclusions on the 5G Infrastructure Association evaluation of the evaluated proposal. In Table 20 below, it is shown whether or not 5G Infrastructure Association has confirmed the proponent’s claims relating to IMT-2020 requirements.

The phrase ‘Requirements fulfilled’ in the tables below indicates that 5G Infrastructure Association Evaluation Group assessment confirms the associated claim from the proponent that the requirement is fulfilled.

In Section III-2.1 the detailed compliance templates are summarized.

## III.2.1 Overall compliance

TABLE 20

5G Infrastructure Association assessment of compliance with requirements

|  |  |  |
| --- | --- | --- |
| Characteristic for evaluation | RIT NR:  5G IA assessment | Section |
| 5th percentile user spectral efficiency | EUHT cannot meet the requirement | Part II-E.1 |
| Average spectral efficiency | EUHT cannot meet the requirement | Part II-E.2 |
| Reliability | EUHT cannot meet the requirement | Part II-E.3 |

It should be noted that the analysis behind the analytical and inspection results is not limited by properties of the test environment; hence all these conclusions are valid for all test environments.

## III.2.2 Detailed compliance templates

### III.2.2.1 Compliance template for services[[4]](#footnote-4)

|  |  |  |
| --- | --- | --- |
|  | Service capability requirements | Evaluator’s comments |
| **5.2.4.1.1** | **Support for wide range of services**  Is the proposal able to support a range of services across different usage scenarios (eMBB, URLLC, and mMTC)?: YES / √NO  Specify which usage scenarios (eMBB, URLLC, and mMTC) the candidate RIT or candidate SRIT can support.(1) | The proposal is not able to support a range of services across different usage scenarios, including, at least, eMBB and URLLC. |
| (1) Refer to the process requirements in IMT-2020/2. | | |

### III.2.2.2 Compliance template for spectrum3

|  |  |
| --- | --- |
|  | Spectrum capability requirements |
| **5.2.4.2.1** | **Frequency bands identified for IMT**  Is the proposal able to utilize at least one frequency band identified for IMT in the ITU Radio Regulations? YES / NO  Specify in which band(s) the candidate RIT or candidate SRIT can be deployed. |
| **5.2.4.2.2** | **Higher Frequency range/band(s)**  Is the proposal able to utilize the higher frequency range/band(s) above 24.25 GHz? YES / NO  Specify in which band(s) the candidate RIT or candidate SRIT can be deployed.  Details are provided in Section II-E.16.  NOTE 1 – In the case of the candidate SRIT, at least one of the component RITs need to fulfil this requirement. |

### III.2.2.3 Compliance template for technical performance3

| Minimum technical performance requirements item (5.2.4.3.x), units, and Report ITU-R M.2410-0 section reference(1) | Category | | | Required value | Value(2) | Requirement met? | Comments (3) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Usage scenario | Test environment | Downlink or uplink |  |  |  |  |
| **5.2.4.3.4** 5th percentile user spectral efficiency (bit/s/Hz) *(4.4)* | eMBB | Indoor Hotspot – eMBB | Downlink | 0.3 | Config-A  0.03~0.24  Config-B 0.01~0.06 | Yes  √ No | c.f.  II-E.1  Not fulfilled in Config-A and B, c.f. |
| Uplink | 0.21 | Config-A  0.08~0.171  Config-B 0.05~0.1 | Yes  √ No |
| eMBB | Dense Urban – eMBB | Downlink | 0.225 |  | Yes  No | c.f.  II-E.1  Not fulfilled in Config-A and B, c.f. |
| Uplink | 0.15 | Config-A  0.09~0.1  Config-B 0 | Yes  √ No |
| eMBB | Rural – eMBB | Downlink | 0.12 |  | Yes  No | c.f.  II-E.1  Not fulfilled in Config-B, c.f. |
| Uplink | 0.045 | 0.017 | Yes  √ No |
| **5.2.4.3.5** Average spectral efficiency (bit/s/Hz/ TRxP) *(4.5)* | eMBB | Indoor Hotspot – eMBB | Downlink | 9 | Config-A  4.09~7.34  Config-B 4.77~5.42 | Yes  √ No | c.f.  II-E.2  Not fulfilled in Config-A and B, c.f. |
| Uplink | 6.75 | Config-A  2.71~4.08  Config-B 2.48~3.61 | Yes  √ No |
| eMBB | Dense Urban – eMBB | Downlink | 7.8 | Config-A  7.409~7.68  Config-B 5.53 | Yes  √ No | c.f.  E-II.2  Not fulfilled in Config-A and B, c.f. |
| Uplink | 5.4 | Config-A  3.627~3.58  Config-B 1.7 | Yes  √ No |
| eMBB | Rural – eMBB | Downlink | 3.3 |  | Yes  No | c.f.  E-II.2  Not fulfilled in Config-B, c.f. |
| Uplink | 1.6 | 3.6 | Yes  √ No | c.f.  E-II.2  Not fulfilled in Config-B, c.f. |
| **5.2.4.3.11** Reliability *(4.10)* | URLLC | Urban Macro –URLLC | Uplink or Downlink | 1-10−5 success probability of transmitting a layer 2 PDU (protocol data unit) of size 32 bytes within 1 ms in channel quality of coverage edge | DL: 99.54%  UL: 92.37% | Yes  √ No | c.f.  E-II.3  Not fulfilled in Config-B, c.f. |
| (1) As defined in Report ITU-R [M.2410-0](https://www.itu.int/pub/R-REP-M.2410).  (2) According to the evaluation methodology specified in Report ITU-R [M.2412-0](https://www.itu.int/pub/R-REP-M.2412).  (3) Proponents should report their selected evaluation methodology of the Connection density, the channel model variant used, and evaluation configuration(s) with their exact values (e.g. antenna element number, bandwidth, etc.) per test environment, and could provide other relevant information as well. For details, refer to Report ITU-R M.2412-0, in particular, § 7.1.3 for the evaluation methodologies, § 8.4 for the evaluation configurations per each test environment, and Annex 1 on the channel model variants.  (4) Refer to § 7.3.1 of Report ITU-R M.2412-0. | | | | | | | |

