Radiocommunication Study Groups

Received: 8 February 2020

Document 5D/52-E
10 February 2020
English only

TECHNOLOGY ASPECTS

Director, Radiocommunication Bureau[1,2]

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 IMT-2020/18 (Rev.1)-E [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].

1 Submitted on behalf of the Independent Evaluation Group 5G Infrastructure Association.

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.

ATTACHMENT 1

Part I 3

Administrative aspects of 5G Infrastructure Association 3

I.1 Name of the Independent Evaluation Group 3

I.2 Introduction and background of 5G Infrastructure Association 3

I.3 Method of work 5

I.4 Administrative contact details 5

I.5 Technical contact details 5

I.6 Other pertinent administrative information 6

I.7 Structure of this Report... 6

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

II.B Confirmation of utilization of the ITU-R evaluation guidelines in Report ITU-R M.2412 8

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

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

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

II.E.1 5th percentile user spectral efficiency 9

II.E.1.1 Basic parameters 9

II.E.1.2 EUHT 10

II.E.2 Average spectral efficiency 13

II.E.2.1 Basic parameters 14

II.E.2.2 EUHT 14

II.E.3 Reliability 17

II.E.3.1 Evaluation methodology and KPIs 18

II.E.3.2 Evaluation results for EUHT.. 18

II.F Questions and feedback to WP 5D and/or the proponents or other IEGs 19

Part III. Conclusion 22

III.1 Completeness of submission 22

III.2 Compliance with requirements 22

III.2.1 Overall compliance 22

III.2.2 Detailed compliance templates 22

III.3 Number of test environments meeting all IMT-2020 requirements 25

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

I.5 Technical contact details

Members of the Evaluation Group:

Hakan Batıkhan	Turkcell	hakan.batikhan@turkcell.com.tr
Ioannis-Prodromos Belikaidis	WINGS ICT Solutions	iobelika@wings-ict-solutions.eu
Ömer Bulakci	Huawei	Oemer.Bulakci@huawei.com
Jose Luis Carcel	Universitat Politecnica de Valencia	jocarcer@iteam.upv.es
Yang Changqing	Huawei	changqing.yang@huawei.com
Marcos Rates Crippa	University of Kaiserslautern	crippa@eit.uni-kl.de
Panagiotis Demestichas	WINGS ICT Solutions	pdemest@wings-ict-solutions.eu
Salih Ergut	Turkcell	salih.ergut@turkcell.com.tr
Manuel Fuentes	Universitat Politecnica de Valencia	mafuemue@iteam.upv.es
Eduardo Garro	Universitat Politecnica de Valencia	edgarcre@iteam.upv.es
Andreas Georgakopoulos	WINGS ICT Solutions	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
Marco Gramaglia	UC3M	mgramagl@it.uc3m.es
Ole Grondalen	Telenor	ole.grondalen@telenor.com
Nazli Guney	Turkcell	nazli.guney@turkcell.com.tr
Marie-Helene Hamon	Orange	mhelene.hamon@orange.com
Ahmet Kaplan	Turkcell	ahmet.kaplan@turkcell.com.tr
Cemil Karakus	Turkcell	cemil.karakus@turkcell.com.tr
Evangelos Kosmatos	WINGS ICT Solutions	vkosmatos@wings-ict-solutions.eu
Anastasios Kourtis	National Centre for Scientific Research Demokritos	kourtis@iit.demokritos.gr
Fotis Lazarakis	National Centre for Scientific Research Demokritos	flaz@iit.demokritos.gr
Ji Lianghai	University of Kaiserslautern	ji@eit.uni-kl.de
Hans-Peter Mayer	Nokia	hans-peter.mayer.ext@nokia-bell-labs.com
Werner Mohr	Nokia	werner.mohr@nokia.com
Volker Pauli	Nomor	pauli@nomor.de
Athul Prasad	Nokia Bell-Labs	athul.prasad@nokia-bell-labs.com
Christoph Schmelz	Nokia	christoph.schmelz@nokia-bell-labs.com
Hans Schotten	DFKI/University of Kaiserslautern	schotten@eit.uni-kl.de
Egon Schulz	Huawei	egon.schulz@huawei.com
Vera Stravroulaki	WINGS ICT Solutions	veras@wings-ict-solutions.eu
Ingo Viering	Nomor	viering@nomor.de
Shangbin Wu	Samsung	shangbin.wu@samsung.com
Shao Jiafeng	Huawei	shaojiafeng@huawei.com
Wu Yong	Huawei	wuyong@huawei.com
Xi Meng	ZTE Wistron Telecom AB	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
5^{th} 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 R_i (T_i) denoting the number of correctly received bits of user i, T_i the active session time for user i and W the channel bandwidth, the (normalized) user throughput of user i, r_i, is defined according to equation (4).

$$r_i = \frac{\mathrm{R}_i(T_i)}{T_i \cdot \mathrm{W}}$$

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.1.2.1.2Evaluation 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] *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 $R_i(T)$ 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, SE_{avg} is then defined according to equation (5).

$$\mathrm{SE}_{\mathrm{avg}} = \frac{\sum_{i=1}^{N} \mathrm{R}_i(T)}{T \cdot \mathrm{W} \cdot M}$$

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.