# III.3 Number of test environments meeting all IMT-2020 requirements

Based on our independent evaluation report, at least, 4 test environments cannot meet all IMT-2020 requirements, including Indoor hotspot-eMBB, Dense Urban-eMBB, Rural-eMBB and Urban Macro-URLLC test environments.

Annex A

Detailed assumptions for average and 5th percentile user spectral efficiency

The detailed evaluation assumptions for downlink and uplink are illustrated in Table B-1 and Table B-2, respectively.

Table B-1

Evaluation assumptions for downlink

| **Configuration parameters** | **Dense Urban**  **(Configuration A/B)** | **Indoor Hotspot**  **(Configuration A/B)** | **Rural**  **(Configuration B)** |
| --- | --- | --- | --- |
| Multiple access | OFDMA | OFDMA | OFDMA |
| Duplexing | TDD | TDD | TDD |
| Network synchronization | Synchronized | Synchronized | Synchronized |
| Carrier frequency | For configuration A: 4GHz  For configuration B: 30GHz | For configuration A: 4GHz  For configuration B: 30GHz | 4GHz |
| Modulation | Up to 1024 QAM | Up to 1024 QAM | Up to 256 QAM |
| Coding on data channel | LDPC | LDPC | LDPC |
| Subcarrier spacing | For configuration A: 78.125 kHz;  For configuration B: 390.625kHz | For configuration A: 78.125 kHz  For configuration B: 390.625kHz | 78.125 kHz |
| Simulation bandwidth | For configuration A:20MHz  For configuration B: 100MHz | For configuration A:20MHz  For configuration B: 100MHz | 20 MHz |
| Frame structure | DL:UL = 2:1 | DL:UL = 2:1 | DL:UL = 2:1 |
| Transmission scheme | Adaptive SU/MU-MIMO | Adaptive SU/MU-MIMO | Adaptive SU/MU-MIMO |
| MU dimension | Maximum factor of 4 | Maximum factor of 2 | Maximum factor of 4 |
| SU dimension | Up to 8 layers | Up to 8 layers | For configuration B: up to 8 layers; |
| Codeword (CW)-to-layer mapping | For 1~4 layers, CW1; For 5 layers or more, two CWs | For 1~4 layers, CW1; For 5 layers or more, two CWs | For 1~4 layers, CW1; For 5 layers or more, two CWs |
| DL-SCH transmission | 8 DL-SCH ports in 20MHz bandwidth; 2symbols per 20ms | 8 DL-SCH ports in 20MHz bandwidth; 2symbols per 20ms | 8 DL-SCH ports in 20MHz bandwidth; 2symbols per 20ms |
| CSI feedback | CSI: every 20ms | CSI: every 20ms | CSI: every 20ms |
| Interference measurement | SU-CQI | SU-CQI | SU-CQI |
| ACK/NACK delay | Current frame | Current frame | Current frame |
| Re-transmission delay | Next available frame | Next available frame | Next available frame |
| Antenna configuration at TRxP | 8Rx, (8,4,2,1,1; 1,4) | 8Tx, (8,4,2,1,1; 1,4) | 8Tx, (8,4,2,1,1; 1,4) |
| Antenna configuration at UE | 8Tx, (1,4,2,1,1; 1,4) | 8Rx, (1,4,2,1,1; 1,4) | 8Rx, (1,4,2,1,1; 1,4); |
| Scheduling | PF | PF | PF |
| Receiver | MMSE-IRC | MMSE-IRC | MMSE-IRC |
| Channel estimation | Non-ideal | Non-ideal | Non-ideal |
| TRxP number per site | 3 | 1 TRxP per site;  3 TRxPs per site | 3 |
| Mechanic tilt | 110° in GCS | 110° in GCS | 90° in GCS |
| Electronic tilt | 90° in LCS | 90° in LCS | For Configuration B:100° in LCS; for Configuration C: 92° in LCS |
| Handover margin (dB) | 1 | 1 | 1 |
| Wrapping around method | Geographical distance-based wrapping | No wrap around | Geographical distance-based wrapping |
| Criteria for selection for serving TRxP | RSRP based | RSRP based | RSRP based |
| Overhead | For configuration A:  CCH: 1 symbol / 2ms  DL-SCH: 2symbols / 20ms  DRS: 12 symbols / 2ms  GI: 1 symbol / 2ms  Preamble: 2 symbols / 2ms  SICH: 1 symbol / 2ms  For configuration B: The total overhead is same as that of configuration A. | For configuration A:  CCH: 1 symbol / 2ms  DL-SCH: 2symbols / 20ms  DRS: 12 symbols / 2ms  GI: 1 symbol / 2ms  Preamble: 2 symbols / 2ms  SICH: 1 symbol / 2ms  For configuration B: The total overhead is same as that of configuration A. | CCH: 1 symbol / 2ms  DL-SCH: 2symbols / 20ms  DRS: 12 symbols / 2ms  GI: 1 symbol / 2ms  Preamble: 2 symbols / 2ms  SICH: 1 symbol / 2ms |
| *Note: Other system configuration parameters align with Report ITU-R M.2412.* | | | |

Table B-2

Evaluation assumptions for uplink

|  |  |  |  |
| --- | --- | --- | --- |
| **Configuration parameters** | **Dense Urban**  **(Configuration A/B)** | **Indoor Hotspot**  **(Configuration A/B)** | **Rural**  **(Configuration B/**  **Configuration C)** |
| Multiple access | OFDMA | OFDMA | OFDMA |
| Duplexing | TDD | TDD | TDD |
| Network synchronization | Synchronized | Synchronized | Synchronized |
| Modulation | For configuration A: 4GHz  For configuration B: 30GHz | For configuration A: 4GHz  For configuration B: 30GHz | For configuration B: 4GHz  For configuration C: 700MHz |
| Coding on DL TCH | LDPC | LDPC | LDPC |
| Numerology | For configuration A: 78.125 kHz  For configuration B: 390.625kHz | For configuration A: 78.125 kHz  For configuration B: 390.625kHz | 78.125 kHz |
| Simulation bandwidth | For configuration A:20MHz  For configuration B: 100MHz | For configuration A:20MHz  For configuration B: 100MHz | 20 MHz |
| Frame structure | DL:UL = 2:1 | DL:UL = 2:1 | DL:UL = 2:1 |
| Transmission scheme | Adaptive SU/MU-MIMO | Adaptive SU/MU-MIMO | Adaptive SU/MU-MIMO |
| MU dimension | Maximum factor of 4 | Maximum factor of 2 | Maximum factor of 4 |
| SU dimension | Up to 8 layers | Up to 8 layers | Up to 8 layers for Configuration B; up to 4 layers for Configuration C |
| Codeword (CW)-to-layer mapping | For 1~4 layers, CW1; For 5 layers or more, two CWs | For 1~4 layers, CW1; For 5 layers or more, two CWs | For 1~4 layers, CW1; For 5 layers or more, two CWs |
| UL-SCH transmission | 8 UL-SCH ports; 2symbols per 20ms | 8 UL-SCH ports; 2symbols per 20ms | 8/4 UL-SCH ports; 2symbols per 20ms |
| Re-transmission delay | Next available frame | Next available frame | Next available frame |
| Antenna configuration at TRxP | 8Rx, (8,4,2,1,1; 1,4) | 8Rx, (8,4,2,1,1; 1,4) | 8Rx, (8,4,2,1,1; 1,4) |
| Antenna configuration at UE | 8Tx, (1,4,2,1,1; 1,4) | 8Tx, (1,4,2,1,1; 1,4) | 8Tx, (1,4,2,1,1; 1,4) |
| Scheduling | PF | PF | PF |
| Receiver | MMSE-IRC | MMSE-IRC | MMSE-IRC |
| Channel estimation | Non-ideal | Non-ideal | Non-ideal |
| Power control parameter | P0=-60, alpha = 0.6 | P0=-60, alpha = 0.6 | P0=-60, alpha = 0.6 |
| TRxP number per site | 3 | 1 / 3 | 3 |
| Mechanic tilt | 110° in GCS | 110° in GCS | 90° in GCS |
| Electronic tilt | 90° in LCS | 90° in LCS | 100° in LCS |
| Handover margin (dB) | 1 | 1 | 1 |
| Wrapping around method | Geographical distance-based wrapping | No wrap around | Geographical distance-based wrapping |
| Criteria for selection for serving TRxP | RSRP based | RSRP based | RSRP based |
| Overhead | For configuration A:  UL-SRCH: 2 symbols /20ms  DRS: 6 symbols / 2ms  UL-SCH: 2symbols / 20ms  GI: 1 symbol / 2ms  For configuration B: The total overhead is same as that of configuration A. | For configuration A:  UL-SRCH: 2 symbols /20ms  DRS: 6 symbols / 2ms  UL-SCH: 2symbols / 20ms  GI: 1 symbol / 2ms  For configuration B: The total overhead is same as that of configuration A. | UL-SRCH: 2 symbols /20ms  DRS: 6 symbols / 2ms  UL-SCH: 2symbols / 20ms  GI: 1 symbol / 2ms |