3 Average spectral efficiency corresponds to "spectrum efficiency" in Recommendation ITU-R M.2083.

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.2.2.2.1Evaluation 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.2.2.2.2Evaluation 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* $1\text{-}10^{-5}$ *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 $1\text{-}10^{-5}$ 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).

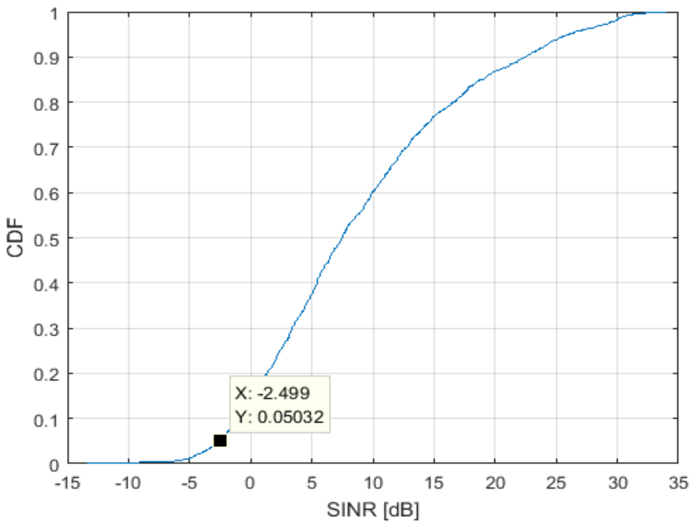
II.E.3.2 Evaluation results for EUHT

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

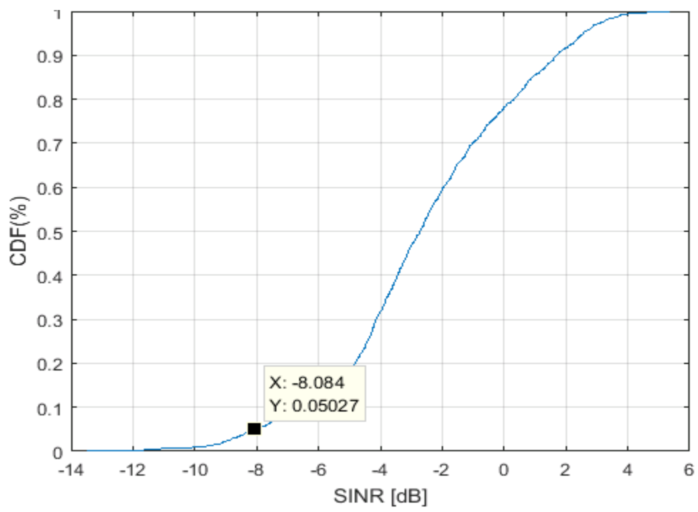
Evaluation results of downlink reliability

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]

	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	The proposal is not able to support a range of services across different usage scenarios, including, at least, eMBB and URLLC.

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.

	Specify which usage scenarios (eMBB, URLLC, and mMTC) the candidate RIT or candidate SRIT can support.(1)	

(1) Refer to the process requirements in IMT-2020/2.

III.2.2.2 Compliance template for spectrum[3]

	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 performance[3]

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	

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**				
	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.

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				
5.2.4.3.11 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.

(2) According to the evaluation methodology specified in Report ITU-R M.2412-0.

(3) Proponents should report their selected evaluation methodology of the Connection density, the channel model variant used, and evaluation configuration(s) with their exact values (e.g. antenna element number, bandwidth, etc.) per test environment, and could provide other relevant information as well. For details, refer to Report ITU-R M.2412-0, in particular, § 7.1.3 for the evaluation methodologies, § 8.4 for the evaluation configurations per each test environment, and Annex 1 on the channel model variants.

(4) Refer to § 7.3.1 of Report ITU-R M.2412-0.

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	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	CCH: 1 symbol / 2ms DL-SCH: 2symbols / 20ms DRS: 12 symbols / 2ms GI: 1 symbol / 2ms Preamble: 2 symbols / 2ms SICH: 1 symbol / 2ms

Configuration parameters	Dense Urban (Configuration A/B)	Indoor Hotspot (Configuration A/B)	Rural (Configuration B)
	overhead is same as that of configuration A.	overhead is same as that of configuration A.	

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, (11/2017).

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

[3] ITU-R: Guidelines for evaluation of radio interface technologies for IMT-2020. Report ITU-R M.2412-0, (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, Geneva, December 2019.