*Note: Other system configuration parameters align with Report ITU-R M.2412.*

Annex B

Detailed assumptions for reliability

The detailed system-level and link-level evaluation assumptions for downlink are illustrated in Table C-1 and Table C-2, respectively.

Table C-1

System-level evaluation assumptions for downlink reliability

|  |  |
| --- | --- |
| **Configuration parameters** | **Urban macro - URLLC** |
| Multiple access | OFDMA |
| Duplexing | TDD |
| Modulation | Up to 1024 QAM |
| Numerology | 78.125 kHz SCS |
| Simulation bandwdith | 20 MHz |
| Frame structure | DL:UL = 2:1 |
| DL transmission scheme | SU-MIMO |
| DL MU dimension | N/A |
| DL SU dimension | 1 |
| Antenna configuration at TRxP | 8Tx, (8,4,2,1,1; 1,4) |
| Antenna configuration at UE | 2Rx, (1,1,2,1,1; 1,1) |
| Scheduling | PF |
| Receiver | MMSE-IRC |
| Channel estimation | Non-ideal |
| Carrier frequency for evaluation | 4 GHz |
| UE speeds of interest | for indoor 3 km/h, for outdoor 30 km/h |
| TRxP number per site | 3 |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) |
| Electronic tilt | 99 degree |
| Handover margin (dB) | 1 |
| Wrapping around method | Geographical distance-based wrapping |
| Criteria for selection for serving TRxP | RSRP based |

*Note: Other system configuration parameters align with Report ITU-R M.2412.*

Table C-2

Link-level evaluation assumptions for downlink reliability

|  |  |
| --- | --- |
| **Configuration parameters** | **Urban macro - URLLC** |
| Carrier frequency for evaluation | 4 GHz |
| Waveform | CP-OFDM |
| Numerology | 78.125 kHz SCS |
| Simulation bandwdith | 20 MHz |
| Channel model | TDL-C |
| Scaled delay spread | 363ns |
| UE Speed | for indoor 3 km/h |
| Antenna configuration at TRxP | 8T |
| Antenna configuration at UE | 2R |
| TXRU pattern at TRxP | 0dBi Omni-directional |
| TXRU pattern at UE | 0dBi Omni-directional |
| TCH Transmission mode | SU-MIMO |
| TCH Modulation and coding | LDPC with code rate = 4/7, QPSK 12 repetitions align with the assumption in [4] |
| Channel estimation | Non-ideal |
| CCH transmission scheme | 56 bit payload includes CRC |
| CCH Modulation and coding | TBCC with code rate = 1/2, QPSK 12 repetition |
| Packet size for TCH | 256 bit |
| DRS configuration | 2 symbols |

The detailed system-level and link-level evaluation assumptions for uplink are illustrated in Table C-3 and Table C-4, respectively.

Table C-3

System-level evaluation assumptions for uplink reliability

|  |  |
| --- | --- |
| **Configuration parameters** | **Urban macro - URLLC** |
| Multiple access | OFDMA |
| Carrier frequency for evaluation | 4 GHz |
| Duplexing | TDD |
| Modulation | Up to 1024QAM |
| Numerology | 78.125 kHz SCS |
| Simulation bandwdith | 20 MHz |
| Frame structure | DL:UL = 2:1 |
| UL Transmission scheme | SU-MIMO |
| UL SU dimension | 1 |
| Antenna configuration at TRxP | 8Rx, (M, N, P, Mg, Ng; Mp, Np) = (8,4,2,1,1; 1,4) |
| Antenna configuration at UE | 2Tx, (M, N, P, Mg, Ng; Mp, Np) = (1,1,2,1,1; 1,1) |
| Scheduling | PF |
| Receiver | MMSE-IRC |
| Channel estimation | Non-ideal |
| Power control parameters | P0= -86, alpha = 0.8 |
| TRxP number per site | 3 |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) |
| Electronic tilt | 99 degree |
| Handover margin (dB) | 1 |
| Wrapping around method | Geographical distance-based wrapping |
| Criteria for selection for serving TRxP | RSRP based |
| Carrier frequency for evaluation | 4 GHz |

*Note: Other system configuration parameters align with Report ITU-R M.2412.*

Table C-4

Link-level evaluation assumptions for uplink reliability

|  |  |
| --- | --- |
| **Configuration parameters** | **Urban macro - URLLC** |
| Carrier frequency | 4 GHz |
| Waveform | CP-OFDM |
| Numerology | 78.125 kHz SCS |
| Channel model | TDL-iii |
| Scaled delay spread | 363ns |
| UE Speed | for indoor 3 km/h |
| Antenna configuration at TRxP | 8R |
| Antenna configuration at UE | 2T |
| TXRU pattern at TRxP | 0dBi Omni-directional |
| TXRU pattern at UE | 0dBi Omni-directional |
| TCH Transmission mode | SU-MIMO |
| TCH modulation and coding | LDPC with code rate = 4/7, QPSK 8 repetitions align with the assumption in [4] |
| Channel estimation | Non-ideal |
| TRxP receiver type | MMSE |
| Packet size | 256 bit |
| DRS configuration | 2 symbols |

*Note: Other system configuration parameters align with Report ITU-R M.2412.*

References

[1] ITU-R: Minimum requirements related to technical performance for IMT-2020 radio interface(s). [Report ITU-R M.2410-0](https://www.itu.int/pub/R-REP-M.2410), (11/2017).

[2] ITU-R: Requirements, evaluation criteria and submission templates for the development of IMT-2020. [Report ITU-R M.2411-0](https://www.itu.int/pub/R-REP-M.2411), (11/2017).

[3] ITU-R: Guidelines for evaluation of radio interface technologies for IMT-2020. [Report ITU-R M.2412-0](https://www.itu.int/pub/R-REP-M.2412), (10/2017).

[4] ITU-R WP5D: Acknowledgement of Candidate RIT Submission from Nufront Proponent under Step 3 of the IMT-2020 Process. Document IMT-2020/18-(Rev.1)E, 23 December 2019.

[5] ITU-R WP 5D: Information of the evaluation for the terrestrial components of the radio interface(s) for IMT-2020. Liaison statement to registered Independent Evaluation Groups. Document 5D/TEMP/769(Rev 1), 16 July 2019.

[6] Nufront: Updated submission of candidate IMT-2020 Radio Interface Technology (EUHT), Contribution [5D/1300](https://www.itu.int/md/R15-WP5D-C-1300/en), Geneva, December 2019.

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

1. Submitted on behalf of the Independent Evaluation Group 5G Infrastructure Association. [↑](#footnote-ref-1)
2. This contribution is based on work underway within the research in 5G PPP and 5G Infrastructure Association, see <https://5g-ppp.eu/>. The views expressed in this contribution do not necessarily represent the 5G PPP. [↑](#footnote-ref-2)
3. Average spectral efficiency corresponds to “spectrum efficiency” in Recommendation [ITU‑R M.2083](https://www.itu.int/rec/R-REC-M.2083/en). [↑](#footnote-ref-3)
4. If a proponent determines that a specific question does not apply, the proponent should indicate that this is the case and provide a rationale for why it does not apply. [↑](#footnote-ref-4)